ANALYZING TECHNOLOGICAL INFLUENCES ON HEALTHCARE WORKER BURNOUT

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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

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Introduction

In 2022 U.S. Surgeon General Vivek Murthy published an advisory explaining the negative impacts of physician burnout on patient care and worker livelihood. He explains how "Burnout among health workers has harmful consequences for patient care and safety, such as decreased time spent between provider and patient, increased medical errors and hospital-acquired infections among patients, and staffing shortages" (Murthy, 2022, p. 7). The advisory describes how physician burnout is caused by many factors, the most prevalent one being the quantity of administrative work healthcare workers had to do both inside and outside of working hours. The rapid growth of artificial intelligence (AI) technologies has helped to accelerate productivity over the past decade, especially with the rise of machine learning (ML) and generative AI. These technologies help streamline processes by efficiently analyzing and interpreting substantial amounts of data like humans and integrating newly structured data onto usable platforms. As AI continues to become more powerful and prevalent in society, it is important to consider its applications in the healthcare industry.

Susan Leigh Star's Ethnography of Infrastructure (1999) provides a framework for analyzing how AI systems can be built into healthcare and combat physician burnout. Star's framework outlines the importance of considering infrastructural aspects for creating a working and usable system, which helps to inform the research done within this paper. Proper integration of AI systems requires working with preexisting technological infrastructures that are deeply embedded into the healthcare industry, aiding physicians by reducing excessive administrative work that could be done by an artificial intelligence system. This framework helps analyze and uncover aspects of interconnectivity in healthcare systems, teams and technologies and provides insight as to how AI can be integrated into healthcare in the future to reduce excessive workload.

AI in Healthcare

There are many ways in which AI can aid healthcare workers throughout their workday. The main goal of using AI in healthcare is to offload work typically done by a human to a computer. A study in 2016 found that healthcare workers across various specialties were spending over a third of their day doing desk work and electronic health record (EHR) tasks (Sinsky et al., 2016). This drastically reduces the time a physician can spend with a patient which creates a weaker patient-physician relationship and can potentially worsen care. By offloading some of this work to an AI system, the provider will not only gain access to rich structured data but will also be able to directly focus more of their time toward the patient.

One subset of AI known as natural language processing (NLP) allows computers to interpret and understand human language in a meaningful way. NLP is commonly used in dictation and voice recognition systems for transcribing human speech into text. These systems are often built into cell phones and allow users to use speech in place of having to type, using AI to do most of the work. For physicians, this type of system could be extremely helpful as spending less time actively typing on a patient's chart means they have more time to interact with the individual, providing a better overall patient experience. Nuance, a subsidiary of Microsoft and one of the leading innovators in medical AI analysis software, has created a system known as the Dragon Ambient Experience (DAX) Copilot which uses AI and NLP to automatically extract key information from a patient-physician conversation. This system acts as a "virtual scribe" taking note of any key details of the interaction and automatically creating clinical documentation for the healthcare worker to review afterward. Physicians using DAX Copilot were able to reduce their documentation time by 50%, saving an average of seven minutes per encounter (Nuance Communications, 2023).

Artificial Intelligence also has applications in healthcare billing and auditing systems. Computer applications can automate the billing process, finding errors and correcting any discrepancies that could lead to financial problems. Automating this process could help to remove an administrative step that has become necessary in healthcare and would be useful for healthcare organizations and the surrounding financial institutions. These systems use machine learning to make decisions based on prior data which can be especially helpful when making insurance claims. Microsoft has been funding research in this area, using Azure and its other cloud platforms to perfect billing plans and uncover valuable population insights. These systems use AI to create faster turnaround times and increased revenue with more exact and centralized patient financial data (Microsoft, n.d.).

Analyzing Healthcare Systems with the Ethnography of Infrastructure

There are many barriers to designing a successful AI system in healthcare. A working AI system in healthcare does not depend on the system's function performing correctly, but on how well it works within the entire healthcare environment. While systems may have all the features a healthcare worker would want, a system is not useful unless the client uses it in practice. The focus of designing an AI system for healthcare is creating one that will work seamlessly with other technologies workers use regularly and serve the needs of care teams. To create this type of system, research is needed to figure out how healthcare workers use technology, the problems they have and how AI technologies can be designed to work alongside the current organizations. Susan Leigh Star's Ethnography of Infrastructure (1999) can be used to analyze the relationship between technological systems, society, and humans, providing a framework for designing a usable AI system in the healthcare environment.

