An Empirical Study and Simulation of EHR Software in Light of COVID-19

Ayman Ali, Research Thesis

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Abstract

The COVID-19 pandemic has highlighted the need for attention directed towards accurate and accessible disease surveillance. As eighty-five percent of all health data is now processed in electronic form, the healthcare industry is increasingly becoming dependent upon patient healthcare data to facilitate well-coordinated and efficient decisions in a timely manner. Electronic health records can be crucial in unearthing the health disparities found among disadvantaged communities in terms of treatment and patient care. By creating a cloud-based software solution, electronic health records will not only be able to share patient health information to multiple healthcare settings, but also provide earlier disease detection and intervention.

While implementing telemedicine is proving to be advantageous in reducing physical contact and maintaining social distancing guidelines, much of the dismay from clinicians has been towards the challenges with clinical documentation and patient flow. The CDC has stressed the importance of sending electronic health record case reports to public health officials on countless occasions. The software that vendors create are by no means perfect. Therefore, it is of utmost importance to focus on minimizing disruptions and COVID-19 related errors when using the software. In order to devise software aimed at mining sufficient data and providing tools solely directed at patient care, medical practitioners and software vendors are in endless communication. Implementing the necessary features best suited to support the general population requires eradicating any sort of configuration that can contribute to patient harm. This research will look into the role of EHRs in improving data tracking and collection and whether or not this software can be relied upon in the current climate.

Keywords
Introduction

Electronic health records are digital documentations of a patient’s health information, containing every encounter a patient has undergone with the health care system. The Office of the National Coordinator for Health Information Technology (ONC) defines an electronic health record as a digital version of the paper charts patients often receive at doctor offices. The information is electronically stored and the clinical data collected is integral in diagnosing an individual. The clinical data obtained is the baseline in which all healthcare processes subscribe to including decision support, health outcome analysis, billing and claims processing and health maintenance.¹ The most effective electronic health records provide a real-time, patient-centric record that becomes readily visible and securely accessible for patients and medical personnel² which has been especially important as a result of the pandemic. Users can eliminate redundant paperwork, easily update records, and prevent any errors that may result from recording patient information, an issue that is simply not the case when dealing with physical documents. However, most electronic health records are only capable of processing a patient’s age, sex, medications, vital signs, previous medical history, labwork, and a radiology report if applicable.

Background


As a result of the unstable environment we find ourselves in today, EHRs are becoming increasingly integral for healthcare workers in assessing the signs and symptoms of patients and whether COVID-19 exposure is present. From the medicine prescribed to the clinical research constantly conducted, the information or data gathered can go a long way in determining the best treatments and outcomes for each patient. Due to their complexity, EHR systems are not able to effectively analyze each patient. Not only is the software time-consuming, it is also expensive which makes software enhancement hard to achieve. EHR systems struggle with high capacity situations whereby thousands of patients are in play. Monitoring and tracking fifty to one hundred patients is common and makes the exchange of health information difficult to maintain. The development of EHR mobile applications is touted as being helpful for clinicians struggling to come to grips with EHR systems and data analysis; an app designed to guide users while also tackling some of the limitations of the software in evaluating and managing potential COVID-19 cases could reduce the stress and time that is often lost when providing care.3 While most EHRs can document all the necessary information in treating a COVID-19 patient, there is not enough real world data (RWD) that allows clinicians to effectively study trends and treatment patterns from those returning a positive test. RWD trumps traditional research techniques and will ultimately prove to be essential when finding a suitable vaccine. The more data there is, the easier it becomes to come up with an accurate vaccine.

**Purpose of Study**

The purpose of the study is to analyze the EHR software prototype created as well as researching how numerous EHR vendors have developed and modified their software to suit the needs of clinicians working to better understand and treat COVID-19. The ability of electronic

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health records to cope with the demands brought by the pandemic are being witnessed firsthand. Taking onboard recommendations from doctors or creating a forum for users to share their best practices, information, and advice alleviates the pressure put on software vendors and will allow them to come up with better solutions that can ultimately be key in getting a foothold on this disease. The software prototype our group created complies with HIPAA (Health Insurance Portability and Accountability Act) and securely stores patient data and information. Due to the time constraints in which the software prototype was created, the key functionalities we were unable to develop include recording diagnostic tests, positive cases, hotspot locations, treatments/medications, lab results, and patient progress.

**Research Questions**

- Can EHR data help predict COVID-19 outcomes and mortality?
- Do electronic health records have the ability to diagnose vulnerable, COVID-19 patients?
- Are EHRs up to the challenge of assisting with vaccine efforts and do they have the ability to monitor and record the millions of vaccine doses being administered?

