Impact of Automated Healthcare Technology on Accessibility

A research paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Sciences
University of Virginia Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree of Bachelor of Science, School of Engineering

Leah Bianchi
Spring 2021

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

Signatures _____ Date _____
Author name

Signatures _____ Date _____
Advisor name, Department of Engineering and Society

Introduction

The United States healthcare system currently faces several accessibility issues. For example, in 2018, 8.5% of Americans, or 27.5 million people, did not have insurance (Bureau, n.d.). Hospitals can cover their care when necessary, but it strains the system, leading to medical errors and poor patient care. Automated technology is a tool used to increase efficiency in a variety of industries, however, adoption in healthcare has been slower. These algorithms and devices could offer solutions to increase efficiencies and decrease errors and inconsistencies in the workforce so more patients can receive high quality care. The most widespread attempt at automation in healthcare is with Electronic Medical Records (EMRs). However, these systems have many usability concerns which decrease the healthcare providers inclination to utilize them to a full extent. The social construct of technology (SCOT) framework is best suited to explore the complexities of this issue and how technology can help or hurt its relevant social groups. The central goal for my research project is to understand how specific automated technologies are utilized in healthcare, determine how they affect their relevant social groups, and investigate their effects on accessibility to healthcare. Three distinct, specific technologies will be investigated according to the SCOT framework to determine how they can improve or detract from accessibility to healthcare in the US. They are Electronic Medical Records (EMRs), automated infection tracking algorithms, and a web app to provide cognitive behavioral therapy (CBT) to veterans.

Social Construction of Technology Overview

The social construct of technology (SCOT) framework is best suited to research the interactions between technologies and their social groups, the necessary trade-offs, and benefits

they yield. One tenet of the SCOT framework is understanding the different social groups that interact with the technology. This will be slightly different for the technologies I look into, but for all of them, the core groups are composed of healthcare practitioners (doctors, nurses, physicians' assistants (PAs)), patients, and regulating bodies (the government, hospital administration). The next tenet is interpretive flexibility. Analyzing this will require determining how the technologies benefit some while excluding others and relating this to trade-offs that must be compromised in order to make the system usable to all social groups. This will often focus on how engineers research and attempt to mold the systems to fit the needs of the different groups when they design systems. The last tenet is problems and conflicts. This will require determining the problems that each social group faces and exploring how technologies can mitigate them. These concepts will allow me to relate the issues to accessibility of healthcare because usability and mitigation of barriers with technology directly affects how many patients can be seen by practitioners.

Accessibility to Healthcare in United States

The United States is unique with respect to how it delivers healthcare. While it leads the world in cutting edge technology, there are many problems regarding high costs, low quality of care, and shortages in the workforce. One problem preventing patients from being able to see doctors is the high cost of deductibles, copays, and out-of-pocket expenses in the US. As the system becomes increasingly complex and decentralized, the overhead costs increase and make access to medicine less possible for uninsured Americans (Council (US) et al., 2013). Another problem is the geographic spread of healthcare providers across the US. There are many people living in rural areas that do not have access to medical care because of distance (Comer, 2015).

This problem is exacerbated for certain subpopulations of the patient social group, for example: veteran patients with PTSD or low-income patients with decreased access to transportation. It effects veterans specifically because PTSD symptoms are improved by conditions that "reduce overstimulation, hyperarousal, and interpersonal conflict." (Possemato et al., 2015). Another problem is patient anxiety associated with healthcare, generally surrounding quality of care. One example of this are high rate of hospital acquired infections (HAIs) combined with incentives for hospital administration and infection preventionists to aim for specificity, rather than sensitivity, when making diagnoses (Trick, 2013). This can also lead to high patient return rates, which puts further strain on healthcare systems (Pliakos et al., 2018). This effects veterans specifically as well, because of a tendency for this social group to stigmatize mental health, believe it will not be helpful or induce stress(Possemato et al., 2015).

Accessibility to healthcare is vital for many ethical and practical reasons. In practical terms, a healthier population is more capable of working and supporting the economy. Allowing more patients access to healthcare has benefits to hospitals as well. If more insured patients are seen, the hospital brings in more money. Therefore, it is practical to increase efficiency and reduce bottlenecks preventing providers from being able to see as many patients as possible.

