How Electronic Healthcare can Save Lives

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Abstract:

While other industries have adopted recent technological advancements to become more profitable and successful, the healthcare industry has lagged behind. Many modern healthcare frameworks feature electronic records, backed by the government, which do support health outcomes. Though most hospitals have implemented some type of electronic health system, however, many are still unable to share data with the electronic health systems of other hospitals and facilities—severely limiting the overall effectiveness of electronic healthcare. This paper analyzes papers and surveys regarding the effects of and opinions towards modern electronic health systems. Studies demonstrate that with proper planning and execution, electronic healthcare and the health information exchange (HIE) can bring great clinical and financial benefits. The hard-to-achieve goal of interoperability, in particular, has been shown to improve health outcomes. However, contemporary implementations of electronic health systems face both technical and cultural challenges, so certain political, economic, and social factors must be in place in order for an electronic health system implementation to realize its full potential. This paper also details a survey conducted by the researcher taken by various health professionals regarding electronic health system usage and opinions. Both the review of literature and data collection provide general support for electronic health systems.

Introduction:

The United States of America, the country so renowned for its innovation and enterprise, has fallen behind when it comes to the healthcare industry. With the advent of electronic healthcare, many countries have adopted widespread electronic health systems, including the United States. However, what the USA's electronic healthcare system lacks is the ability to share information between various systems. This lack of data sharing capability leads to fragmented care. To resolve this issue, the Obama administration issued the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, which provided incentives for electronic health record (EHR) vendors to support the transfer of data between different systems. Unfortunately, the HITECH Act faced many barriers that prevented its goal from being realized, which will be discussed. Minimizing these barriers would benefit healthcare immensely. A survey intervention conducted by the researcher supports the mentioned benefits and limitations of electronic health systems. This paper will argue that electronic health system implementations do have the potential to improve health outcomes because (i) they have shown clear benefits, (ii) their negative aspects can be minimized, and (iii) they can be improved through sufficient funding, cooperation, planning, and execution.

Review of Literature:

The value of electronic healthcare can be seen in the clinical and financial benefits that it brings, most notably interoperability. Interoperability can be defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (Lehne, 2019). The definition of interoperability can be further expanded to fit into

the context of health systems by distinguishing between technical, syntactic, semantic, and organizational interoperability, all of which are crucial for interoperability as a whole. Technical interoperability "ensures basic data exchange capabilities between systems", such as transferring files from a computer to a USB drive (Lehne, 2019). However, simply moving information from point A to point B is not enough for electronic healthcare, because point B must also be able to interpret the data. Syntactic interoperability solves this problem by specifying "the format and structure of the data" to make sure that transferred health data can be parsed by all health systems (Lehne, 2019). Currently, Health Level Seven International (HL7) open and international standards dictate how data should be formatted before sending it to other systems. Alongside syntactic exists semantic interoperability, which ensures that the meaning of "medical terminologies, nomenclatures, and ontologies," or medical concepts in general, can be shared among different systems in order to establish a common language for medical terms understandable by all health systems (Lehne, 2019). Finally, organizational interoperability lies in the domain of business. It "requires common business processes and workflows" that enable and provide incentives for interoperable data exchange to create a seamless healthcare workflow (Lehne, 2019). The combination of these four variants of interoperability can pay substantial dividends by vastly improving medicine.

By allowing data to be shared in an interconnected digital health infrastructure, interoperable electronic health system implementations can improve performance in many medical fields. For instance, an interoperable health record could process information from multiple health systems and across institutional boundaries: when one region's health system has limited data, it can pull data from another region. This data can be fed into AI algorithms and big

data analytics to analyze trends or patterns that can identify at-risk patients (Lehne, 2019). Interoperable health systems can also advance medical research. Interoperable real-world data collected from EHRs can be used for national or global observational studies. When syntactic and semantic interoperability are in play, researchers have to do less work to process health data. In a broader sense, electronic health systems with interoperability lead to interinstitutional and international cooperation between health companies. For example, when one country wants to study a rare disease but they have limited cases, an interoperable electronic health system allows the country to pool relevant data from other countries facing the same disease for research purposes. By utilizing all four pillars of interoperability listed above, electronic health systems can overcome barriers between individuals, organizations, and countries.