**Research Limitations**

The thesis paper presented is subject to change due to the nature of the pandemic and the research findings that are constantly being unearthed. Furthermore, software prototypes tend to take 2 to 3 years to develop. Our group had 4 months to design a functional electronic health record with the basic features being tested. As a result, the software prototype simulated as a part of this research paper does not accurately portray the efforts of current software vendors in prepping for the pandemic.
History of Electronic Health Records

The first medical records were introduced in the fifth century B.C. by the Greek physician, Hippocrates. According to Hippocrates, medical records were instrumental in adequately detecting the cause of disease and accurately tracing the course of disease. Medical records were primarily in the form of paper repositories as they were no other viable reporting methods. Fortunately, electronic health records have come a long way from their entry into the medical space in the 1960s. Over the past few years, EHRs have vastly expanded the amount of components present such as online scheduling, billing, order entry and management, patient support via chatbots, security, and effortless accessibility of records for patients. The efficiency and effectiveness of electronic health records, relative to paper logs, when it comes to maintaining patient records is what makes the switch to EHRs appealing.

Surprisingly, it was not too long ago that paper records were still the norm. Paper records prevented multiple individuals from readily accessing the records. It also made for difficult maintenance as records required constant updating and editing, all of which was done manually. These limitations meant it would take months for records to be available for a physician, but that timeline is typically much shorter for doctors. The pile-up of papers also increased the likelihood of important documents being lost or destroyed. As a result, physicians decided to control access to records by locking doors or requiring identification and sign in/out protocols for authorized users. In the case that unauthorized users succeeded in breaching those barriers, there would be no way of realizing who viewed those records.

EHR vs. EMR

EHR and EMR are commonly used interchangeably when discussing electronic health systems. EMR or electronic medical record is a digital version of a patient’s medical chart.
Electronic medical records do not take into account mental health, physical well-being, smoking, or drinking, but are more suited to issues that would force a patient to visit a doctor’s office or hospital. An electronic medical record can be viewed like a medical repository whereby patient information, diagnoses, treatments, and other documents are stored and accessed by multiple users.4

Apart from the obvious differentiator of medical vs health, electronic health records represent the bigger picture. It encompasses a broader view of a person’s wellness.5 They are more than just everyday wellness checks, medical visits, or any other information that a doctor may possess. EHRs tend to have broader functionalities that enable health and wellness such as care coordination and patient engagement. They go beyond standard clinical data collected in the clinician's office and are inclusive of an eclectic outlook on a patient’s care.6 While medical records are connected within the doctor’s office or across a health enterprise, the setup and connectivity of EHRs allow for information to be shared among various platforms. If a patient leaves a health enterprise, that digital record is stored at that specific enterprise in a digital format. The advantage of switching to an EHR system is the option for hospitals that may not have a patient on record possessing the capability to seamlessly pull and connect that information to whomever calls for it. The effect of the coronavirus pandemic has highlighted the significance of medical systems sharing information with other health care providers, such as laboratories and


specialists, so they contain the necessary data recorded from all the clinicians involved in the patient’s care.\(^7\)

In contrast to paper-based records, the convenience attributed with electronic health records over the standard techniques used today include quick data retrieval, ease and speed of data input, ease of access, improved format and content of records, enhanced communication with external health care providers, more information about the patients provided care, motivation of staff to enter data, better communication among staff and improved performance appraisal by management.\(^8\) Such features mean EHRs are being increasingly used for research and clinical trial recruitment due to the depth and breadth of the information they contain as well as new technological tools to mine, assimilate, analyze, link, reproduce, and transmit information.\(^9\) A process known as EHR phenotyping would be responsible in assisting researchers to identify cohorts of patients with precise attributes by applying high-throughput algorithms to EHR data to classify patients based on exact constellations of information (e.g., demographics, symptoms, diagnoses, procedures, laboratory values, vital signs, medications, lifestyle and environmental factors).\(^10\)

**EHR Software Standards**

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The Health Information Technology for Economic and Clinical Health Act (HITECH) provides states and communities across the country support in creating an effective health information exchange (HIE) software. The act enables clinicians, health care staff, and patients to access and share patients’ medical information while also improving the completeness of patients’ records. This in turn improves the safety, quality, and effectiveness of care while also lowering costs. In addition, the Institute of Medicine expects all electronic health records to possess patient support, administrative processes, reporting and population health information, order entry/management, results management, decision support management, health information and data, and electronic communication and connectivity. In order for patient data to be shared, electronic health records must possess interoperable capabilities. Healthcare workers count on patient information being retrieved and transferred across multiple health systems to perform various tasks geared towards health-care delivery whilst maintaining the standards of practice. These core functions are what purchasers and sellers of EHR software must keep in mind.

