

THE EFFECT OF AUTOMATION IN HEALTHCARE ON PATIENT OUTCOMES

A Research Paper submitted to the Department of Engineering and Society

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

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

Eamon McElhinney

Spring 2023

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

Kent A. Wayland, Department of Engineering and Society

Introduction

Automation is how we use technologies to perform tasks that would have been previously done with manual care. Automated systems and technologies are so common in our day-to-day lives that we hardly notice them. Automation has been a benefit to technological efficiency since its pioneering by Henry Ford in 1913 during the assembly of his first automobile, and our society has continued that legacy in introducing automation in every viable aspect of our lives. In healthcare, automation has been adopted for a wide scope of uses such as patient registration, appointment scheduling, and electronic record keeping. Automation has many significant advantages that cannot be disputed, it can improve efficiency and accuracy, lower operating costs, and improve safety conditions. In health care these advantages are not only beneficial from a purely monetary perspective but can also mean the literal difference between life and death when both the quantity and quality of care can be improved. However, there are also many potentially harmful impacts of introducing automation such as human job loss, and certain disadvantages that are more specific to healthcare and are more dangerous due to the environment they are being enacted upon. Problems such as privacy concerns, quality of care reduction, and personal interaction reduction, can all be severely impactful and when placed in the framework of medical care where failure means more than monetary loss and customer dissatisfaction these problems are tenfold.

Studying the many contradicting opinions on the use of automated technologies and assessing the advantages and disadvantages of them is nothing novel or noteworthy. The scope of this debate is vast and biases towards or against these technologies are as rife as they are blatant in their roots. Automation tends to be more cost effective in the long term despite a typically steeper initial investment, leading to larger profit margins that are of greater concern to

investors or individuals in more managerial positions than they will be to others. Automation also tends to vastly disrupt employment in every system it is introduced to. It is a valid argument that these technologies may create as many jobs as they destroy or even create more in the long run, however this does not take into account that the type of person who loses their job to an automated technology is typically not the same that finds themselves employed due to a new position created after the fact. I believe that these arguments are far more nuanced and push further beyond personal gain and detriment when studying the way these technologies affect the system of healthcare. The purpose of this paper is to offer a deeper understanding into this complex problem for a complex system so that those who are responsible for the implementation of automated technologies can be better prepared for the impacts that their actions may have.

Background

The history of automation in medicine is stock full of landmark technologies dating as far back as to the late 19th century when the first X-ray machine was invented (Sansare et al., 2011). The field of medical diagnosis was revolutionized by this technology, and it paved the way for the acceptance and development of other automated medical technologies. In the 20th century, the introduction of electronic devices and computer technologies spurred further innovation in the medical field. The cardiac pacemaker was developed in the 1950s, allowing for the regulation of the heartbeat of patients with arrhythmias (Aquilina, 2006). The first kidney dialysis machines were introduced in the 1960s and the 1970s saw the development of the first computed tomography (CT) scanners, which allowed doctors to obtain detailed images of the human body. By the 1980s internal imaging was further improved upon with the creation of magnetic resonance imaging (MRI) technology (*Medical Devices and Technology across the Years*, n.d.). All of these technologies have become essential tools in the hands of today's

medical professionals. As these tools have emerged and developed over time, they have made healthcare safer, more efficient, and more effective.

However, in the modern era the goal posts have shifted. Technological change will continue to define and restructure the systems of medical practice, but automation is one such change that has caused and will continue to cause large-scale disruptions in the industry. I apply automation as a broader term for the series of technological developments that in theory will increase efficiency, but they do so by taking tasks away from humans and utilizing machines instead. The key difference here being that instead of a mutual betterment of technology and medical professional, automated technologies are being further developed and relied upon but the people who they are meant to be made for are being left behind. Rather than producing tools that will benefit the professionals who wield them there has been a remarkable increase in the development of technologies that would replace human hands in the medical world. A notable example being the development of robotic surgical systems that would allow surgeons to perform operations remotely via a computer console and arguably with greater precision and control. In a broader sense automation in healthcare has removed the need for many interactions between patients and healthcare providers. Tasks that may be considered menial such as patient registration and appointment scheduling can be performed without any human interface. The potential consequences of this reduction in social interaction are what will be explored in this paper.