Specific Technologies

Electronic Medical Records

Overview of EMRs

EMRs originally emerged as a tool for congregation of large amount of data points that would be extremely tedious to keep track of on paper, such as data from devices like bedside monitors and IV alarms (Evans, 2016). However, as time progressed, practitioners become

increasing reliant on them while the systems become decentralized and not adept at fitting into their workflow.

Relevant Social Groups

The main social group for EMRs are the healthcare providers that use them, including doctors, nurses, and PAs. This group requires EMRs to store patient data, communicate with patients, the government, hospital administration, and all groups of patients indirectly influence or are influenced by the adoption and use of this tool.

Problems Social Groups Face and How Technology Can Mitigate Them

Practitioners face the most drastic problems, since their workflow is dependent on how usable their EMR system is. The problems include that systems are difficult to navigate, have many features that they do not use and just crowd the screen, and even just have an aesthetically poor use of color (Rose et al., 2005). One option to mitigate this problem is a practitioner creating their own add-ons for the system, but many practitioners are not equipped with computational skills and if the add-on system is not made correctly, it could jeopardize patient safety and privacy (Rose et al., 2005). Engineers can make design decisions that mitigate the problems, such as determining where certain features should be placed and how they should be implemented. For example, one problem that was researched by the Rose et al. team was that the screen for a doctor to write a letter to a patient had a default that was difficult to change, however they wanted to in order to add a 'human touch' to the practice (Rose et al., 2005).

Patients are also a social group that interacts with these technologies. While the doctors' workflow revolves around the systems, patients only access them for things like viewing

diagnostic results and appointments. These patients often say they want systems that display information in a gentle way that helps them gain a full understanding of their health concerns (Goldberg et al., 2011).

Interpretive Flexibility: How Tech Benefits Some While Excluding Others + Trade-Offs Necessary for Adoption

A technological trade off that must be considered in EMRs is the need for lots of information and data without compromising usability. A key idea for practitioners would be that the systems need to help them perform routine and deliver high quality outcomes while ensuring the usability does not lead to critical errors (Goldberg et al., 2011). One example of this is alarms within the systems. While adding alarms for every possible negative outcomes might seem beneficial to patients, it clutters screens and leads to a tendency for practitioners to ignore even the most important one, increasing medical errors (Simpson & Lyndon, 2019). Another trade off to consider is that the EMRs ensure patient privacy, but also may need interoperability between different systems. One study shows that a majority of patients support computerized sharing of information and believe that the benefits of computerization outweighed the risk of confidentiality loss (Perera et al., 2011).

Relationship to Accessibility

EMRs currently create logistical problems as they require doctors to spend lots of time troubleshooting a computer system rather than helping patients. By optimizing the tasks doctors have to carry on their EMRs, they would be able to see more patients and focus on patient care rather than their computers. It could also directly improve the accessibility patients have to their

records. Current systems tend to be daunting to those unfamiliar with healthcare but obtaining input from patients and designing system in such a way that they are well suited to patient-specific needs would allow patients to better utilize and involve themselves in healthcare.

Automated Infection Control

Overview

The current CDC Prevention Status Reports list hospital acquired infections as the third most critical public health problem in the US, emphasizing the need for improvements to prevention detection, and response (*Prevention Status Reports (PSR) | CDC*, 2020). Underreporting has been shown to be common in regard to tracking rates of HAIs within hospitals for several reasons. Literature has proven this phenomenon by carrying out random sampling in hospitals and showing actual infection rates are greater than the rates reported by hospitals (Trick, 2013). Certain stakeholders benefit from lower than accurate reported rates of infection. The consequences are actually lower to hospital administration and individual practitioners to when specificity is favored over sensitivity in tests (Trick, 2013). For example, hospital's reputations are improved when they implement testing protocols that test more but are less likely to yield a positive result, leading to better funding. But it harms the social group (patients) it is supposed to help. Cognitive science shows that clinicians can sometimes be biased in their decision-making processes as emotions like anxiety, compliance, and fear influence how infections are diagnosed and reported. Subjectivity in recognizing symptoms is also a problem that practitioners face. For example, some practitioners may test or report a UTI due to the presence of upper pelvic pain, while some do not.