The HITECH Act, enacted under the Recovery Act of 2009 by President Obama, was established as a provision of incentive payments for critical-access hospitals if meaningful use of certified EHR technology was on record. Meaningful use depends on interoperability and whether systems will be able to communicate with each other for information exchange. The guidelines of meaningful use require electronic health records to improve the quality, efficiency, security, access, and communication in the delivery of health care among other functions. The

United States government has provided $17 billion in available incentives to assist physicians and health care facilities implement certified EHR systems that meet federal qualifications.\textsuperscript{12} Cost estimates to implement a fully functional EHR system will vary depending on a variety of factors including the vendor, number of users, additional tools, and more.\textsuperscript{13} In some cases, the equipment, software, training and one year of support can cost upwards of $200,000. HITECH incentives cover some, but not all of the costs of switching to electronic records. Seemingly, larger practices are more likely to be the ones capable of affording EHR software. Statistics show that large primary care practices are more apt to implement EHR systems than other types of practices. Large group practices that consist of fifty or more physicians were four times more likely to have a fully functional system than with physicians in practices of three or less physicians.\textsuperscript{14}

**EHR Issues With Medical Staff**

Physician attitudes toward EHRs and “Meaningful Use” vary from satisfaction to displeasure. Physicians who have already adopted an EHR system are generally satisfied with their system and the benefits it provides. However, supplying an EHR system to healthcare workers is simply not enough as the process for EHR users to come to grips with navigating through the system can take four to six months. The introduction to electronic health records in medical environments has led to clinicians reporting a loss in patients due to the wait time to see clinicians being too long in the early stages of implementation. These complications in EHR


disaster preparedness testing for clinicians and physicians further highlights the limitations of the software when dissecting millions of patients over long periods of time. The pandemic has shown the significance of future planning with EHRs, particularly in relation to the integration and familiarity of the software among physicians and staff. There are those that harbor a negative attitude toward documenting resident records in the EHR systems. An empirical research survey was conducted to study the negative impacts caused by the quality of the EHR system. The key findings examined the experiences at 15 academic medical centers, some of which include Michigan, Harvard, and Vanderbilt, concluded that an inadequate approach to the implementation of the system – including lack of training and support – and technical problems with third party products to be an impediment to EHR utilization.¹⁵ The training necessary for an EHR system tends to slow down the office work in the medical environment. Everyone has their tasks redesigned to work with the EHR system and such a period naturally takes time to adjust to.

Usability has been another factor into why electronic health record implementation is a burden for clinicians and physicians. “Usability” refers to how easy, effective, and efficient a piece of software is to use. In a survey paper conducted by the Commonwealth Fund in 2018, primary care physicians were asked the reasons they opposed the use of electronic health record systems. The research findings determined 35% of physicians listed specific electronic health record usability issues with the most common problems being screen navigation, the lack of sufficient performance, and the concern that the data will be lost.¹⁶ Poor usability can not only force healthcare providers to shy away from the software, but could potentially endanger a

patient's health as well. Proposals have been touted by EHR vendors to combat the concerns shared by some users and the ways in which to overcome the difficulties navigating through the software. The goal for any software developer or engineer is to constantly review input from the public when it comes to software implementation. In this instance, user interface redesign, training and support, additional assistance functions, and hardware allocation were all considered in the hopes of encouraging the medical staff to use the software system. These types of case studies which delve into the issues of software implementation highlight the significance of public trust. It is essential that users are comfortable and engineers are looking to improve the user experience. The success of the research enterprise depends on building and maintaining public trust, and patient input is critical to developing sound approaches to the research use of EHRs.17

There are as many issues that arise when making the switch to an EHR system. Medical facilities must take into account the cost, training, and any disruption to the normal workflow that can become an issue when caring for patients. Physicians are constantly occupied examining patients, treating illnesses, interpreting diagnostic tests, and prescribing treatment plans. Having a system in place that ends up becoming a burden can shy clinicians and physicians away from ever using an electronic health record. Their experiences responding to the pandemic, along with patient reviews, will shape how the medical field will move forward in finding innovative ways to practice medicine and interact with electronic records in the future.

**Interoperability**

During the initial stages of the pandemic, setbacks were evident from data sharing. The inability to retrieve important data has been a detriment to healthcare workers operating EHRs during the coronavirus pandemic and has slowed down the process of predicting and understanding COVID-19. One of the issues many EHR developers currently face is interoperability, a feature that has the potential to enhance decision making, but instead has tended to be a weakness within EHR infrastructure, leading to patient data being stranded across a sea of disparate systems. The dilemma some physicians face is connected to the electronic health record being utilized. At the moment, certain healthcare systems have invested in electronic health records that account for interoperability while some healthcare systems may possess an EHR that does not provide that functionality. The issue stems from the various amounts of software systems being implemented for hospitals across the country. Different EHR softwares are being utilized in each health system which makes interoperability more difficult to achieve.

