Effective and Systematic Adoption of Medical AI Devices

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

Rohan Dipak Patel

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

Signature *Rohan Patel* Date 5/11/2021
Rohan Dipak Patel

Approved ______________________ Date 5/11/2021
Sean Ferguson, Department of Engineering and Society

Effective and Systematic Adoption of Medical AI Devices

Conversation of AI technologies have been in the medical field for the past 70 years (Kaul et al., 2020). In fact, institutions around the United States have been implementing and executing AI technologies into practice since the early 2000s, however, most institutions have still been in the conversational phase (Kononenko, 2001). Many scholars, and experts in the medical field believe that the reluctance to implement AI in the medical field comes from the fear of change associated with AI (Frank et al., 2019). This change is negatively connotated, and often raises questions about the intent of the technology. Such questions consist of "Is this technology meant for the augmentation of workers, or the replacement of workers?" or "How will this technology affect human interaction?". Physicians, patients, and clients all experience similar trepidations and worries about the intent of the technology (Ahuja, 2019). Understanding and considering these feelings brings about an opportunity for the massive, and systematic adoption of AI technologies. Thus, this thesis will focus on what we need to know in order to implement AI in the medical field. This paper will take an independent two-pronged approach in adopting medical AI, the first approach deals with the physician's reluctance to implement AI due to the uncertainty of AI's intent. This analysis will be done by using a Technology Acceptance Model (TAM) framework to find physician values in the existing hospital-physician system, and how a designer of AI technologies can implement these values into their AI designs. We focus on the physicians values in this approach since experts and surveys suggest physicians are the key influencers on hospital purchasing decisions (*Selling to Hospitals*, 2017). The second approach deals with increasing landscape pressures on the hospital-physician system to adopt medical AI. This will be achieved by using a Multi-Level Perspective (MLP) Theory by Geels &

Schot (Geels & Schot, 2007) to witness how even with reluctance in the niche level, with strong enough pressures in the landscape levels we can have an adoption of the AI device.

Consensus of Medical AI's Intent on Hospital-Physician System

The hospital-physician system is one of the most unique systems seen within any sector or branch of society, and it is fundamentally driven through the sociotechnical interactions between physicians, clients, patients as well as medical tools or technologies (Burns & Muller, 2008). In laymen's term, the system is the collaborative essence of the physician's skills with the hospital's tools, facilities, and resources. Some examples of the hospital-physician system consist of the patient-physician relationship, as well as the physician's feeling of relevancy. In the most fundamental sense, the physician-patient relationship is defined as a consensual relationship in which the patient knowingly seeks the physician's assistance and in which the physician knowingly accepts the person as a patient. Within the physician-patient relationship there are four models which consists of the paternalistic model, the informative model, the interpretive model, and the deliberative model (Emanuel & Emanuel, 1992). Each model serves its own purpose to help provide the best course of action for the patient, for example, the deliberative model seeks to help the patient choose the best health related values by acting as a teacher or friend and engaging the patient in meaningful dialogue (Gedge & Waluchow, 2012). Next, we have the physician's feeling of relevancy which can simply be defined as how meaningful the physician feels their work is within a hospital (Atherley & Meeuwissen, 2020). In addition, the physician's feeling of relevancy can also be seen as an umbrella term that considers how the physician generally feels within his setting. A low feeling of relevancy often leads to decreased empathy towards patients, increased substance use, burnout, and increased frequencies of medical error, while a high feeling of relevancy leads to productive work (Patel et al., 2018).

Now that I have defined the Hospital-physician system, as well as listed some examples, we can view how experts feel about Medical AI as a tool within the system. Overall, AI's potential effect on the hospital-physician system is unknown and is currently a subject of debate. Many medical experts posit that it can be negative, or positive, and the lack of concrete evidence for either side is due to the short time period in which medical AI technologies have been implemented as well as the limited amount of AI technologies implemented (Ahuja, 2019; Amisha et al., 2019). To elaborate this point let's take the patient-physician relationship, and physician's feeling of relevancy as examples. In the case for patient-physician relationship, debates about if artificial intelligence will help or harm the relationship have been cited in numerous articles. Experts in medicine such as Abby Norman (2018) and Bertalan Meskó (2017) state how "your future doctor may not be human", and how AI is "The Stethoscope of the 21st Century" implying how physicians will likely be replaced, ending the physician-patient relationship (*Artificial Intelligence Is the Stethoscope of the 21st Century*, 2017; *Your Future Doctor May Not Be Human. This Is the Rise of AI in Medicine.*, 2018). While other experts such as Krittanawong (2018) state physicians are still needed for traditional physical exams, especially in areas such as neurology, which require high-level patient-physician interaction (Krittanawong, 2018). For physician's feeling of relevancy we see a similar debate, however before we get to the debate one must understand that the feeling of relevancy is affected by many factors such as daily interactions, the type of work conducted, and most importantly the tools/ technologies used in a given day. Often, socio-technical interactions can aid in increasing the physician's relevancy through supplying a means for augmenting the physician's abilities, however the opposite is true if the technology is poorly designed (Alperin, 2020). The debate asks experts whether AI is likely to support and augment physicians by taking away the routine parts of a physician's work and enabling the physician to spend more time with their patients, or if the AI will take away all parts of the physician's work (Pearson, 2017; Recht & Bryan, 2017). The former helps in removing arduous/redundant tasks allotting time for more important tasks which ultimately benefits both relevancy and patient-physician relationship, while the latter decreases relevancy. In both of these examples we see the overarching theme that experts are conflicted about medical AI's intent in the hospital-physician system.