Next, electronic health systems are beneficial in that they help physicians perform tasks at the point-of-care. For one, EHR interoperability reduces the amount of duplicate testing on patients. A study by Stewart, Fernandes, Rodriguez-Huertas, and Landzberg of duplicate testing between two Boston hospitals, each with their own EHR, concluded that 32 percent of patients transferred from one site to the other in a 2-year period experienced duplicate testing. The root of the cause was the incompatible EHRs of the two hospitals, which led to incomplete data exchange and costly duplicate tests. Implementation of interoperable EHRs between institutions with prior test results included as well as decision support could minimize the duplication of testing, resulting in at least modest savings (Stewert et al., 2010).

Another benefit of electronic health system implementations is enhanced patient care. In a study by King, Patel, Jamoom, and Furukawa, 78% of physicians around the United States who used EHRs thought that their EHR enhanced patient care overall. The more experience a

physician had with the EHR, the more they were likely to claim that it benefited their patient care, and abilities to provide recommended care, order appropriate tests, and facilitate patient communication (King et al., 2014, p.392). These findings suggest an EHR learning curve, as physicians become more accustomed to the benefits of EHRs over time. As seen by the amount of satisfied EHR-using physicians, the time it takes to get used to an EHR is worth it. Furthermore, EHRs help greatly with physicians' decision making. According to Brady Miller, lead developer of the OpenEMR medical record system (the most popular EHR by installations), OpenEMR has the ability to detect trends in a single patient's history or across many patients to determine what specific trait causes a certain disease or illness. The software provides these trends and other information, such as alerts about prescription stockouts, as suggestions to help the physician make more informed decisions about what to prescribe a patient, what medications to order, or what to watch out for to prevent a disease from spreading (Miller, 2019). An EHR, or any other interoperable electronic health system implementation is an invaluable asset to any physician at the point-of-care.

To conclude this section, one lesser-known benefit of electronic healthcare is better training of students in the field of medicine. A study by Tierny, Pageler, Kahana, Pantaleoni, and Longhurst regarding the training of medical learners using EHRs concluded that EHRs can be used for the optimal education experience in many fields ranging from patient care to professionalism. For instance, EHRs can reduce the time to access medical histories or retrieve data and provide remote access. They can also help students learn how to take more efficient notes and interact with patients through the EHR better, which helps to reduce the EHR learning curve (Tierny et al., 2013, p. 748). Thus, medical students are more adequately prepared when

entering the professional realm, leading to better health outcomes overall. However, many argue that the negative factors of electronic health counteract its benefits, preventing health outcomes from being improved. Contemporary research, however, refutes this claim.

Recent studies support that the negative factors of electronic health can be minimized primarily through the health information exchange (HIE). "HIE" is essentially another term for interoperability, as it defines "the process of sharing patient-level electronic health information between different organizations" (Vest, 2010). Because humans are by nature mobile, health information is required in many different locations simultaneously but not acquired. Healthcare professionals widely identify HIE as a solution to these problems, yet attempts to facilitate HIE over the past two decades have failed (Vest, 2010). A reflection upon the problems and lessons of HIE efforts offer revelations for increasing the probability of successful HIE facilitation.

One of the earliest HIE efforts arose in 1990: community health management information systems (CHMISs) initiated by The Hartford Foundation (Vest, 2010). CHMISs featured a centralized data repository that distributed data to stakeholders. However, CHMISs faced opposition from patients who worried about the privacy of their information. Additionally, competing stakeholders in CHMISs often refused to exchange information, and CHMISs struggled to shift from government funding to self-sustaining revenue, resulting in their failure. Thus, for a successful HIE, a "clearly defined purpose and effective political support" must be present in order to dissuade fears about data sharing (Vest, 2010). HIE requires collaboration among competitors; larger incentives would minimize the chances of a HIE failing. Sufficient funding must be in place and able to sustain the lifetime of EHR systems, or at least until the systems are self-sustaining. Though grants do help to overcome start-up costs, they cannot be

depended on if a HIE wishes to be sustainable (Vest, 2010). Long-term financial insecurity for a HIE leads to uncertainty regarding its profitability, so proper strategies must be implemented to overcome the obstacles encountered in past HIE efforts. These may include employing institutional incentives and regulation, treating "HIE as a public good," and "rely[ing] on the effects of disruptive innovations" on EHRs (Vest, 2010).