Interoperability covers aspects of data sharing and will ultimately determine whether data from diagnostic tests, locations of confirmed positive cases, the denominator of total tests administered, treatment results, evolving case definitions, and other sectors of data can limit the spread of COVID-19. Data sharing is essential in the response of the pandemic and, as a result, data must flow and conversations on interoperability must be treated like the public health issues they are. When done correctly, data can be exchanged in a timely manner. Physicians would get a better sense of what medications have worked and those that did not elicit a response while

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18 Toklu, Hale Z. and Prashad, Rakesh (2020) "Research and Data Mining During the COVID-19 Pandemic,” *HCA Healthcare Journal of Medicine:* Vol. 1 : Iss. 5 , Article 1. DOI: 10.36518/2689-0216.1197 Available at: [https://scholarlycommons.hcahealthcare.com/hcahealthcarejournal/vol1/iss5/1](https://scholarlycommons.hcahealthcare.com/hcahealthcarejournal/vol1/iss5/1)

also looking into other similar factors among patients whether it be age, demographic, or prior health conditions.

It is natural for data gathering to be a struggle for clinicians operating EHR software. EHR is still a fairly new technology in the medical industry and the current health information infrastructure does not support large-scale integration. Without having access to health information from various medical practices, clinicians would be missing a big chunk of a patient’s health picture. There needs to be a standard system where — no matter the EHR — when a cardiologist logs in, that particular cardiologist is able to see cardiology-specific information about the patient up front. Unfortunately, EHR software is not at a stage where specific data can be sorted or shared. There simply isn’t enough time in a provider’s day to sort through that kind of data for every patient, or even a select few. As a result, EHR systems that are struggling to communicate with each other have been resigned to faxing patient information to overcome issues with data sharing. Oftentimes, public health agencies are having to rely on outdated methods to gather and send data as software suppliers such as Cerner Corporation and Epic Systems are incapable of sharing information from one system to the other. These efforts have delayed response efforts and have led to more errors being glaring when transferring patient information.

Had the pandemic occurred in 2025, the issue of interoperability might not have been as detrimental to dealing with the spread of the virus. Instead of EHR software, perhaps AI and machine learning would be able to better handle the needs of healthcare in easily transferring, sharing and analyzing patient data. In order for EHR software to be integral in mitigating COVID-19, vendors need to incorporate ways to record a patient's travel history, symptoms, the
COVID hotspots a patient was spotted in via zip code and various social history questions. As COVID-19 has highlighted the health inequities among Black and Latino Americans, it's important that such data can be extracted or deduced in an electronic health record. If a fully integrated EHR that contains a uniform software is incorporated, information would be shared not only with frontline physicians, but health record administrators and hospitals across the globe. The ability to share records with numerous authorized healthcare providers and organizations is mainly why EHRs were initially created. The information would then be able to be passed on to pharmacies, emergency facilities, school and workplace clinics, medical imaging facilities, laboratories, and more. Sharing information is integral in getting the right diagnosis and preventing complications. At the moment, there are very few systems capable of storing coronavirus-related information and constantly updating patient records when necessary.

**API Integration**

Although the transition to EHRs has brought frustration among clinicians who anticipated the electronic capture of health information to make patient care more effective, there is an effort to decrease the workload many patients and clinicians currently face. Congress passed the 21st Century Cures Act 2016 to address the inadequacies found in health information exchanges. The provisions of the Cures Act stressed the importance of improving interoperability among electronic health records and, in the words of National Coordinator for Health IT Donald Rucker, MD, create a health system where information flows appropriately and securely to patients and their clinicians [that] will help coordinate care and reduce costs by making care faster and less duplicative.22 The second rollout of changes takes place in July 2021 when organizations are expected to improve data sharing across disparate networks, advance a trusted exchange

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framework and a common agreement for exchange between health information networks nationally, and promote the use of APIs (Application Programming Interfaces) to support patients' ability to have greater access to their health information.

The Cures Act will also allow providers to switch EHRs and take the data from the former along with them to the new EHR. As more and more EHRs lose their customers to more effective software vendors, the competition that will ramp up in the process will drive much needed improvement in relation to the user experience. The rules allow physicians to select the EHR vendor they are most content with, rather than the one their hospital or medical group is utilizing. While it may seem burdensome at first, these procedures will go a long way towards both patients and physicians realizing the true benefits of EHRs.23

The introduction to API implementation has already been welcomed by many. This mandate opens the door for EHR organizations to provide care management to individual members or members from other health plans. 24 APIs or application programming interfaces grants a software program the ability to access the services provided by another software program. APIs hold the keys to a newly transformed healthcare data sharing platform and have been successfully incorporated in the airline industry as well as in online and smartphone banking. When booking a flight, withdrawing some money, or buying a pair of shoes online, application programming interfaces are at play. IT developers build APIs that let various web browsers access an airline’s database or ticket system. Without API-enabled websites, there

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23 How President Biden Can Improve Health Data Sharing For COVID-19 And Beyond, “ Health Affairs Blog, March 1, 2021. DOI: 10.1377/hblog20210223.611803

would be an over reliance on customer service representatives each time an individual wanted to book a flight or buy an item online.