In the aforementioned paragraphs we have discussed how there is debate/ conflicted viewpoints on medical AI's effect or intent in the hospital-physician system. The ultimate debate can be simplified to the question: "Will medical AI be here to augment or replace?". It is largely this uncertainty that has led many physicians to be weary/ skeptical in the implementation of medical AI devices (Powell, 2020; Singh et al., 2020). However, even though there might not be unity, medical AI has been at the fringes of medical practice, and there is the potential for massive, systematic adoption. This adoption must not ignore the possibility of medical AI replacing physicians, but acknowledge it through understanding stakeholder's values within medical AI, and by using value-sensitive design to achieve said optimal designs, while cognitively preventing designs that can lead to the negative potentials. In the next section of this paper, we will uncover physician's key values with medical AI technologies through the use of a Technology Acceptance Model (TAM) and how value sensitive design can be used to help engineers achieve an optimal design. In this case optimal design refers to preventing design choices that extinguish physician's values. After, the Technology Acceptance Model section, I will introduce another method for medical AI adoption, which ignores physician's skepticism for medical AI's intent, through increasing pressures at the landscape level (see section: Medical AI Adoption Approach 2 (Multi-level Perspective Theory)).

Medical AI Adoption Approach 1 (Technology Acceptance Model)

The Technology Acceptance Model (TAM) is a model which in the most fundamental sense helps us answer the question "Why do people use technologies?". Specifically, it helps us understand why a person would choose a particular technology within a work context. The original theory states that people choose the technology that is the most useful and easy to use. It is important to understand that TAM says very little about the technology itself, rather TAM focuses on what the individual believes or perceives the technology to be. In other words, whether the technology is actually useful or actually easy to use is not a matter of the technology, but our values and perceptions (Legris et al., 2003). The physician's acceptance of medical AI technologies can be modeled by TAM (Chuttur, 2009). However, the original TAM model has many limitations, the most significant being TAM does not tell us how to make technology easy to use or useful; TAM does not give us any design advice (Chuttur, 2009; Marangunić & Granić, 2015). This is why I will use an alternative TAM theory adapted to the physician that suggest reasons for why physicians adopt technologies (Yarbrough & Smith, 2007). In this altered version of TAM (see Figure 1) Yarbrough & Smith (2007) introduces a new variable representing physician barriers to technology as well as consider expectations physician's form about a technology and whether these expectations are conformed or disconfirmed when they engage with the technology. They predict that the variable representing barriers to technology will indirectly influence technology acceptance through perceived usefulness, perceived ease of use, and the attitudinal construct. Thus, TAM serves to provide a better understanding of physician's values/ perceptions when accepting a technology, as well as inform about barriers

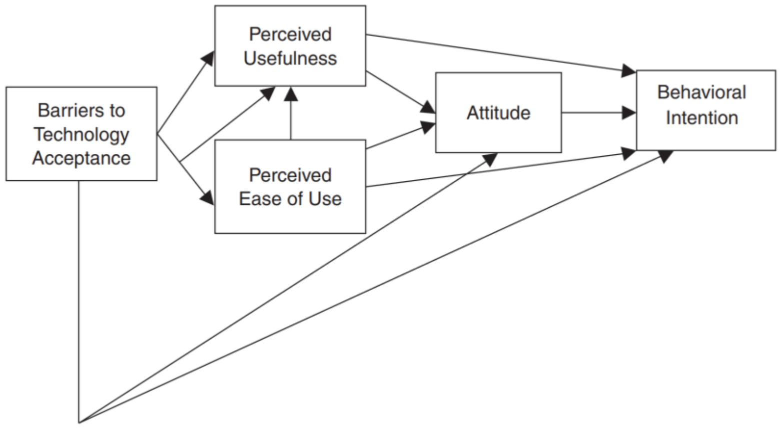

Figure 1: Physician Adapted TAM: *This figure showcases the altered TAM model that considers barriers to technology acceptance as well as important factors for technology acceptance such as perceived usefulness and ease of use. Taken from (Yarbrough & Smith, 2007)*