Automation in health care has its benefits, but it runs the risk of neglecting the social needs of the patients it should be aiding. With advances in robotics, and artificial intelligence, our healthcare is changing and with it has come “the rise of the data-driven physician” (*Stanford Medicine’s 2020 Health Trends Report spotlights the rise of the data-driven physician*, n.d.).

Our current and future doctors are now being trained and re-trained to provide care in addition to navigating a sea of data that is collected about every aspect of our lives. This means that more and more diagnoses will be done automatically without the need for human interaction. These diagnoses will soon be much quicker and more accurate than those of a medical professional, but we are simultaneously slowly but surely turning the process of healing into something decidedly unhuman.

Human beings are inherently social creatures, cooperation with one another lies at the very heart of human society and we have relied on it to survive and thrive throughout our entire history as a species (“The Cooperative Human,” 2018). This aspect of humanity is so core to our being that the absence of it is deadly. It is so fundamental to who we are that long term social isolation results in the release of stress hormones such as cortisol, which over time causes inflammation and a weakened immune system (*Loneliness Is Bad for Your Health*, n.d.). It literally makes us sick. Recent studies have shown that “social isolation significantly increased a person’s risk of premature death from all causes, a risk that may rival those of smoking, obesity, and physical inactivity” as well as being “associated with about a 50% percent increased risk of dementia” (*Loneliness and Social Isolation Linked to Serious Health Conditions*, 2021). These health risks are significant and are extremely relevant in how we should be treating patients. According to the National Academies of Sciences, “loneliness among heart failure patients was associated with a nearly 4 times increased risk of death, 68% increased risk of hospitalization, and 57% increased risk of emergency department visits” (National Academies of Sciences, 2020, p. 1). This data is significant and while there is no one automated device or even a few that are causing significant harm to patient’s mental health, by relying on these technologies more and more we are slowly limiting the relationship between patients and healthcare providers.

Method

In order to provide an analysis of this complex system that can be utilized by future engineers for their consideration before implementing new automated technologies, there are several fundamental questions that need to be answered. The underlying principles that affect whether it is advantageous or not need to be firmly established. The large potential problem that is identified above is that automation is causing a gradual decay in the relationship people have with their primary caregivers. But what defines this relationship? In order to decide whether a technology could harm this aspect of care, first we must evaluate what makes a good relationship of this kind. On the other side of this issue, we must then look at what is causing harm to this relationship currently. Once that is clear it is easier to assess whether a technology will be able to suitably demonstrate the factors that are integral to this relationship and whether or not it will result in further degradation. The new technology such as robotic surgery or AI controlled patient interfaces needs to demonstrate that that it can replicate that which it is replacing, or if it ever can. To answer these questions and to better interpret the functions of this system I analyzed select literature on the topics of the doctor-patient relationship, and the loss of trust that is formed with technology replacing human interaction, such as AI or automated systems.

Results/Discussion

The foundation of a strong relationship requires a development of trust between the two actors. The first ever published report in which trust between the patient and their physician was assessed as a predictor of other health outcomes was created by Safran et al., (1998). There were seven defining elements of primary care that were defined in their study: accessibility, continuity, comprehensiveness, integration, clinical interaction, interpersonal treatment, and trust. Each of these elements was evaluated for their relationship between three outcomes:

adherence to physician's advice, patient satisfaction, and improved health status. Data for this study was derived from cross-sectional observation of 7204 adults employed by the Commonwealth of Massachusetts. The patient's trust in their physician showed the strongest correlation between the likelihood of complete satisfaction with their caregiver over all other variables. With other factors being equal higher reported trust was also strongly associated with higher rates of adherence to their treatment plan and was one of the leading correlates for self-reported improvements of health. This study did not prove that trust was an independent variable that would have a direct relationship to improved patient health, however it does demonstrate that trust is the leading factor for all three important outcomes of care. This implies that establishing a level of trust early on in a doctor-patient relationship will not only dramatically increase the likelihood of the patient adhering to the actual prescribed plan but does also correspond with improved health independent of that increased adherence. The correlation between high trust and improved health when all other factors were equal cannot be ignored. This data set implies that an abstract emotion is having an effect on the outcome of care. This conclusion agrees with the inversely detrimental relationship between loneliness or rather the absence of social interaction and patient health. All of this becomes more noteworthy when we apply the context of how changes in the United States healthcare system are beginning to be viewed as "threatening to the quality of physician-patient relationships" (Safran et al., 1998). The traditional relationship between doctor and patient was characterized by a personal connection, empathy, and again mutual trust. There is concern that advances in technology and changes in the healthcare system are responsible for the subtle erosion of these essential elements to deliver quality care.

The quality of good care relies on more factors than just trust but how prioritizing efficiency over quality can be detrimental to the entire caregiving process requires further analysis. Meyerhoefer et al., (2018), performed a thorough examination of how the installation of electronic health records (EHRs) affected both provider and patient satisfaction with care. EHRs are a form of automated medical technology that most of the healthcare world has now become entirely dependent on. The study spanned five years of surveying clinical providers on their experience and satisfaction with the EHR technology and patients on their own satisfaction with their care but without any allusion to the EHRs in the patients' survey. The timeline of this study was broken into three main stages defined by the level of implementation of the technology in the providers system. There was initial dissent among the clinical providers and physicians in particular were the most dissatisfied with the change to their work process however, provider satisfaction was found to improve with the availability of information that became readily available to them following Stages 2 and 3. Despite providers widely finding the technology to be easier and more efficient patients were unhappy with the change that this brought to their experience with their physician. Patient satisfaction decreased drastically after installation of the EHR and while further reductions were not as prominent in the subsequent stages it did continue to degrade. The main detriments to the patient's experience were reported as the EHRs serving as a distraction and causing an inhibition of eye contact between patients and providers that left them feeling uncared for and unimportant. The findings of this study were confined to a relatively small environment that delivered a specific type of care, obstetrics, and gynecology (OB/GYN), and were not performed over an incredibly long time period that might have displayed a recovery in satisfaction after the initial disruption the introduction of new technology caused. Despite those allowances the data provided serves as a multipurpose display

of the potential harm in pushing new automated technologies into these systems. A substantial change in the work process that results from innovations such as EHRs harms both physicians and their patients. Another facet of this is that the practice of an automated system in the examination room created a barrier between the patient and the physician due to another level of decay in the human aspect of this process. The doctor-patient relationship has evolved over time, from a paternalistic model where the physician had complete control over decision-making, to a more collaborative approach where the patient is seen as an active participant in their healthcare. In this modern approach, patients are encouraged to ask questions, provide feedback, and contribute to the decision-making process. This approach also acknowledges the patient's cultural and personal values, preferences, and needs. Effective communication is a cornerstone of the doctor-patient relationship. Clear, concise, and empathetic communication by the physician helps patients understand their medical conditions and treatment options. This, in turn, promotes trust, compliance, and better health outcomes. However, the emergence of electronic health records, telemedicine, and other technological innovations have led to a general decrease in face-to-face interactions between doctors and patients. There has been a sharp reduction in the actual time that doctors spend with their patients, and this disconnect continues to grow. There are several underlying factors that can be identified as potential causes for this, but undeniably the use of automated medical technologies is one of them. When patients do not feel like they have the full attention of their caregiver it can lead to patients feeling isolated and disconnected from the person who is meant to be in their corner all the way. The trust that patients put in others to help them and heal them is significant and to let that trust rot away is a disservice to the foundation of the entire system of healthcare. Reduced personal interaction can also lead to misunderstandings and miscommunications. When patients interact with automated systems,

they may not be able to ask questions or seek clarification about their healthcare needs. This can lead to misunderstandings or mistakes that could have been avoided through direct communication with a healthcare provider. Patients may also feel that their healthcare needs are not being met if they are not able to communicate their concerns and preferences to their healthcare providers. Furthermore, reduced personal interaction can be particularly detrimental for patients who require specialized care. Patients with chronic conditions or mental health issues may require more personalized care that considers their unique needs and preferences.