Star emphasizes the importance of seeing infrastructure as part of a human organization rather than imagining it as a system of substrates. Through her research, Star found that considering infrastructural aspects was much more effective for designing a working system than analyzing strictly human needs. From this she created a new definition of infrastructure, focusing on nine key properties that can be used to analyze social and technical factors of successful infrastructure. Star also highlights three tricks for uncovering the hidden features that she has learned throughout her research and time studying infrastructure that can help guide the research being done in this paper.

One key property of infrastructure that will be helpful in designing a working AI system for healthcare is embeddedness. The idea of embeddedness unveils the hidden interdependence of infrastructure, revealing its integration into other technologies and systems. Subcomponents within a system are intricately interlinked without being at once noticeable, providing invisible functionality for the larger supersystem. As previously mentioned, designing an AI system for healthcare aid requires deep integration with preexisting technologies which follows this infrastructural principle of embeddedness. Viewing technology as infrastructure and considering how AI can be used to improve that technology will help to design a system that works seamlessly with current infrastructure and simultaneously improves worker productivity.

To effectively embed an AI system into healthcare infrastructure, it is important to consider what Star calls the "paradoxes of infrastructure." In her research, Star discovered the fragility of infrastructure systems and how even the smallest change in routine can disrupt an entire workflow. To understand a system, one must consider not only visible but also invisible processes of work that are occurring simultaneously. Visible processes mostly concentrate on the functionality, such as button presses or keystrokes, needed to perform a certain action.

Conversely, invisible processes deal with articulation tasks which Star defines in another paper as "…all the tasks needed to coordinate a particular task, including scheduling subtasks, recovering from errors, and assembling resources" (Gerson & Star, 1986, p. 258). When analyzing healthcare infrastructure, "invisible" functionality of the system must be considered as much as if not more than the "visible" components. Digging deep into articulation tasks and understanding the user's workflow will help to provide insight into how integration can take place without disrupting routine.

Another key aspect of infrastructure from Star's paper is the embodiment of standards. The concept of embodiment of standards deals with how infrastructures use common interfaces to work together and how standards shape the scope of the system. Medicine has many standards, some that are universally recognized and some that are more specific to a particular organization. Designing an AI system to follow these standards is important for creating a system that is usable and understandable by its clients. Embodiment of standards allows integration of AI systems into preexisting infrastructures by ensuring interoperability across various systems. For AI technology to be successful, there needs to be a deep understanding of the standards healthcare workers use to create a system that works effectively with healthcare workers and the systems they interact with.

In any infrastructure, it is crucial to consider what Star refers to as "invisible work." These are the people and processes that are often overlooked in large technological systems but provide essential functionality to those systems. This involves looking at current infrastructure and learning how processes are currently embedded within the system to do necessary work. AI systems must also be designed to support primary users without neglecting secondary users. For healthcare, this means building a system for healthcare workers like physicians and nurses but

also considering the larger team such as IT technicians who may be essential to supporting a working system.

Star's idea of invisibility can also be applied outside of invisible workers of a system. Although this research focuses on using AI to decrease healthcare worker burnout, it is important to simultaneously consider the role patients play in the current infrastructure. Current technologies make aspects of a healthcare worker's job easier, but patients may find that technology degrades personal time and physician relationships. A 2018 study that tracked how healthcare professionals spent their time during a 12-hour workday found that physicians only spent 14.73% of their time in patient rooms (Butler et al., 2018). This creates an "invisible" patient that is overlooked in the current technological infrastructure. Getting feedback from a larger team and unveiling invisible workers and consumers will help to design a system that functions smoothly for all users and is beneficial to those most affected by it.

Research Methods and Question

To design a usable artificial intelligence system for healthcare that works to reduce worker burnout, the question must first be asked: How is technology currently used in healthcare systems and how does it influence physician burnout and patient care? Using Star's framework as a guideline, current technologies and systems can be analyzed at a deeper level by considering the many aspects of infrastructure and how it can be improved for both patient and provider. This means considering both the "visible" and "invisible" aspects of healthcare technology infrastructure as described by Star. Once the current infrastructure is found, it will be much easier to see the specific areas where AI technologies can be beneficial to healthcare workers, and it can be decided how to best implement these technologies based on current interoperability practices and standards.

To find the current problems with infrastructure, a literature review was conducted to show the technological challenges that healthcare workers face and how these challenges can influence burnout and patient care. This review includes various papers and discussions obtained from medical literature databases like PubMed, OVID Medline, and the Cochrane Library. Articles were collected using keyword searches with combinations of the following words and phrases: “burnout,” “healthcare technology,” “patient physician relationship,” “usability,” “technology-induced stress,” “physician satisfaction,” “EHR” and “health system integration.” Articles were initially selected based on how well the information given in the abstract aligned with the topic. Selected articles were then analyzed through the infrastructural lens, considering the various aspects outlined by Star and taking perspectives from both patient and provider. For this review there was no restriction on dates but most of the literature selected was from the 21st century to keep information as relevant and up to date as possible.