that make physicians hesitant to embrace new technologies designed to increase efficiency and improve quality in a health care setting (Yarbrough & Smith, 2007). In our context, we can use TAM's perceived usefulness and perceived ease of use blocks (see Figure 1) to analyze and find values/ perceptions associated with what physician's want in medical AI technologies. In addition, the variable considering barriers to technology acceptance have already been defined in "Consensus of Medical AI's Intent on Hospital-Physician System", which is the underlaying uncertainty of AI being for augmentation or replacement. In the following paragraphs we will identify these values as well as analyze how uncertainty of AI's intent influences these values.

Using perceived usefulness, we can discover values that are associated with a physician when accepting a medical AI technology. In the hospital-physician system usefulness, according to Dr. Collier (2014), can be boiled down to answering five questions: Does it work? How well does it work? Is it solving a problem that needs to be solved? Will it be around long? Is it trying to do too much? (Collier, 2014). Much more specifically, Dr. Davenport and Dr. Kalakota (2019) state that usefulness for AI in healthcare stems from the AI being accurate, precise, and ultimately suggestive (T. Davenport & Kalakota, 2019). Dr. Davenport (2019) and Dr. Kalakota (2019) stress that important and final decision should still be made by physicians, humans, and board directors. Once autonomy is taken away from humans, and the AI algorithm switches from a suggestive model to a 100% diagnostic model, the likelihood for physicians to deem a technology "useful" is extremely unlikely. This phenomenon is due to the hospital-physician system being built off of socio-technical systems, and removing human interactions completely changes the foundation on which the system was built off of, leading to possible unknowns, disruptions, and disasters. Understanding Collier's (2014) five questions for general usefulness of medical technology, along with Davenport/ Kalakota's (2019) understand of what makes good medical AI technologies we can see emerging values. I believe these values can be boiled down to 3 core values: Autonomy, physicians want the final say; accuracy, physicians need technologies that will offer correct information, having false information causes doubt, confusion, and ultimately sets back the physician; and robustness/ precision, physicians need technologies that are functional even with a highly diverse patient population.

Using perceived ease of use, we can discover other values that are associated with a physician when accepting a medical AI technology. When thinking about ease of use in the hospital-physician system Collier (2014) poses the question: How would it [the questioned technology] work in the clinical environment (Collier, 2014)? Many medical AI products have been developed by programmers or hardware designers with great technological skills, however this does not mean the AI product is functional in the hospital environment, which tends to have unique time pressures and constraint. In addition, technology drives healthcare more than any other force, and in the future, it will continue to develop in dramatic ways. This forces physicians to interact with countless types of technology, devices, and screens in a given day (Thimbleby, 2013). The result of these countless types of technologies are that physicians continue to be required to adapt to the technology and to its frequent changes. Adapting to each nuance/ difference in each technology often result in major issues within the physician's productivity, for example, the constant use of these technologies leads to click fatigue, physician burnout, eye strains, and headaches. Thus, when considering perceived ease of use within the hospital-physician system many expert places excruciating emphasis on intuitive design (Sieck et al., 2020). Specifically, experts such as Park (2019), Alexander (2009), and Staggers (2009) place an emphasis on how physician's perceived ease of use is highly correlated when the technology shares values of effectiveness, efficiency, and is satisfying to use. Effectiveness includes the usefulness of a tool to complete tasks, and the safety of the tool. Examples of efficiency include productivity such as the time to complete specific tasks, the number of clicks to perform tasks, the costs of the tools and/or the amount of training time needed for users to learn a software application. Satisfaction can include the perception of any aspect of the tool and typically includes perceptions about workload or the effectiveness of the specific design (Alexander & Staggers, 2009; Park, 2019).

From the TAM analysis we have identified five unique values that are important to physician's when implementing a medical AI technology: autonomy, precision, effectiveness/ accuracy, efficiency, and satisfaction. However, as Yarbrough & Smith (2007) stated (see Figure 1) the uncertainty associated with medical AI's intent directly affects the values of perceived usefulness and ease of use. In our case we can break down medical AI's intent in two categories: a positive intent and a negative intent. The positive encompasses medical AI as a supplement or augmentation to the physician, while the negative encompasses medical AI as a replacement for the physician. Assuming these are the only two intents, we can break down how each value is affected by each category. Table 1 showcases the results of the effected values:

Table 1: How AI's intent affects Physicians Values: *This table showcases how the intent of the technology changes the values associated/ perceived with the technology.*