The efficiency and convenience that APIs bring to the table can only be good news to the healthcare sector. APIs being incorporated into EHRs would mean that patients would be able to easily access their information. APIs would also act as another avenue for healthcare providers and clinicians to share important health information securely. Ultimately, the implementation of application programming interfaces can lead to a reduction of medication errors, duplicate testing, re-admission, and an improvement in decision making. API-enabled EHRs can revolutionize the healthcare system to decrease the burden benefiting both patients and clinicians; health-IT developers can use APIs to build apps and other innovative software products that have the potential to integrate information from multiple EHRs and precisely target clinicians’ needs — well beyond what’s currently available. As a result, clinicians will have the opportunity to utilize new and powerful apps that improve patient care and treatment.

The latest interoperability ruling mandates standards-based exchange of health information through information sockets i.e. application programming interfaces, or APIs. Had this capability existed across all U.S. electronic health records, the ability for health systems to securely share information in public health emergencies would be vastly improved. Furthermore, the Trusted Exchange Framework and the Common Agreement is moving forward with plans to outline an approach for nationwide electronic health information exchange that would assist clinicians and other healthcare providers in accessing patient health data from a variety of health


information networks (HINs). As long as one HIN is connected, patient information can be extracted from HINs across the country. The safety and security involved in this process is what truly makes this plan incredibly favorable for clinicians when treating patients suffering from COVID-19.

EHR Hosting & Health Exchange

EHRs are hosted on computers either locally or remotely. Remote EHR systems are described as “cloud-based” or “internet-based” while local systems are primarily found in the practice office. Cloud-based EHRs rapidly launch EHR systems while minimizing management effort and cost. Most cloud computing platforms have the potential to reduce maintenance costs, hardware and software costs, and run-time failures. However, the main challenge with taking this route is the data security. There is a lower level of data access and control compared to an on-site, local EHR system. Locally hosted EHRs contain data that is stored on server computers at the location in which the EHR is being utilized. As a result, there is no need for outside organizations to be trusted with the security of a patient’s data. The security of the servers is in the hands of those setting up the software. Local hosted systems need to conduct data backups regularly, but do not require reliable, high-speed internet access to perform as required.

Consumer-Directed Exchange

The ability to send and receive secure information electronically between care clinicians is known as directed exchange. The directed exchange process entails easy patient information exchange such as laboratory results and discharge summaries being encrypted in order for health care professionals to have the ability to carry out coordinated care. Consumer-directed exchange, where apps and APIs help patients aggregate data where and when they wish, similar to how they aggregate their data in the internet world, will offer innovative potential and opportunities
for population health.\textsuperscript{27} There are currently three key forms of health information exchange (HIE) in addition to consumer directed exchange; the other two being query-based exchange and consumer-mediated exchange.

**Query-Based Exchange**

Query-based exchange is a process for clinicians to search or request information on a patient from other clinicians and can be a viable option in relation to COVID-19 patients. If a clinician receives laboratory results electronically and incorporates them into an electronic health record (EHR) they can generate a list of patients with COVID-19. The clinician can then compare the symptoms and issues that various patients experience or the medications that have elicited an improved response in a patient’s condition. Emergency room physicians who can utilize query-based exchange to access patient information—such as medications, recent radiology images, and problem lists—might adjust treatment plans to avoid adverse medication reactions or duplicative testing.\textsuperscript{28} Query-based exchange has the ability to assist a provider in obtaining a patient’s previous care record, allowing them to make safer decisions about the care of the patient and future treatments.

**Consumer-Mediated Exchange**

Consumer-Mediated Exchange is a process for patients to control the use of their health information while also allowing them to manage their health care online in a similar fashion to how they might manage their finances through online banking. Consumer-mediated exchange fits in well with the current climate as most patients find it difficult to travel to medical facilities. Similar to tele-health and tele-medicine where patients who struggle with transportation or poor


\textsuperscript{28} “Introduction.” \textit{Health IT Playbook}, www.healthit.gov/playbook/full/.
health due to their location or financial situation can access a healthcare clinician from home, consumer-mediated exchanges have patients as active participants in their health planning. Patients have the option to track and monitor their own health, identify and correct missing health information or billing information, and provide their information to other providers if they so choose. Many EHR systems are also striving to incorporate secure telemedicine components such as remote appointments to give patients not comfortable with leaving their homes the ability to engage in virtual appointments with their physicians on the software. As a result, EHR software vastly improves access to healthcare from home to help mitigate the impact and spread of the virus.

The pandemic has shown that providers are willing to recognize the potential of EHR software in improving patient care. Clinicians moved quickly to adopt the software in order to deliver care virtually. One medical practice, St. Joseph Health, saw virtual urgent care visits jump from 50 per day to 1,500 per day; and the Department of Veterans Affairs retooled its telehealth system to handle more than 15,000 patients in the system at any one time when its prior capacity could only accommodate 3,000 at once. Telemedicine allows clinicians to connect with patients around the world from the comfort of their home. The information stored in the EHR can be displayed from anywhere as well. With a few clicks, users have the access to easily navigate through an EHR without any training.