Results

For this research, eight articles were analyzed to find how healthcare technologies influenced worker burnout and affected patient care. The findings from the research were naturally split into two separate sections which under Star’s framework can be considered as visible and invisible pieces to infrastructure. Visible aspects included those working directly with healthcare technologies like physicians and nurses while invisible aspects focus primarily on patients and how they are affected both directly and indirectly by technology. These two sections will be explored in detail to uncover how infrastructure can lead to burnout and hurt patient care. This information will then be used in the discussion section to discuss how AI can be used to make improvements to the current arrangement.

Technological Influence on Physician Burnout

Since the introduction of the EHR, healthcare workers have had to work closely with computer technologies as a basic duty of their everyday job. Over the years, technological improvements have enabled physicians to do more of their job electronically. In 2021, around 88% of office-based physicians in the United States used some form of an EHR (*FastStats*, 2023). Unfortunately, despite the productivity helps most new technologies promise, the digital age of medicine has come with its own set of issues. A 2021 review of the effects of health information technology (HIT) on clinician burnout symptoms found that HIT usage can create time and workload burdens for those using them. The review synthesized results from 21 different observational studies that examined HIT as a contributor to clinician burnout. Studies used in the review found that EHR usage has become a large part of a clinician's day, spending an average of 4.5 hours in office and 1.4 hours out of office during a 11.4-hour workday. The studies also explored the impacts on clinician workflow and workload, finding certain aspects of the EHR to have negatively changed clinical workflow and to be correlated with burnout. This is mostly due to large volumes of information or alerts from various sources that healthcare workers are expected to handle simultaneously and efficiently (Wu et al., 2021).

A 2017 survey-based study found similar issues when it came to HIT usage. The study aimed to quantify how well technology-induced stress can predict physician burnout. Gardner et al employed various measures to assess HIT-related stress across different specialties. They examined how EHRs contribute to frustration in a respondent's daily routine, the amount of time respondents spent using EHRs at home, and the sufficiency of time given for documentation. Among EHR users, 70% reported HIT-related stress which was found to have a correlation to those who reported symptoms of burnout. Time was once again identified as a significant factor

influencing burnout among physicians. Those who spent more time working at home were found to be 1.9 times more likely to experience burnout. Similarly, those who were afforded less sufficient time for documentation were found to be 2.8 times more likely to experience burnout (Gardner et al., 2018).

The literature review also found many workflow issues with technological systems in healthcare. In *Taking Action Against Clinician Burnout: A Systems Approach to Professional Well-Being* (2019) the author discusses the various usability issues associated with EHR systems. The author explains how most clinicians find EHR systems valuable over the old paper charting system, but overall satisfaction is still low. These problems are typically linked to the structural design of EHRs and arise from confusing displays or unintuitive navigation that do not align with clinician workflow. A 2015 study found EHR design problems led to missed information when nurses tried to access patient information. Data was often duplicated or redundant, making it more difficult to find correct information and adding to cognitive workload (Gephart et al., 2015). These usability issues create frustration towards healthcare technologies, which the earlier study by Gardner et al found can make symptoms of burnout 2.4 times more likely (Gardner et al., 2018).

Patient Experience of Healthcare Technology

Technology has also been found to influence patient care and patient-clinician interaction. A 2016 review and analysis of studies concerning computer use during patient interaction found many adverse effects on patient care. The analysis included multiple findings of clinicians having difficulty dividing attention between patient and computer. HIT/EHR systems were also reported to direct the conversation, having a negative impact on a patient's ability to ask questions during a routine visit (Crampton et al., 2016). Using computer systems to

take notes, search a chart or fill a prescription often created prolonged gaps of silence, which some studies found could result in difficulty keeping the conversation on topic or the patient having to restate the topic they wished to discuss (Newman et al., 2010). Despite lower communication levels, medical visits involving EHR usage have been shown to be longer with lower levels of non-verbal communication. This reduced interaction time can create a less patient-oriented feel, making technology feel like a barrier between patient and clinician rather than a facilitator. Healthcare technologies can be a powerful learning tool for both patient and provider and it is important to use the technology as a communication tool rather than a mediator (Marino et al., 2023).