Positive Intent: Augmentation	
Autonomy	Autonomy will be preserved. The physicians will still be able to have the final say, allowing for the physician to remain autonomous. In addition, the tool will aid in solving arduous, laborious, or mundane tasks ultimately improving the perceived usefulness (Ahuja, 2019).
Precision	Precision will ultimately be enhanced. Having the two sources rather than one will ultimately serve to check one another, and aid in converging to similar results more often (Martin, 2019). Improving perceived usefulness.
Effectiveness/ accuracy	Effectiveness will ultimately be enhanced. Similar to precision having two sources rather than one will serve as a checking system, resulting in more accurate results (Martin, 2019). Improving perceived usefulness and ease of use.
Efficiency	Efficiency will ultimately be enhanced. Given the normal time physicians take to segment, classify, or evaluate biomarkers medical AI can do it in a fraction of the time (Bohr & Memarzadeh, 2020; Martin, 2019). Improving perception of ease to use.
Satisfaction	Satisfaction will be enhanced. Since AI's intent is for augmentation scholars posit that the design of medical AI devices will be user-friendly and guided for the physician (Ahuja, 2019). Improving perception of ease to use.

Negative Intent: Replacement	
Autonomy	Autonomy will be completely destroyed. Since the technology's intent is to replace the physician, the physician will have no say. Decreasing the perceived usefulness (Ahuja, 2019).
Precision	Precision will ultimately be inconsistent. Having one constant and algorithmic source will aid in converging to similar results when the data the model trained off of is diverse (Martin, 2019). Improving perceived usefulness. However, introducing new or unique data will cause the model to be irregular. Ultimately, perceived usefulness decreases due to inconsistencies.
Effectiveness/ accuracy	Effectiveness will ultimately be inconsistent as well. For a similar reason for precision, if the model is trained off of a diverse data set the model is likely

	to be robust. However, introduction of unique data will result in inaccurate biomarkers. Ultimately, perceived usefulness and ease of use decreases (Martin, 2019).
Efficiency	Efficiency will ultimately be enhanced. Given the normal time physicians take to segment, classify, or evaluate biomarkers medical AI can do it in a fraction of the time (Bohr & Memarzadeh, 2020; Martin, 2019). Improving perception of ease to use.
Satisfaction	Satisfaction will be completely destroyed. Since AI's intent is for replacement scholars posit that the design of medical AI devices will be optimized for software engineers, not physicians (Ahuja, 2019). Decreasing perception of ease to use.

As we can see from Table 1, the positive intent generally bolsters all the values associated with perception of usefulness and perception of ease to use. According to the TAM model this likely means that if AI's intent is positive physician acceptance of medical AI will be high. This will also allow a systematic adoption of medical AI since it is the physician's skepticism for AI's intent that has largely created an impasse situation (Powell, 2020; Singh et al., 2020). On the contrary, from Table 1 we can see how the negative intent generally lowers all the values associated with usefulness and ease to use. If medical AI's intent lies close to replacement of AI, TAM predicts a rejection of medical AI's adoption into the hospital-physician system. Given this situation I will now propose how engineers can use value sensitive design to help guide physician's understanding of medical AI towards the positive intent, leading to systemic adoption of medical AI.

Value sensitive design is a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner (Friedman et al., 2002). Human values consist of what are important to people in their lives, with a focus on ethics and morality. The key reason I am taking an interest in value sensitive design is because it emphases the direct and indirect values of key stakeholders. In our case we want medical AI engineers and designers to be cognizant of the five values we listed in Table 1. The first step in implementing value sensitive design is to switch from a design trade-offs language to a much more encompassing value tension language. The design trade-offs approach conveys you must design for one value at the expense for another. In contrast, the value tension approach conveys the idea of values potentially in opposition but it allows for solutions that balance each value in relation to the others such that the adjudication of the tension holds each value intact (Friedman, 2018; Miller et al., 2007). For our values in Table 1 a design trade-off approach might maximize one value which will help the perception of usefulness or ease to use, however it will not hold every value to that standard, ultimately making the grand perception of the technology unattractive. However, with a value tension approach we might not maximize any one value, but we can hold each value to a prevalent standard, making the grand perception of the technology attractive. Using a value tension approach will help physicians realize that medical AI technology shares similar values with themselves, revealing the intent of the technology clearer. Another, key tool that AI engineers should use in tandem with value tensions is value scenarios. Value Scenarios are crafted, speculative accounts of a proposed technology's interaction with society. Value scenarios help the designer to think about direct and indirect stakeholders as well as help the designer recognize long term problems or conflicts with the technology (Friedman, 2018). For our specific problem, having designers implement value scenarios focused on physician's interactions with the technology can help grant insights to how different design choices might limit values or augment values listed in Table 1. Using value scenarios in tandem with value tensions can help designers showcase values the physicians want within their technology, allowing for a much higher probability of adoption according to TAM. This will ultimately reveal medical AI's intent as an augmentation tool, and resonate with physicians that share the same values with the technology.