Security

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Due to the instantaneous nature of electronic health records, patients records must be updated immediately after each patient visit or anytime changes take place. Failure to do so could result in inaccurate data being passed around as well as a host of other risks. The nature in which EHRs store private health information means that interoperability requires a secure method such as an encrypted network for information to be shared among hospitals and numerous health care providers. Whenever an EHR system is being created, HIPAA requirements for the security of an EHR system is a mandatory feature. Under HIPAA guidelines, EHR data is considered protected health information due to the amount of sensitive demographic information collected and stored in EHR platforms. Health information such as diagnoses, treatment information, medical test results, and prescription information are considered protected health information under HIPAA, as are national identification numbers and demographic information such as birth dates, gender, ethnicity, and contact and emergency contact. Consequently, EHR providers must be HIPAA compliant in order to protect a client’s healthcare data from security incidents and government fines.

The security of a patient’s information is a constant concern for physicians as there is always the risk of a data breach. The healthcare industry was estimated to cost the US $4 billion by the end of last year, in part, because of data breaches. Furthermore, a study conducted in 2006 by the Healthcare Financial Management Association (HFMA) researched the status of EHR systems and the barriers preventing EHR adoption from being across the country. Surprisingly, the issue of interoperability and data privacy were as apparent back then as they are now. Senior healthcare finance executives at hospitals were surveyed to identify ways for the government to

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^30“Protected Health Information (PHI).” Protected Health Information (PHI) - CIO Wiki, cio-wiki.org/index.php?title=Protected_Health_Information_%28PHI%29&oldid=8043.
move through with EHR implementation at a nation-wide scale. Apart from the lack of funding, interoperability, and data-sharing coalitions available to hospitals, the responses identified two of the greatest risks being related to (1) privacy of data-access control and (2) inaccurate patient information due to periodic and not real-time updates.  

Security Methods

A verification process that allows a select few, such as authorized personnel, access to a patient’s private health information can assist in qualming any security fears clinicians may have. Electronic health records tend to be protected by encryption requesting secure login credentials from the user that act as a level of defense in preventing someone from making unauthorized adjustments to the patient’s chart and other information. Encryption eliminates the fear of records being copied, scanned, or faxed which is why electronic health records will always triumph paper records. A user’s access should be based upon pre established, role-based privileges. In a physician practice, the nurse and the receptionist, would have very different tasks and responsibilities; therefore, they do not have access to the same information. Hence, designating user privileges is a critical aspect of health record security: all users have access to the information they need to fulfill their roles and responsibilities, and they must know that they are accountable for use or misuse of the information they view and change. Electronic health records can even set up audit trails which assists in determining the people that access a patient’s records and what modifications have been made to a patient’s health information. Audits will notify staff if people that are not authorized view information as well as documentary evidence


of the sequence of activities that have been affected at any time. These methods can only be utilized for electronic records as paper records would have no way of figuring out the last person that viewed or edited a patient’s charts.

**Security Concerns**

The most common security method revolves around security patches and data backup of systems. These steps are integral in preventing a ransomware outage in which key information is stolen. It is important that all computer system administration procedures are constantly being monitored as unsecure patient health records can be a target for cyber criminals. In 2020, WannaCry ransomware was able to devastate the healthcare industry through exploiting unpatched medical devices. In order for cyber threats to be properly managed and ransomware incidents to be contained, storing patients’ records securely involves much more than controlling access to confidential information. In the event of a natural disaster or a security breach, data backup will ensure patient information will still be available. Confidential health information can still be restored from an offsite backup and get back up and running much more quickly than if a medical practice decided to stick to a paper-based system. Updating health systems is integral in repairing security holes, detecting and eliminating bugs and removing features that are no longer needed. Cybercriminals prey on unpatched security holes and will often look to code that targets and exploits vulnerabilities in a malicious manner. By releasing software updates quickly, IT departments can wipe the system and update it with the backup data, allowing clinicians to simply focus on diagnosing and treating patients without the fear of security troubles getting in the way.

**Possible Improvements In Data Workflow**
The Covid-19 pandemic has jarringly highlighted the gaps within the U.S. healthcare system. The vast amount of data information that must be gathered simply cannot be harvested properly under this system and those in the healthcare system are finding it overwhelming to deal with. One of the issues is the lack of development currently taking place for electronic health records. At the moment, EHR software is incapable of tracking hundreds of patients, tracking outbreaks, tracking the latest information regarding effective treatment or vaccine development, and monitoring the effects a treatment may have on a patient. The truth of the matter is that electronic health record systems are constructed to track and bill procedures rather than provide optimal patient care. Due to the way most electronic health record systems are built, a clinician can struggle to detect the issues a patient may suffer from. While (EHRs) provide physicians with the data and tools to treat their patients more efficiently, EHR design, customization or configuration can contribute to patient harm and a difficulty in accessing real-time data analytics. This, in part, is a result of the splitting of health information across various tabs. Patient information is divided into multiple sections such as diagnoses, vital signs, medications, imaging, and so on. This structure can affect the manner in which patients are treated for COVID-19. A general template of an EHR interface overlooks the most essential aspect of uncovering any vulnerabilities which is the actual health data. As COVID-19 spreads across the world, crucial data is becoming more difficult to harvest. Such an issue can possibly lead to an inaccurate representation of a patient’s risk for COVID-19.