There are more problems facing interoperability aside from those encountered by the previous HIE efforts described above. The most prominent originate from the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, which "has provided more than $35 billion in incentives to promote and expand the adoption and use of EHRs by eligible hospitals and healthcare professionals" (Reisman, 2017). HITECH involved three stages -- data capture and sharing, advance clinical processes, and improved outcomes -- each of which had measures of "Meaningful Use". Fulfilled "Meaningful Use" measures would enable a provider to be eligible for incentives. Although HITECH has led to a 96% EHR adoption rate by hospitals in the United States, its goal of achieving widespread interoperability has not been fulfilled. By 2015, only 12% of providers had completed stage 2 of HITECH, which involves implementing HIE (Reisman, 2017). Some argue that HITECH's misaligned incentives are to blame, claiming that "stage 1 of meaningful use includes neither any requirements nor vision for interoperability, allowing EHR systems to be designed and adopted in ways that did not take HIE into account. By stage 2 or 3, many providers could not justify the fees required to interface their EHRs with other healthcare providers" (Reisman, 2017). Interoperability is notoriously difficult to implement in electronic health systems, so considerable foresight must be employed when planning an intervention.

In order to determine whether HIEs and interoperability have indeed improved health outcomes in a certain region, health professionals must be able to evaluate interoperability. The *PLOS Medicine* Editors suggest that eHealth needs a reality check given the number of failed HIE efforts. They found that while many evaluations of interoperability in electronic health systems have been conducted, "many are of poor quality, few have low risk of bias, and very few have found clinically significant benefits of the interventions." More studies should be conducted in low-to-middle income countries to evaluate the feasibility of interoperability in such settings ("A Reality Check", 2013). In essence, electronic health system vendors must decide upon a common standard for evaluating their health systems' interoperability capabilities, which includes evaluating "why, what, and under what conditions [they] work" ("A Reality Check", 2013). Were such a standard in place, less interoperable electronic health sharing architectures would be identified and dealt with more efficiently, minimizing the negative aspects of a lack of a HIE.

After the negative aspects of electronic healthcare are mostly minimized using the methods described above, the focus shifts to maximizing the potential of electronic healthcare. Studies demonstrate that certain preconditions and factors must be present for an electronic health system intervention to be successful. First and foremost, open standards should be in place to ensure conformity between data formats during data exchange. Health Level 7 (HL7) Fast Healthcare Interoperability (FHIR) is an up-and-coming health messaging standard (Bender & Sartipi, 2013). Based on RESTful and agile principles, FHIR is made very simple to implement after the failure of the complicated HL7v3 standard in the 1990s. Nevertheless, a single health

messaging standard has been an elusive goal: while some have adopted FHIR due to its simplicity, others disagree with its lack of complexity and prefer to use HL7v2 from 1989 (Bender & Sartipi, 2013). To maximize the potential of electronic healthcare, a universal open health messaging standard, most likely FHIR, must be adopted by all.

To further emphasize the positive factors of electronic health, focus must be placed on human factors while designing and utilizing EHRs. Medical researchers Wildenbos, Peute, and Jaspers, after studying ten research papers "evaluating the impact of patient-centered eHealth applications on patient care," concluded that "a more complete understanding of the influence of human factors on eHealth integral usage within the healthcare system" is needed to maximize the effectiveness and minimize the detriments of eHealth services (Wildenbos et al., 2016). By human factors, the authors refer to self-efficacy and perceived social support. In a healthcare context, a patient's self-efficacy "concerns a patient's confidence in his/her abilities to change certain unhealthy behavior patterns or to appropriately self-manage his disease" (Wildenbos et al., 2016). A patient's self-efficacy directly correlates with his/her satisfaction with the use of EHRs because self-efficacy levels guide behavior changes with regards to diet and exercise which in turn lead to more conscientious monitoring of one's health using EHRs. Perceived social support can also be "a very important psychological variable" in improving health outcomes. EHRs with social support features like forums or voice chats increase patients' motivation to return to the website, increasing their self-efficacy (Wildenbos et al., 2016). Electronic health system vendors must take these human factors into account to empower the users of their systems and motivate them to improve their own health outcomes.