Relevant Social Groups

The social groups for this technology include practitioners, patients, hospital administration, and governmental bodies such as the CDC and state governments. The current system enables practices that underreport HAIs because the stakeholders most financially at risk for higher rates are the hospital administrators in charge of deciding how testing is carried out and the practitioners who could get in trouble if an infection was proven to be their fault.

Problems Different Social Groups Face and How Technology Can Mitigate Them

The problem the patient social group faces in a healthcare structure that underreports nosocomial infections is decreased diagnostic testing leading to morbidity and mortality, longer hospital stays, and greater likelihood of needing to return to the hospital (Trick, 2013)(Burgmann et al., 2010). In a healthcare structure that overreports rates of infections, patients with false positives could also face higher costs to pay for tests that turn out to be unnecessary (Pliakos et al., 2018). These costs would affect other stakeholders as well, such as insurance companies and government bodies responsible for Medicaid and Medicare.

The problem faced by practitioners and administrators when infection rates are underreported is the possibility of missing infections that would lead to longer hospital stays, higher morbidity and mortality rates, and higher rates of patients returning to the hospital, however it has been shown that hospitals face fewer consequences from failing to report rates than from investigating all possible infections (Trick, 2013). The problems faced by this social group when infections are over-reported include external audits, loss of funding, and board reviews (Trick, 2013).

Automated infection tracking can mitigate the problems faced by both major social groups in a few ways. One is shifting away from the current dichotomous way of reporting either

the presence or absence of an infection and replacing it with a sliding scale based on probabilities determined by an algorithm (Trick, 2013). This would keep the rates reported by automated technology similar to the current reported rates. It would also increase involvement from clinicians as they would have the final say in whether certain boundary cases should be reported and further tested or not. Probabilities reported by automated infection tracking would also help decrease alarm fatigue by adding alerts that practitioners can confidently ignore if the probabilities fall below a threshold. It would help patients by decreasing practitioner's cognitive bias in evaluating symptoms and making it difficult and transparent for administrators to manipulate data (Trick, 2013).

Interpretive Flexibility: How Tech Benefits Some While Excluding Others + Trade-Offs Necessary for Adoption

The current system enables practices that underreport HAIs because the stakeholders most financially at risk for higher rates are the hospital administrators in charge of deciding how testing is carried out and the practitioners who could get in trouble if an infection was proven to be their fault. Therefore, it benefits these groups while putting patients at risk. A poorly implemented technological solution would overreport rates of infection, which could harm hospitals and practitioners as reports can lead to audits and board reviews (Trick, 2013). Furthermore, higher reports of HAIs would contribute to alarm fatigue, as more potential infections may just become more alerts that practitioners feel the need to ignore (Simpson & Lyndon, 2019).

Trade-offs are necessary in order to allow seamless adoption of this technology by practitioners and administrators. A key change will need to be how higher rates of infections in

hospitals are handled by government agencies. If better infection tracking leads to more positive results and therefore, over time, better outcomes for patients, hospitals should not be financially strained. The automated technology should also never completely replace the need for clinicians.

Relationship to Accessibility

HAIs have been shown to increase resource consumption by elongating patient stays and often requiring them to return to hospitals. Reducing the number of patients staying at hospitals for preventable reasons would ideally prevent bottlenecks and overflow in hospitals. Automated infection tracking could streamline the process of finding and fighting infections early, which may appear to consume more resources in the short term but would cut costs long term.

Cognitive Behavioral Therapy Web App for Veterans

Overview

Veterans are a subpopulation of the patient social group that faces unique barriers in regard to the way the interact with the healthcare system. 37-39% of veterans have PTSD, 23-27% experience alcohol abuse, and 16% suffer from both (Possemato et al., 2015). Certain adaptations of Cognitive Behavioral Therapy (CBT) have been shown to be an effective treatment method for these specific ailments by measuring the effects on improved health and sleep impairment, however veterans face obstacles when it comes to receiving the treatment (Galovski et al., 2009). Veterans tend to have a reluctancy to seek treatment due to perceived views that it will not be helpful or induce distress as well as stigma around seeking mental healthcare (Possemato et al., 2015). There are also practical barriers such as transportation, geographical spreads of practitioners, costs of healthcare, and avoidance symptoms typical of

PTSD (Possemato et al., 2015). The geographical spread problems are common among victims of PTSD because living in a rural area can help mitigate PTSD symptoms such as overstimulation, hyperarousal, and interpersonal conflict (Possemato et al., 2015). Despite this, veterans are likely to seek our primary care for physical symptoms of PTSD and alcohol abuse, which allows an opportunity for brief assessment and intervention recommendations (Possemato et al., 2015).