Let's consider a scenario in which engineers use these methods to help get their algorithm implemented. In this example we consider a segmentation algorithm made by Carina Medicals: the algorithm segments myocardium scaring post infarction among other biomarkers (Feng et al., 2021). When designing the software that will encompass this algorithm Dr. Feng et al. (2021) underwent a value sensitive design session to help realize what they can do to reflect physician values. Firstly, they took on a value tension view and started to optimize the five values in Table 1. For precision and accuracy, they made sure to train the algorithm off a diverse biobank of patients, as well as introduce image augmentation to further diversify the model. For autonomy they purposely used passive diction and including phrases such as "suggested region of scar", without ever telling the physician what to do. For efficiency the model was optimized for fasted computational times, and for satisfaction the UI design was to mimic the UI of an iPhone for most intuitive design. After initial testing with a set of 2 physicians, they both agreed that they would adopt this technology within their hospital-physician system.

Medical AI Adoption Approach 2 (Multi-level Perspective Theory)

In Medical AI Adoption Approach 1 we focus on the microscopic level to help undo the gridlock caused by physician's being reluctant to adopt medical AI due to not knowing its intent. In this adoption approach we focus on the macroscopic level and look at how increasing exterior stakeholder pressures on the microscopic level can force the adoption of medical AI. In order to do this, we will be using a framework called Multi-level Perspective Theory (MLP). MLP, developed by Arie Rip and Rene Kemp, is a transitional framework that concerns itself with the way in how society and sociotechnical systems change and develop (Caletrío, 2015). MLP states how during a systems transformation three levels interact. These levels are classified at the regime level, the landscape level, and the niche level. The landscape refers to global or social trends that occur which influence and pressure the regime, the regime which is mainstream society that is supported by social norms and integrated systems, and the niche developments where new ideas are allowed to grow until they have an opportunity to challenge the existing regime (Geels & Schot, 2007). In our scenario, the landscape and regime levels encompass exterior pressures while the medical AI technology is within the microscopic niche level. In the next paragraph I will uncover the current regime and landscape pressures, and discuss how they are not enough to overpower the gridlock faced at the niche level.

Starting off with the landscape pressures many experts in the medical field have identified a constant need for faster, more accurate, and adaptable medical technologies within the hospital-physician system (Thimbleby, 2013). This global and social trend has been in the medical filed since its conception, I mean why not have better tools to save more lives? However, this pressure currently has been accelerated by the wake of the COVID-19 pandemic, and public disapproval with the health sector (NW et al., 2021). In fact, pressures have been witnessed across the globe to help find new diagnostic, treatment, and monitoring systems for disease states, especially for COVID-19 (*NIH Harnesses AI for COVID-19 Diagnosis, Treatment, and Monitoring*, 2020). In addition, another landscape pressure consists of the "AI revolution". Specifically, in almost every field of U.S. industry AI has been used to advance, augment, and further the capabilities of technologies/ sociotechnical interactions (T. H. Davenport, 2018). The medical field and the hospital-physician system is no different, and as stated in the beginning of the paper institutions have begun to witness the benefits of AI in the medical field (Rong et al., 2020). I believe these are two of the main landscape pressures placed on the regime. In the regime level we have the status quo. The status quo for most diagnostic tools, monitoring tools, as well as treatment systems in the hospital-physician system is a mix of manual and technological efforts (Ahuja, 2019). While these efforts do get the job done, they often take a lot of time, result in burnout, fatigue, and are often subjective/ error prone. For example, let's consider the radiology department in the hospital-physician system. Technologies such as X-rays, MRI machines, and CT-scans will help the physician obtain raw data from patients, the technological effort, however that is all they will do. Then the physician must examine the raw data and spend anywhere from 2-10 hours segmenting, identifying, or using external probabilistic algorithms that must be tuned for a specific patient in order to identify important biomarkers, the manual effort (Recht & Bryan, 2017). One can understand how in a 2–10 hour session of dissecting an image errors and inaccuracies can be formed. Lastly, the niche development would be the introduction of AI technologies. AI technologies provide solutions to the pressures placed on the regime level by the landscape, they are efficient, adaptable, and when trained properly result in high accuracies and precisions (Park, 2019). However, as we can see AI technologies are not being adopted at rate in which the landscape pressures can be resolved. This low adoption rate stems from the fact that physicians are the key influencer on hospital purchasing decisions, and how they are internally gridlocked by the intent of medical AI (*Selling to Hospitals*, 2017). We can think of this scenario as a balance beam where currently landscape pressures on the regime are not enough to outweigh physician's reluctancy to adopt medical AI technologies. However, in the following paragraph I introduce how adding an additional pressure at the landscape level can tip the balance beam towards adoption of medical AI regardless of physician's perception.