Furthermore, electronic health systems must be consistently intervened with using case studies and experiments in order to judge their success or failure. For instance, many studies demonstrate growing rates of physician burnout due to increased EHR use along with decreased facetime with patients. Healthcare professors Wang, Ouyang, Hom, Chi, and Chen argue that "there exists a pressing need to improve physician-computer-patient interactions by streamlining EHR workflow...via interventions to improve EHR design and usage by evaluating the systems." The authors themselves conducted an intervention by analyzing almost 16 million logged interactions with the Stanford Epic EHR system over the course of three years to "systematically characterize the intensity of EHR usage across different inpatient medicine rotations and roles" (Wang et al., 2019). They found that physicians working the night shift tended to abruptly cease their EHR activities at the end of their shift, while the day team tended to linger well beyond the end of their shift. As such, Stanford-based healthcare professionals would be more inclined to consider those who work the night shift when attempting to improve physician-computer-patient interactions thanks to the authors' targeted intervention (Wang et al., 2019). More well-planned and comprehensive interventions and analysis of EHR usage like Wang's team's study would serve to improve health outcomes by identifying the groups most negatively affected by the EHR.

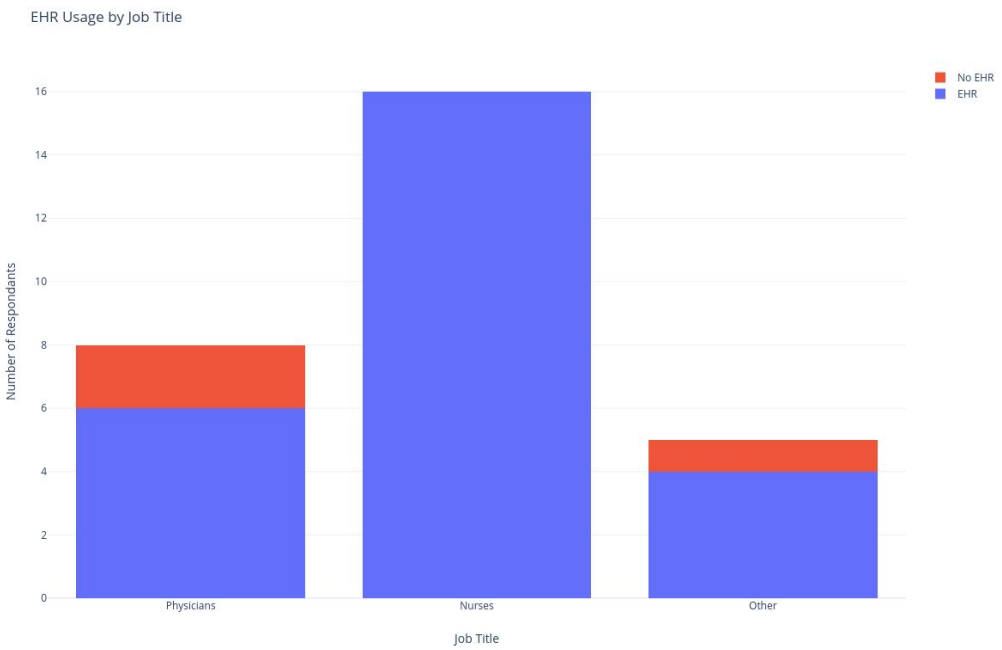
Research Methods and Data Collection:

After noticing a lack of general data regarding healthcare workers' opinions regarding electronic health records in the literature surveyed, the researcher conducted his own intervention. The researcher created a survey containing questions relevant to the research