Relevant Social Groups

The relevant social groups here primarily include veterans, specifically worked with by Possemato et al. were those who served overseas in Afghanistan and Iraq. Another social group is practitioners who want to help this social group but are unable due to the aforementioned barriers as well as government organizations responsible for the care of their veterans, especially VA hospitals.

Problems Different Social Groups Face and How Technology Can Mitigate Them

The problems veterans face include geographic access to healthcare, high costs, PTSD avoidance symptoms, and mental health stigmas (Possemato et al., 2015). These problems are shared by the practitioners and VA hospitals who want to provide aid, with the problem of healthcare costs and resources more heavily weighted on VA hospitals and Tricare. Primary care practitioners have the added problem that a full length treatment plan, which can range from 8-12 hour long sessions, does not fit in well with their workflow (Possemato et al., 2015).

Technology offers solutions to mitigate these problems in a few ways. First, the use of a web app does not require a patient to be in a geographic area with plentiful mental health

resources. This mitigates problems associated with high populations of veterans who move to rural areas. It also helps with problems such as mental health stigma, trauma-related avoidance, and inconvenience by allowing patients to receive therapies in the privacy of their homes at whatever times work for them (Possemato et al., 2015). It can mitigate costs and overload on primary care providers by providing a way for practitioners to recommend an alternate source of therapy.

Interpretive Flexibility: How Tech Benefits Some While Excluding Others + Trade-Offs Necessary for Adoption

There are several ways in which this system benefits certain subsets of veterans with PTSD and substance abuse than others. For example, it almost completely excludes veterans without access to technology or without experience with technology. It also benefits those who are self-motivated to improve. There are many more specific problems such as women's issues, parenting concerns, and spirituality that were out of scope of this specific project and are not dealt with (Possemato et al., 2015). These problems show that this system should in no way completely replace real, one on one therapies typically administered by practitioners.

Another important consideration is that there may be some easily implemented features that would benefit some veterans while putting others at risk for extreme emotional distress. Specifically, written exposure modules that were shown to be effective and many veterans would be willing to try (Possemato et al., 2015). Therefore, a trade-off was to make these techniques optional to veterans, and to only provide them after other skills, such as relaxation techniques, that would prepare them had been completed (Possemato et al., 2015).

Another consideration is the high privacy consideration among this subpopulation of patients. Veterans explained in the Possemoto et al. study that they would not answer questions truthfully unless privacy was ensured and even anonymity (Possemato et al., 2015).

In regard to patients dealing with substance abuse problems, a system teaching only practices of abstaining completely from alcohol would exclude patients who did not plan to stop completely. Therefore, it was important for the system to focus on risk reduction rather than abstinence (Possemato et al., 2015).

Relationship to Accessibility

Veterans are a social group whose mental health has specific needs. Although technology-based therapies may not be well suited for all patients who require CBT, certain characteristics of the social group mean that a technology-based tool leads to positive outcomes for a majority of cases. Providing an automated technology to meet these needs decreases the burden on primary care practitioners who often care to the physical manifestations of the PTSD and alcohol abuse. If a majority of veterans can be treated using this tool, it allows practitioners to focus their attention on those who need more direct intervention.

Conclusion

There are many problems with accessibility to healthcare in the united states that can be linked to bottlenecks in hospitals due to medical errors, inefficiencies, and lack of inexpensive resources. Automated technology plays a key role in streamlining processes within the system in a safe and effective way. Alternate tools provided directly to patients can decrease their dependance on the healthcare system, leading to less strain on practitioners as well as better

outcomes for the patients in some cases. However, barriers between engineers and the healthcare industry often prevent technology from performing as it is needed. When design decisions make these technologies fit seamlessly into the workflow of practitioners, they will be readily adopted.