The most effective landscape pressures consist of introducing a social norm or global trend that results in a decrease in public perception of the hospital-physician system. We briefly saw this pressure in action during the global COVID-19 pandemic. With the pandemic many individuals started to replace a positive perception of the hospital-physician system for a much more negative perception. This was largely due to hospitals not have fast enough diagnostic technologies, enough beds, as well as a shortage in staffing ("Hospitals in Half the States Are Facing a Massive Staffing Shortage," 2020). With the perception of the hospital-physician system in peril, hospital executives took charge to implement faster technologies and in fact even some AI technologies (*AI-Powered Solutions in Tackling COVID-19 and Beyond*, 2020; *NIH Harnesses AI for COVID-19 Diagnosis, Treatment, and Monitoring*, 2020). This leads me to hypothesize that additional landscape pressures resulting in affecting the hospital-physician perception can lead to medical AI's adoption. To explain my hypothesis further let's examine the steps that a hospital would take from negative perception to adopting AI. We first start with a landscape pressure that directly affects the systems public perception. This can be anything from public perception that hospitals are too slow in diagnostics, they are not as efficient as possible etc. When public perception drops that is when the executives of the hospital, specifically the Chief Medical Officer (CMO) begins to implement cost effective strategies for improving clinical performance (HealthITAnalytics, 2014). Now, while I did state physician's do have a large influence in spending, they are not the ones actually spending, administrators are. Administrators oversee budgeting and finance and establish hospital policies and procedures, and thus wield significant influence on a hospital's purchasing decisions. In that regard, "selling to hospitals" often means "selling to administrators.". Once the CMO implements a strategy they will often go to administrators to help execute their plan (Longnecker et al., 2007). In fact, around 71% of administrators initiate purchasing decisions when replacing used or outdated technology (*Selling to Hospitals*, 2017). This is where medical AI technology companies such as Carina Medicals LLC, IBM Watson Health, or Google Health can come in with their efficient, accurate, and precise AI technologies. This method directly bypasses physician perception since the administrator is working under direct commands from the CMO. Simply put, it is a matter of the public pressure forcing executives to improve public perceptions, and that overpowers what the physicians want. Through adding additional landscape pressures that introduce the possibility of lowering the hospital-physician system we can tip the balance beam for systemic adoption of medical AI devices.

Conclusion

Medical AI has been around in conversation for the last 70 year (Kaul et al., 2020). However, implementation of medical AI in hospitals have largely been gridlocked by the physician's reluctance. At this current point in time medical AI's intent in the hospital-physician system is unknown and can be boiled down to either the augmentation of physicians or the replacement of physicians. It is this uncertainty, that prevents physicians from adopting medical AI, through their influence as key personal that help decide what technologies hospitals decide to purchase (*Selling to Hospitals*, 2017). In this paper, I introduce an independent dual-pronged approach to help facilitate the effective and systematic adoption of medical AI technologies. The first approach uses a Technology Acceptance Model or TAM to help understand values physicians care about within their technologies/ tools. These values were: autonomy, precision, effectiveness, efficiency, and satisfaction. Then I suggest methods to use value sensitive design, in the form of value tensions and value scenarios, to help designers of medical AI implement critical values within their technologies. This aids to help physicians realize medical AI's positive intent and increases the probability of medical AI's adoption into the hospital-physician system. The second approach ignores the physician's uncertainty about medical AI's intent and uses Multi-level perspective theory to identify a key result from a landscape pressure that overpowers the physician's gridlock. In this analysis I have found that any type of landscape pressure that negatively affects a hospital-physician's systems perception is the most likely to tip the balance beam towards adoption of medical AI technology regardless of physician's opinion.

References

Ahuja, A. S. (2019). The impact of artificial intelligence in medicine on the future role of the physician. *PeerJ*, *7*. https://doi.org/10.7717/peerj.7702

AI-powered solutions in tackling COVID-19 and beyond. (2020, December 14). Healthcare IT News. https://www.healthcareitnews.com/news/apac/ai-powered-solutions-tackling-covid-19-and-beyond

Alexander, G. A., & Staggers, N. (2009). A Systematic Review on the Designs of Clinical Technology: Findings and Recommendations for Future Research. *ANS. Advances in Nursing Science*, *32*(3), 252–279. https://doi.org/10.1097/ANS.0b013e3181b0d737

Alperin, P. (2020, October 23). *TECHNOLOGY TO BOOST PRODUCTIVITY IN YOUR PRACTICE*. https://www.physicianleaders.org/news/technology-to-boost-productivity-in-your-practice