In an ideal scenario, a patient showing symptoms of COVID-19 could go to the emergency room and the physicians present would have the ability to locate that patient’s full medical history without any complications as interoperability would allow this access to be granted to various hospitals in the event that a uniform, shared electronic health system is
introduced. Such a system, as initially described, would rule out any fear of duplicative diagnostic tests being conducted. In the event that a patient is discharged, doctors would be able to track the health and progress of the patient with real-time access to data and figure out whether additional support may be required in order to avoid further risk complications. For electronic health record suppliers struggling to detect underlying conditions would be to monitor cardiovascular, gastrointestinal or other indicators of infectious diseases such as influenza, pneumonia and hepatitis and having the software generate an automated alert for any symptom consistent with COVID-19, which communities could use to prompt testing.33 Due to the high volume of workflow and data within current electronic health records, the need for rapid updates is essential in detecting individuals with the virus.

A redesign of EHRs towards a plan-centric system is an up and coming solution that could bypass restrictions in software updates. Companies such as Intermountain Healthcare, Virginia Mason, and Kaiser Permanente are pioneering the way in which a healthcare business model should operate. An EHR redesign would incorporate the latest evidence-based treatments into each patient’s care plan based on their current status and underlying health conditions, and then feeding back data on how each patient responded in order to improve the plan for the next patient.34 The capabilities of such a software workflow could transform outcomes and save thousands of lives. Previous designs of EHRs focused on documenting patient information during a visit, retrieving lab results, or sending prescriptions to a pharmacy, but nothing has been done to keep up with medical advancements John Glaser, an executive in residence at Harvard Medical School, proposes an interesting evolution of electronic health records to address the


health part by helping providers plan for what they want to happen and keeping those plans on track if we design them with that goal in mind.\textsuperscript{35} Some of the components listed in Glaser’s article include:

- A library of care plans, or a master plan, that covers a wide range of circumstances to help display treatment plans that suit the unique needs of each patient.
- Algorithms to form a patient’s master plan in which appropriate algorithms are combined to treat various symptoms at once.
- A care team support whereby individual team members — the patient’s primary care provider, specialists, nurse practitioners, pharmacists, case managers and the patient — would view the patient’s plan while also having the ability to edit the plan or assign tasks among themselves.
- The ability to traverse care settings, geographies, and different EHRs (interoperability).
- Decision support and suggesting changes in the patient plan when appropriate.
- Reminding team members of upcoming and overdue activities.
- Analytics for individual patients and populations in quantifying the efficiency of the plan and applying the same metrics to the general population if there is information that can be useful to treating others.

All of these features would allow health departments to be on the same page in ensuring the right care is administered or whether or not the plan may need to be adjusted when analyzing a patient. Furthermore, data collected should help improve the decisions made by clinicians in dealing with patients infected with COVID-19. One of the benefits such a model would provide

is efficient execution in discovering new treatments or uncovering undetected clinical evidence such as the discovery of blood clotting in COVID-19 patients. Subsequently, clinicians would find it much easier to identify treatment options originating from the rapid pace of medical discovery and alert providers if patient care plans have deviated from the target level. The model can also be updated to eliminate outdated treatment methods that may have proved to be ineffective or notify clinicians when a patient deviates from the plan or misses an appointment. A patient-centric model relies on logical decisions being made when studying the data provided. Clinicians get a detailed view of a patient’s conditions and the medical evidence will not only save the physician time, but also improve the quality of care. The improved setup and workflow regarding health information exchanges between various regional or state hospitals enables clinicians to obtain patient data from numerous care settings in order to have a complete picture of the patient. From the patient’s perspective, they would have the freedom and transparency to view their own health data, health status, alter their care plan if affected by COVID-19, and participate or connect with patients in similar situations in a care community.