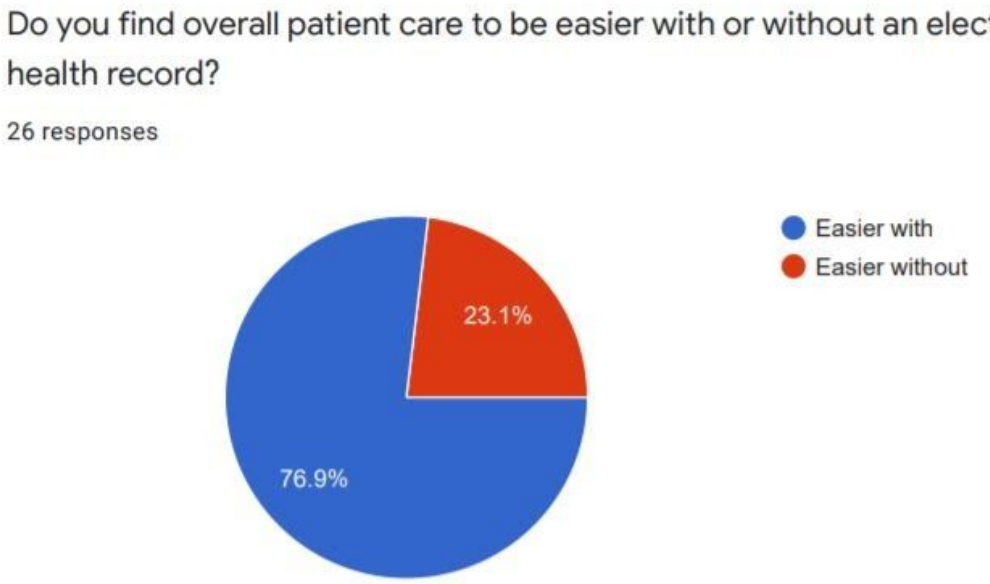
question of whether or not electronic healthcare improves health outcomes. The survey first asks the respondent for his/her job title and whether or not he/she uses an electronic health record in his/her daily work routine (Appendix A). If the respondent does use an EHR, the survey asks a variety of questions about his/her EHR usage and opinions, including the number of hours he/she spends on an EHR on a typical work day, how helpful the EHR is at facilitating communication with patients, and any issues he/she finds with EHRs. The survey was created with Google Forms and respondents were found from healthcare communities on the online forum reddit.com during the months of March and April 2020.

Results and Data Analysis:

The researcher received a total of 28 responses from healthcare workers. Of the 29 respondents, 8 identified themselves as physicians, 16 identified themselves as nurses, and 5 identified themselves as another health profession (Appendix A).



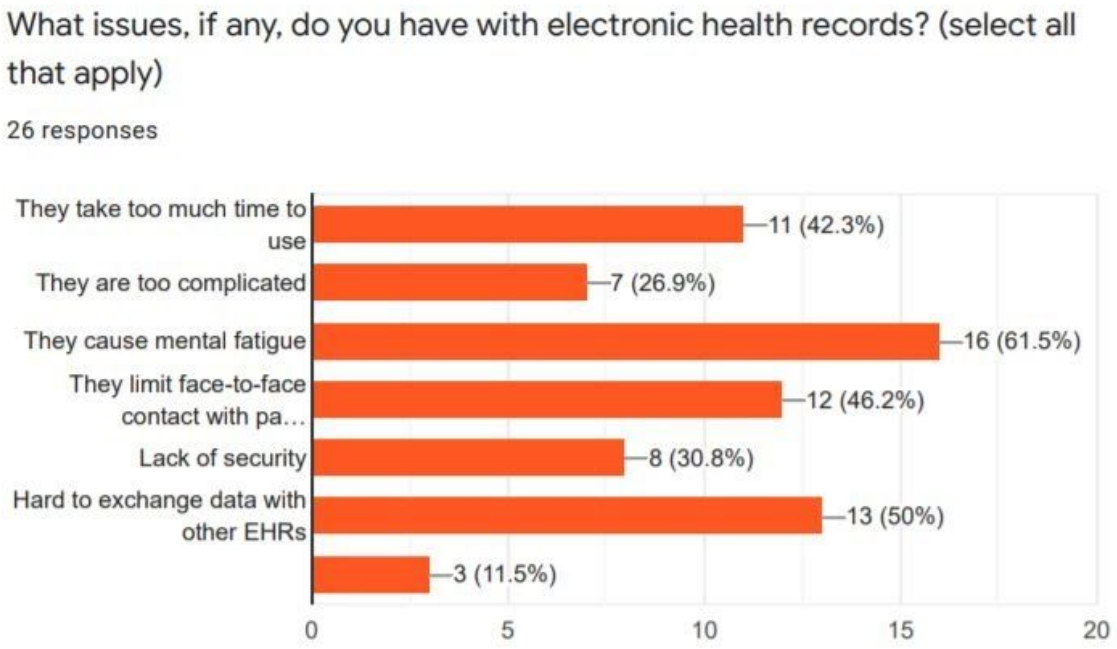
Appendix A also indicates that 26 of the 29 respondents use an EHR in their daily work routine, which is statistically reasonable given that the vast majority of hospitals and office-based healthcare facilities in the United States use EHRs. It is also notable that all nurse respondents used an EHR in their daily work routine compared to ¾ of physician respondents, implying that nurses are more experienced with EHRs due to the nature of their roles.