References

Bureau, U. C. (n.d.). *Health Insurance Coverage in the United States: 2018*. The United States Census Bureau. Retrieved December 7, 2020, from https://www.census.gov/library/publications/2019/demo/p60-267.html

Burgmann, H., Hiesmayr, J. M., Savey, A., Bauer, P., Metnitz, B., & Metnitz, P. G. H. (2010). Impact of nosocomial infections on clinical outcome and resource consumption in critically ill patients. *Intensive Care Medicine*, *36*(9), 1597–1601. https://doi.org/10.1007/s00134-010-1941-2

Comer, J. S. (2015). Introduction to the Special Series: Applying New Technologies to Extend the Scope and Accessibility of Mental Health Care. *Cognitive and Behavioral Practice*, *22*(3), 253–257. https://doi.org/10.1016/j.cbpra.2015.04.002

Council (US), N. R., Medicine (US), I. of, Woolf, S. H., & Aron, L. (2013). Public Health and Medical Care Systems. In *U.S. Health in International Perspective: Shorter Lives, Poorer Health*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK154484/

Evans, R. S. (2016). Electronic Health Records: Then, Now, and in the Future. *Yearbook of Medical Informatics*, *Suppl 1*, S48–S61. https://doi.org/10.15265/IYS-2016-s006

Galovski, T. E., Monson, C., Bruce, S. E., & Resick, P. A. (2009). Does cognitive–behavioral therapy for PTSD improve perceived health and sleep impairment? *Journal of Traumatic Stress*, *22*(3), 197–204. https://doi.org/10.1002/jts.20418

Goldberg, L., Lide, B., Lowry, S., Massett, H. A., O'Connell, T., Preece, J., Quesenbery, W., & Shneiderman, B. (2011). Usability and Accessibility in Consumer Health Informatics.

American Journal of Preventive Medicine, *40*(5), S187–S197. https://doi.org/10.1016/j.amepre.2011.01.009

Perera, G., Holbrook, A., Thabane, L., Foster, G., & Willison, D. J. (2011). Views on health information sharing and privacy from primary care practices using electronic medical records. *International Journal of Medical Informatics*, *80*(2), 94–101. https://doi.org/10.1016/j.ijmedinf.2010.11.005

Pliakos, E. E., Andreatos, N., Shehadeh, F., Ziakas, P. D., & Mylonakis, E. (2018). The Cost-Effectiveness of Rapid Diagnostic Testing for the Diagnosis of Bloodstream Infections with or without Antimicrobial Stewardship. *Clinical Microbiology Reviews*, *31*(3). https://doi.org/10.1128/CMR.00095-17

Possemato, K., Acosta, M. C., Fuentes, J., Lantinga, L. J., Marsch, L. A., Maisto, S. A., Grabinski, M., & Rosenblum, A. (2015). A Web-Based Self-Management Program for Recent Combat Veterans With PTSD and Substance Misuse: Program Development and Veteran Feedback. *Cognitive and Behavioral Practice*, *22*(3), 345–358. https://doi.org/10.1016/j.cbpra.2014.03.005

Prevention Status Reports (PSR) | CDC. (2020, September 2). https://www.cdc.gov/psr/index.html

Rose, A. F., Schnipper, J. L., Park, E. R., Poon, E. G., Li, Q., & Middleton, B. (2005). Using qualitative studies to improve the usability of an EMR. *Journal of Biomedical Informatics*, *38*(1), 51–60. https://doi.org/10.1016/j.jbi.2004.11.006

Simpson, K. R., & Lyndon, A. (2019). False Alarms and Overmonitoring: Major Factors in Alarm Fatigue Among Labor Nurses. *Journal of Nursing Care Quality*, *34*(1), 66–72. https://doi.org/10.1097/NCQ.0000000000000335

Trick, W. E. (2013). Decision Making During Healthcare-Associated Infection Surveillance: A Rationale for Automation. *Clinical Infectious Diseases*, *57*(3), 434–440. https://doi.org/10.1093/cid/cit249