Automated systems may not be able to provide the same level of personalized care as a healthcare provider who is able to interact with patients directly and make recommendations based on their individual needs. This increased focus on efficiency and productivity allows for greater quantity of care, but they sacrifice quality in doing so, and in the realm of public health quality should always be prioritized.

Conclusion

Automated technologies is a redundant term in the modern era. A vast majority of the innovations of the present and future that will be introduced to the medical world will be developed around some form of an automated process that makes the work we can do more efficient, more accurate, more cost-effective, or some combination of them all. This form of automation will just become increasingly controversial as artificial intelligence becomes more commonplace and begins to make its way more strongly into the complex system of healthcare. These developments to current practice and the emergence of new tools and methodologies will undoubtedly improve many outcomes and save many lives. The complete automation of the registration process and scheduling of appointments has made it easier to manage and organize massive quantities of patients, EHRs provide physicians with a detailed record of a patient's

medical history that they can access with ease. These technologies and ones that are yet to be created will continue to improve our process and the results will show for that. In doing so, however, we have been reducing our caregivers to technicians. The “data-driven physician,” a term coined by Stanford Medicine, shows the beginnings of what the people who dedicate their lives in the service of others are becoming. We are social creatures who do not do well on our own, our bodies begin to fail us in the absence of social interaction. It is integral to our survival as an individual that we are part of a community. Caring for each other is hard coded into our DNA, people devote years of study learning how best to take care of complete strangers. Providing medical care is so inherently human that to give up part of that process to machinery and automated systems is something I find disheartening. The purpose of this paper was to provide a better understanding of the ways our technology affects us and the unexpected consequences that can result from how we choose to interact with them. My hope is that engineers take care to consider the full implications of what they create. That even when a machine can do a job better than a human in every conceivable way there needs to be an amount of deliberation on whether it is worth it to further chip away at the humanness of taking care of another person.

Works Cited

Aquilina, O. (2006). A brief history of cardiac pacing. *Images in Paediatric Cardiology*, 8(2), 17–81.

Loneliness and Social Isolation Linked to Serious Health Conditions. (2021, April 30).

<https://www.cdc.gov/aging/publications/features/lonely-older-adults.html>

Loneliness is bad for your health. (n.d.). MSUToday | Michigan State University. Retrieved April 10, 2023, from <https://msutoday.msu.edu/news/2018/loneliness-is-bad-for-your-health>

Medical devices and technology across the years. (n.d.). Retrieved April 9, 2023, from

<https://medicine.yale.edu/news/yale-medicine-magazine/article/medical-devices-and-technology-across-the-years/>

Meyerhoefer, C. D., Sherer, S. A., Deily, M. E., Chou, S.-Y., Guo, X., Chen, J., Sheinberg, M., & Levick, D. (2018). Provider and patient satisfaction with the integration of ambulatory and hospital EHR systems. *Journal of the American Medical Informatics Association*, 25(8), 1054–1063. <https://doi.org/10.1093/jamia/ocy048>

National Academies of Sciences, E. (2020). *Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System*. <https://doi.org/10.17226/25663>

Safran, D. G., Taira, D. A., Rogers, W. H., Kosinski, M., Ware, J. E., & Tarlov, A. R. (1998). Linking primary care performance to outcomes of care. *The Journal of Family Practice*, 47(3), 213–220.

Sansare, K., Khanna, V., & Karjodkar, F. (2011). Early victims of X-rays: A tribute and current perception. *Dentomaxillofacial Radiology*, *40*(2), 123–125.

<https://doi.org/10.1259/dmfr/73488299>

Stanford Medicine's 2020 Health Trends Report spotlights the rise of the data-driven physician.

(n.d.). News Center. Retrieved October 26, 2022, from <http://med.stanford.edu/news/all-news/2020/01/health-trends-report-spotlights-rise-of-data-driven-physician.html>

The cooperative human. (2018). *Nature Human Behaviour*, *2*(7), Article 7.

<https://doi.org/10.1038/s41562-018-0389-1>