From the 26 respondents who do use an EHR in their daily work routine, the survey produced some interesting results (Appendix B). They spend an average of 4.1 hours on an EHR during the work day, quite a significant amount. However, a little over ¾ considered patient care to be easier with an EHR despite the long hours, which speaks to the benefits of electronic healthcare.

The respondents were also asked to rate how beneficial various aspects of EHRs are from 1 to 5, where 1 is not helpful at all and 5 is very helpful. They found that EHRs were quite helpful at making their workflow smoother, rather helpful at alerting them to errors or trends in

patient data, and not very helpful at facilitating communication with patients (Appendix B). The smoother workflow is likely a result of the note-taking and form-entering capacities of EHRs. Error and trend detection is also a feature found in many widely-used EHRs, such as OpenEMR. On the other hand, patients may not be keen to communicate with doctors or nurses electronically, explaining the lack of positive feedback regarding communication via the EHR.



The final survey question dealt with the issues the respondents had with EHRs. Their top three concerns with EHR were 1) that they cause mental fatigue, 2) that it is too hard to exchange data with EHRs, and 3) that they limit face-to-face contact with patients (Appendix B). All three of these issues are prominent points of dissatisfaction within the electronic healthcare community, as referenced above. The problem of mental fatigue and burnout from staring at a screen for extended periods of time highlights the need to increase the efficiency of EHR use. EHRs also take time away from physicians and nurses to interact with patients, so a proper

balance must be found between EHR use and provider-patient communication to maximize patient self-efficacy. The least chosen option was that EHRs cannot handle enough data, which is reasonable because hospitals have the capacity to store patient information, the problem is the communication and transfer of that information between and within hospitals.

When comparing the responses of physicians and nurses, nurses report higher levels of satisfaction with EHRs. Half of the physician respondents felt that patient care was easier without EHRs, while only 2 out of 16 nurses felt as such. The respective roles of nurses compared to physicians may be a cause: nurses spend a large amount of time documenting patient encounters and thus receive more EHR training than physicians. A potential resolution to this issue may be delegating some of the EHR tasks normally assigned to physicians to nurses. The nurses would use the EHR more efficiently and willingly than the physicians according to the survey results, and physicians could spend more time interacting with their patients. The combination of these factors would likely lead to improved health outcomes.

Discussion and Conclusion:

The above intervention comes with limitations, most notably that there was no method to verify the legitimacy of each response. Nonetheless, the results of the survey agree with general sentiment towards EHRs, namely that they entail many hours of use per day, they lead to mental fatigue, and that they improve workflow. These findings could contribute to more constructive workflows to improve EHRs as a whole. The researcher would suggest starting with improving interoperability through political and technical means: convincing healthcare corporations to cooperate and then integrating different EHR protocols. Increasing the user-friendliness of

electronic health system design is another point of focus. Finally, the ability of technology to connect people must not be overlooked—communication between patients and providers can be greatly enhanced through electronic healthcare architectures.

The United States' healthcare system is not the most effective due to its lack of widespread interoperability and efficiency considerations. Indeed, this disparity is reflected in an American's average life expectancy of 78, which is subpar compared to its reputation. In contrast, the country of Monaco on the Mediterranean has one of the most comprehensive and interoperable health information exchanges in the world, which correlates with its life expectancy: the highest in the world at 90. If the United States, or underserved countries with lower life expectancies, wish to improve their health outcomes, then creating an interoperable electronic health system must be the first step. In the United States, such a goal is achievable with proper funding, cooperation, planning, and execution, yet countries like Chad cannot. Chad does not have the healthcare foundation already available that would allow an electronic healthcare system to be built on, so it requires assistance from external sources, such as the United States or other open-source health systems like the OpenEMR or OpenMRS. Not only must the United States work together to achieve improved health outcomes through electronic healthcare, it must also strive to improve health outcomes in countries that desperately need it.