A 2021 study of nurses during the COVID-19 pandemic showed correlations between symptoms of burnout and issues with patient care. Burnout and depersonalization were found to be positively correlated meaning nurses who felt more burnt out or experienced more "emotional exhaustion" would create less personal relationship with their patients. The study also found depersonalization to be linked with an increased likelihood of "adverse events." These are different undesirable occurrences that may happen during a regular workday like medication errors, surgical wound infection, and patient falls (Kakemam et al., 2021, p. 1976). While this study did not focus on technology as the direct cause of burnout, it shows the adverse impact of burnout on patients, a phenomenon increasingly linked to technology-induced stress.

Discussion

The research shows the many usability issues with healthcare technologies that create unnecessary workload burdens leading to burnout symptoms. Technology induced stress due to unreliability leading to burnout is not an unfamiliar concept and research has been done to show the link between the two in industries outside of healthcare. A 2024 study using 2019 survey data

from German manufacturing and service companies found workers who experienced more technology-related interruptions were more likely to feel burnt out during the workday (Meyer & Tisch, 2024). This idea of "techno-unreliability" is one that needs to be considered when looking to implement AI into the healthcare ecosystem as these tools should improve productivity without disrupting normal workflow.

The current problems with healthcare technologies do show a promising future for AI in the industry. In Murthy's advisory from 2021, he explains the actions healthcare technology companies must take to improve healthcare worker well-being. The four actions he highlights are designing technology to serve the needs of healthcare teams and patients, designing platforms with the goal of interoperability, strengthening integration of data, and improving seamless storage of and access to health data (Murthy, 2021, pp. 42-44). AI systems have the potential to take all actions in many ways, especially when partnering with EHR or other HIT companies.

The research found that the most significant factor of HIT-related burnout was time, which could easily be regained using AI technology. Automated dictation systems would allow clinicians to drastically reduce their documentation time both inside and outside of patient visits. A 2018 study from Stanford found speech-based entry to be almost three times faster than typing with a relatively low error rate in the final transcription (Ruan et al., 2018). Using this system in an EHR systems would provide an efficient alternative to the standard typing process used today. AI dictation systems may also allow a physician to interact more directly with patients by reducing computer interaction time. Using AI systems as a productivity tool would give healthcare workers more time to interact with patients by spending less time on administrative work. Machine learning systems could be used to provide personalized recommendation plans

for patients to select from, creating a more collaborative relationship between patient and provider.

Considering infrastructural aspects from Star, it is important for these systems to be intuitively embedded into EHR technologies to not disrupt workflow for healthcare workers. As the research shows, workflow disruptions are linked to increased symptoms of burnout. AI systems must work seamlessly and covertly with current technology to aid clinicians without adding unnecessary work to get the system operational. AI systems also have the added benefit of being able to efficiently process and structure data, meaning all data collected with AI could be used to meet interoperability standards and data integration will likely be much stronger.

Conclusion

As burnout continues to affect the livelihood of healthcare workers, organizations and technology companies must acknowledge the influence technology can have. The research conducted in this paper outlines the current challenges with technology, particularly the pervasive use of electronic health records and the effect they can have on healthcare workers' burnout. Simultaneously, the research highlights the potential to understand these issues and create effective solutions using newer technologies like artificial intelligence and machine learning. AI and ML systems continue to increase and improve productivity in various industries and could be used by healthcare organizations to address the root causes of burnout by streamlining administrative tasks, reducing documentation time, and enhancing patient-provider interactions.

While AI systems may not end burnout entirely, they provide a promising solution to reducing overall workload burden in the future of healthcare technology. Through the lens of Susan Leigh Star’s Ethnography of Infrastructure, this paper emphasizes the importance of

considering the overlooked aspects in the development of healthcare information technologies for creating a more sustainable work environment. The successful integration of AI into healthcare infrastructure requires careful consideration of infrastructural aspects, particularly the visible and invisible aspects that this paper focuses on. For AI development to be successful in healthcare, organizations must focus on seamless interoperability with existing technologies, minimizing workflow disruptions, and adhering to established standards and protocols. Additionally, it is crucial to recognize the broader implications of AI adoption on all stakeholders, including patients and secondary users, to create a system that benefits everyone involved.

Moving forward, further research and collaboration between technologists, healthcare providers, and policymakers is essential to harness the full potential of AI in combating physician burnout and improving overall healthcare outcomes. By taking a human-centered approach to development, technology companies can gain an understanding of healthcare workers' needs and concerns with AI technology, enhancing usability and increasing acceptance among stakeholders. At the same time, healthcare organizations must prioritize patient-centered care and use AI technologies to promote collaborative relationships between patient and provider. Using Star's framework as a guideline for development, it may be possible to create a more resilient and sustainable healthcare infrastructure with artificial intelligence that prioritizes both the well-being of healthcare workers and the quality of patient care.

Resources

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