Amisha, Malik, P., Pathania, M., & Rathaur, V. K. (2019). Overview of artificial intelligence in medicine. *Journal of Family Medicine and Primary Care*, *8*(7), 2328–2331. https://doi.org/10.4103/jfmpc.jfmpc_440_19

Artificial Intelligence is the Stethoscope of the 21st Century. (2017, July 18). The Medical Futurist. https://medicalfuturist.com/ibm-watson-is-the-stethoscope-of-the-21st-century

Atherley, A., & Meeuwissen, S. N. E. (2020). Time for change: Overcoming perpetual feelings of inadequacy and silenced struggles in medicine. *Medical Education*, *54*(2), 92–94. https://doi.org/10.1111/medu.14030

Bohr, A., & Memarzadeh, K. (2020). The rise of artificial intelligence in healthcare applications. *Artificial Intelligence in Healthcare*, 25–60. https://doi.org/10.1016/B978-0-12-818438-7.00002-2

Burns, L. R., & Muller, R. W. (2008). Hospital-Physician Collaboration: Landscape of Economic Integration and Impact on Clinical Integration. *The Milbank Quarterly*, *86*(3), 375–434. https://doi.org/10.1111/j.1468-0009.2008.00527.x

Caletrío, J. (2015). DEBATE Multi-Level Perspective and Theories of Practice: A mistaken controversy? *Mobile Lives Forum*.

Chuttur, M. (2009). *Overview of the Technology Acceptance Model: Origins, Developments and Future Directions*. 24.

Collier, R. (2014). Medical technology: The good and the bad. *CMAJ : Canadian Medical Association Journal*, *186*(18), 1353. https://doi.org/10.1503/cmaj.109-4931

Davenport, T. H. (2018). *The AI Advantage: How to Put the Artificial Intelligence Revolution to Work*. MIT Press.

Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. *Future Healthcare Journal*, *6*(2), 94–98. https://doi.org/10.7861/futurehosp.6-2-94

Emanuel, E. J., & Emanuel, L. L. (1992). Four Models of the Physician-Patient Relationship. *JAMA*, *267*(16), 2221–2226. https://doi.org/10.1001/jama.1992.03480160079038

Feng, X., Kramer, C. M., Salerno, M., & Meyer, C. H. (2021). Automatic Scar Segmentation from DE-MRI Using 2D Dilated UNet with Rotation-Based Augmentation. In E. Puyol Anton, M. Pop, M. Sermesant, V. Campello, A. Lalande, K. Lekadir, A. Suinesiaputra, O. Camara, & A. Young (Eds.), *Statistical Atlases and Computational Models of the Heart. M&Ms and EMIDEC Challenges* (pp. 400–405). Springer International Publishing. https://doi.org/10.1007/978-3-030-68107-4_42

Frank, M. R., Autor, D., Bessen, J. E., Brynjolfsson, E., Cebrian, M., Deming, D. J., Feldman, M., Groh, M., Lobo, J., Moro, E., Wang, D., Youn, H., & Rahwan, I. (2019). Toward understanding the impact of artificial intelligence on labor. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(14), 6531–6539. https://doi.org/10.1073/pnas.1900949116

Friedman. (2018, March 15). *Moral and Technical Imagination: A Value Sensitive Design Perspective| Batya Friedman | Design@Large*. https://www.youtube.com/watch?v=6HPgN050DIw&t=390s

Friedman, B., Kahn, P. H., & Jr. (2002). *Value Sensitive Design: Theory and Methods*.

Gedge, E. (Boetzkes), & Waluchow, W. J. (2012). *Readings in Health Care Ethics—Second Edition*. Broadview Press.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

HealthITAnalytics. (2014, December 11). *Public Reporting Influences Perceptions of Hospital Quality*. HealthITAnalytics. https://healthitanalytics.com/news/public-reporting-influences-perceptions-of-hospital-quality

Hospitals in half the states are facing a massive staffing shortage. (2020, November 19). *STAT*. https://www.statnews.com/2020/11/19/covid19-hospitals-in-half-the-states-facing-massive-staffing-shortage/

Kaul, V., Enslin, S., & Gross, S. A. (2020). History of artificial intelligence in medicine. *Gastrointestinal Endoscopy*, *92*(4), 807–812. https://doi.org/10.1016/j.gie.2020.06.040

Kononenko, I. (2001). Machine learning for medical diagnosis: History, state of the art and perspective. *Artificial Intelligence in Medicine*, *23*(1), 89–109. https://doi.org/10.1016/S0933-3657(01)00077-X

Krittanawong, C. (2018). The rise of artificial intelligence and the uncertain future for physicians. *European Journal of Internal Medicine*, *48*, e13–e14. https://doi.org/10.1016/j.ejim.2017.06.017