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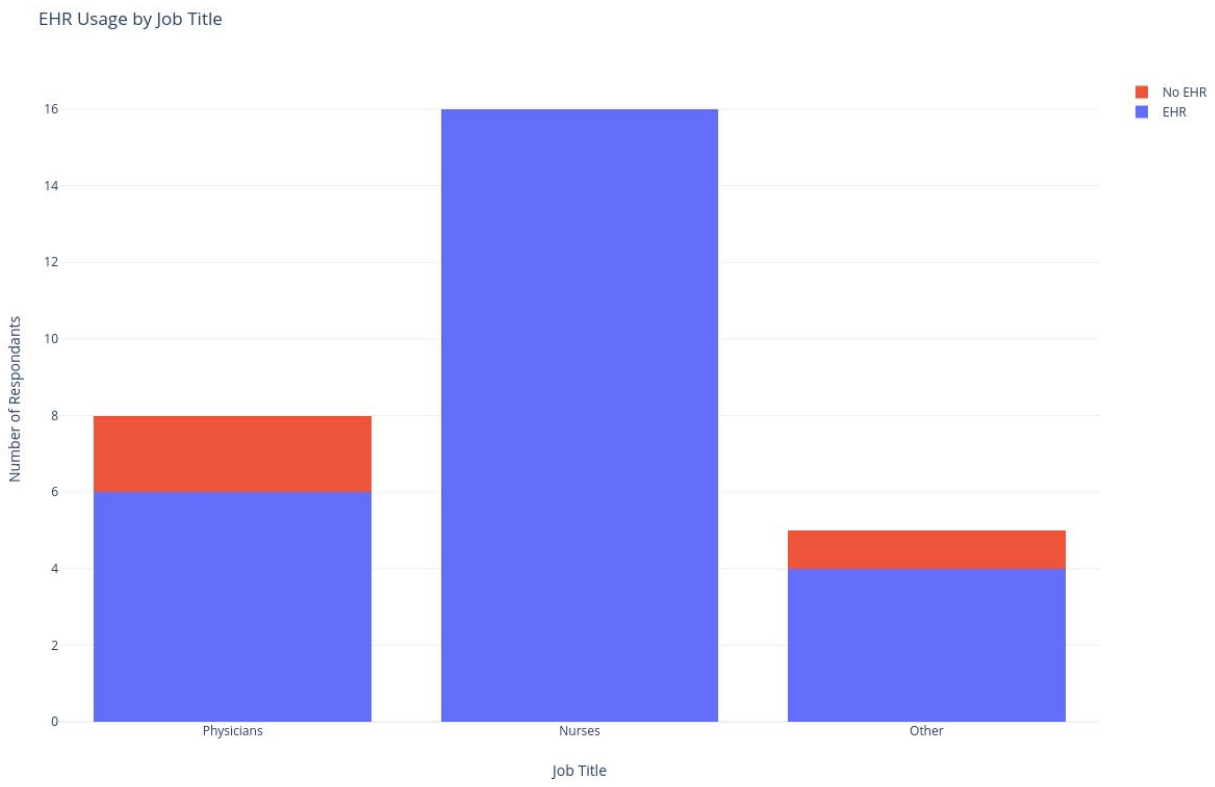
Appendix A


EHR Usage by Job Title
No EHR
EHR
16
14
12
10
8
6
4
2
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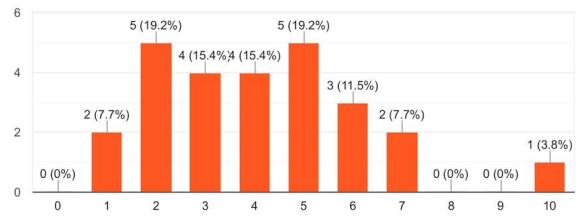
Number of Respondants
Physicians
Nurses
Other
Job Title

Appendix B

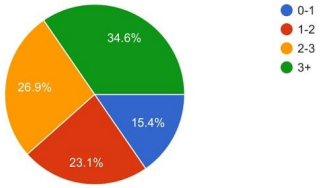
On average, how many hours do you spend on an electronic health record (i.e. on the computer) on a typical work day?

26 responses



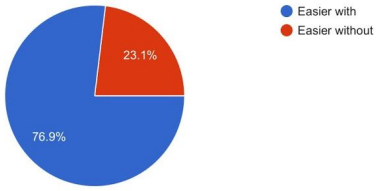
How many years of experience do you have with electronic health records?

26 responses



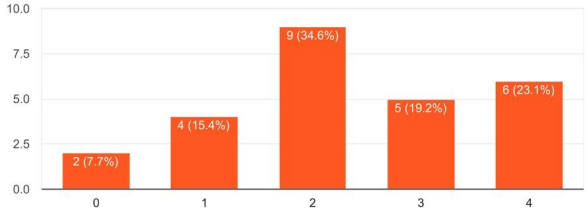
Do you find overall patient care to be easier with or without an electronic health record?

26 responses



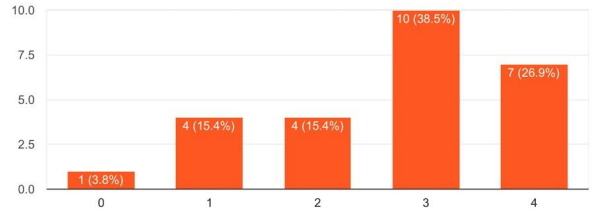
How helpful is your electronic health record at alerting you to errors or trends in patient data?

26 responses



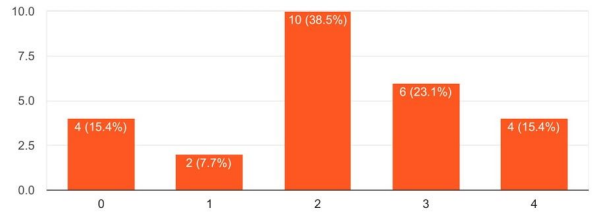
How helpful is your electronic health record at making your workflow smoother/more efficient?

26 responses



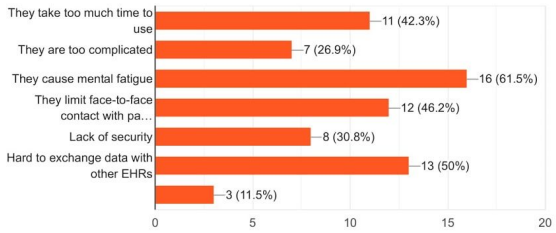
How helpful is your electronic health record at facilitating communication with your patients?

26 responses



What issues, if any, do you have with electronic health records? (select all that apply)

26 responses



Appendix C

Electronic Health Service Survey

Please answer the questions as accurately as possible. Thank you!

* Required

1. What is your job title? *

2. Do you currently use an electronic health record (EHR) in your daily work routine? *

   Mark only one oval.

   - ◯ Yes *Skip to question 3*
   - ◯ No

Skip to question 3

Electronic Health Service Survey Cont.

3. On average, how many hours do you spend on an electronic health record (i.e. on the computer) on a typical work day? *

   Mark only one oval.

0	1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

4. How many years of experience do you have with electronic health records? *

   Mark only one oval.

   - ◯ 0-1
   - ◯ 1-2
   - ◯ 2-3
   - ◯ 3+

5. Do you find overall patient care to be easier with or without an electronic health record? *

   Mark only one oval.

   - ◯ Easier with
   - ◯ Easier without

6. How helpful is your electronic health record at alerting you to errors or trends in patient data? *

   Mark only one oval.

	0	1	2	3	4	
Not helpful at all	◯	◯	◯	◯	◯	Very helpful

7. How helpful is your electronic health record at making your workflow smoother/more efficient? *

   Mark only one oval.

	0	1	2	3	4	
Not helpful at all	◯	◯	◯	◯	◯	Very helpful

8. How helpful is your electronic health record at facilitating communication with your patients? *

Mark only one oval.

	0	1	2	3	4	
Not helpful at all	◯	◯	◯	◯	◯	Very helpful

9. What issues, if any, do you have with electronic health records? (select all that apply) *

Check all that apply.

- [ ] They take too much time to use
- [ ] They are too complicated
- [ ] They cause mental fatigue
- [ ] They limit face-to-face contact with patients
- [ ] Lack of security
- [ ] Hard to exchange data with other EHRs
- [ ] They cannot handle enough information