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*(3), 191–204. https://doi.org/10.1016/S0378-7206(01)00143-4

Longnecker, D. E., Patton, M., & Dickler, R. M. (2007). Roles and Responsibilities of Chief Medical Officers in Member Organizations of the Association of American Medical Colleges. *Academic Medicine*, *82*(3), 258–263. https://doi.org/10.1097/ACM.0b013e31803072fb

Marangunić, N., & Granić, A. (2015). Technology acceptance model: A literature review from 1986 to 2013. *Universal Access in the Information Society*, *14*(1), 81–95. https://doi.org/10.1007/s10209-014-0348-1

Martin, N. (2019). *How Artifical Intelligence Is Advancing Precision Medicine*. Forbes. https://www.forbes.com/sites/nicolemartin1/2019/10/18/how-artifical-intelligence-is-advancing-precision-medicine/

Miller, J. K., Friedman, B., Jancke, G., & Gill, B. (2007). Value tensions in design: The value sensitive design, development, and appropriation of a corporation's groupware system. *Proceedings of the 2007 International ACM Conference on Supporting Group Work*, 281–290. https://doi.org/10.1145/1316624.1316668

NIH harnesses AI for COVID-19 diagnosis, treatment, and monitoring. (2020, August 5). National Institutes of Health (NIH). https://www.nih.gov/news-events/news-releases/nih-harnesses-ai-covid-19-diagnosis-treatment-monitoring

NW, 1615 L. St, Suite 800Washington, & Inquiries, D. 20036USA202-419-4300 | M.-857-8562 | F.-419-4372 | M. (2021, March 5). A Year of U.S. Public Opinion on the Coronavirus Pandemic. *Pew Research Center*. https://www.pewresearch.org/2021/03/05/a-year-of-u-s-public-opinion-on-the-coronavirus-pandemic/

Park, A. (2019). *AI helps physicians with no coding experience create automated tools: Study*. https://www.beckershospitalreview.com/artificial-intelligence/ai-helps-physicians-with-no-coding-experience-create-automated-tools-study.html

Patel, R. S., Bachu, R., Adikey, A., Malik, M., & Shah, M. (2018). Factors Related to Physician Burnout and Its Consequences: A Review. *Behavioral Sciences*, *8*(11). https://doi.org/10.3390/bs8110098

Pearson, D. (2017). *Artificial Intelligence in Radiology: The Game-Changer on Everyone's Mind*. https://www.radiologybusiness.com/topics/technology-management/artificial-intelligence-radiology-game-changer-everyones-mind

Powell, A. P. H. S. (2020, November 11). Risks and benefits of an AI revolution in medicine. *Harvard Gazette*. https://news.harvard.edu/gazette/story/2020/11/risks-and-benefits-of-an-ai-revolution-in-medicine/

Recht, M., & Bryan, R. N. (2017). Artificial Intelligence: Threat or Boon to Radiologists? *Journal of the American College of Radiology: JACR*, *14*(11), 1476–1480. https://doi.org/10.1016/j.jacr.2017.07.007

Rong, G., Mendez, A., Bou Assi, E., Zhao, B., & Sawan, M. (2020). Artificial Intelligence in Healthcare: Review and Prediction Case Studies. *Engineering*, *6*(3), 291–301. https://doi.org/10.1016/j.eng.2019.08.015

Selling to Hospitals: Decision-Makers in Healthcare - B2B Appointment Setting - Custom Calling Campaigns. (2017). https://www.intelemark.com/2017/11/selling-hospitals-decision-makers-healthcare/

Sieck, C. J., Pearl, N., Bright, T. J., & Yen, P.-Y. (2020). A qualitative study of physician perspectives on adaptation to electronic health records. *BMC Medical Informatics and Decision Making*, *20*. https://doi.org/10.1186/s12911-020-1030-6

Singh, R. P., Hom, G. L., Abramoff, M. D., Campbell, J. P., & Chiang, M. F. (2020). Current Challenges and Barriers to Real-World Artificial Intelligence Adoption for the Healthcare System, Provider, and the Patient. *Translational Vision Science & Technology*, *9*(2). https://doi.org/10.1167/tvst.9.2.45

Thimbleby, H. (2013). Technology and the Future of Healthcare. *Journal of Public Health Research*, *2*(3). https://doi.org/10.4081/jphr.2013.e28

Yarbrough, A. K., & Smith, T. B. (2007). Technology acceptance among physicians: A new take on TAM. *Medical Care Research and Review: MCRR*, *64*(6), 650–672. https://doi.org/10.1177/1077558707305942

Your future doctor may not be human. This is the rise of AI in medicine. (2018). Futurism. https://futurism.com/ai-medicine-doctor