**Research Findings on EHR Vendor Output Throughout Pandemic**

These findings are based on contacting EHR vendors and researching articles discussing the EHR vendors that have performed well and tackled the struggles of COVID-19 for its customers. The eight health IT vendors below were selected due to the amount of effort and support they have been providing their customers in the past twelve months in relation to the pandemic. Some of the key components studied include security, support & delivery, user capabilities, vaccination roll-out, the specialty (or area of expertise) a particular vendor brought forth to assist its customers adapt to changes in telehealth, and some of the limitations associated with each vendor. Furthermore, the vendor rating takes into account customer input as well as the impact the EHR vendor has had in helping clinicians ultimately treat their patients.
<table>
<thead>
<tr>
<th>EHR Vendor &amp; Rating</th>
<th>Security</th>
<th>User Capabilities</th>
<th>Support &amp; Delivery</th>
<th>Unique Features</th>
<th>Limitation</th>
<th>Vaccination Roll-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allscripts (6.7)</td>
<td>issues with login credentials</td>
<td>identifying and tracking patients with confirmed and suspected coronavirus disease</td>
<td>inconsistent feedback</td>
<td>created a plan for clients to implement telehealth (Follow MyHealth)</td>
<td>improve the clarity of scanned images in patient's EHR, software would freeze</td>
<td>partner with VaxCare to lower vaccine costs and increase efficiency</td>
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<tr>
<td>Athenahealth (7.4)</td>
<td>system updates</td>
<td>FaceTime integration</td>
<td>patient outreach and practice workflow recommendation and support to practices</td>
<td>advanced scheduling</td>
<td>telehealth integration</td>
<td>partnering with clients that are participating in early vaccination efforts</td>
</tr>
<tr>
<td>Cerner (8)</td>
<td>rapid software updates</td>
<td>analytics tracking, scheduling, identify vaccines needed</td>
<td>patient-first strategy</td>
<td>available to all provider clients</td>
<td>document vaccines at large scale improving</td>
<td>mass vaccination solution at no cost</td>
</tr>
<tr>
<td>DrChrono (7.9)</td>
<td>transport encryption and backup measures</td>
<td>HIPAA-compliant patient portal to keep patients updated in real time</td>
<td>updated content in its knowledge base to keep users informed</td>
<td>the first EHR app for iPad and iPhone</td>
<td>poor support and service</td>
<td>zero waste scheduling and capacity optimization allowing distributors to vaccinate more patients</td>
</tr>
<tr>
<td>Vendor</td>
<td>Feature Description</td>
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<tr>
<td>Epic (8.1)</td>
<td>Standard for larger practices or hospitals, mobile healthcare, practice on-the-go</td>
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<td></td>
<td>Weekly upgrades and constant communication</td>
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<td></td>
<td>1,000/day patients with automation</td>
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<td></td>
<td>Difficult to learn and navigate</td>
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<td></td>
<td>100 COVID-19 vaccination sites across the country have implemented its EHR software</td>
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<tr>
<td>NextGen Healthcare (7.9)</td>
<td>Integrated risk solutions, enable providers to document the particular vaccine provided to each patient, prioritize a plan for their specific situation, Access and share patient information seamlessly through a national data exchange, improve tracking to strip out, document and record only COVID-19 vaccine info, equip the EHR to be able to document vaccine administration</td>
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<tr>
<td>Meditech (7.9)</td>
<td>Enables the control of info access with varying security levels, free-of-charge software, scheduling solution to drive the vaccine appointment sequence, positive communication skills, surveillance monitoring registries and order sets, vaccine scheduling and reminders, build vaccine codes into their system</td>
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<tr>
<td>Greenway Health (6.5)</td>
<td>No risk of sensitive information being misplaced, destroyed, focus on patients, recognizing patterns and eliminating the chances of receiving the same treatment twice, primary concern is ensuring clients have what they need, users can access the EHR without an internet connection, transmit vaccine info to state registries, no news or updates regarding vaccine plans</td>
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</table>

Figure 3. EHR Vendor Comparison Regarding COVID-19 Navigation
The EHR vendor with the highest rating, Epic, is also seen as one of the most widely used EHR software providers. Initially, Epic was only able to effectively record travel screening questions and symptoms. Over time, their update releases have been supported to potentially improve clinicians’ ability to spot COVID-19 patients. This is not the first time Epic has played a major role in fighting off infectious diseases. 2014 saw the Epic-designed electronic health record as essential in the ability to detect and quickly respond to Ebola as travel information was being recorded. Some of the issues facing Epic relate to the addition of new symptoms, new hotspots, new risk factors, or comorbidities and whether new updates can keep up with constant briefings by the CDC or WHO.

There is not much that generally separates each EHR vendor studied. The common goal between each vendor is better health outcomes which is achieved by providing clinicians with all
of a patient’s health information in one place. Instead of having to search through various systems, most of the EHR vendors studied have put in place solutions so clinicians are spending more time with their patients. Enhancing access to secure information at the touch of your fingertips from anywhere in the world has been a positive sign that EHR technology has the ability to analyse and share data in real time. These developments have ultimately led to a reduction in clinician burnout as EHR vendors have understood the challenges the pandemic has brought to numerous medical practices.

**EHR Vaccine Rollout**

Scientists have been working around the clock to muster an effective vaccine capable of preventing the spread of COVID-19. Efforts are being ramped up to track COVID-19 vaccinations. The more research and real-world data clinicians have at their disposal signifies focus being shifted to recording vaccine treatment and outcome trends. Admittedly, this will be the first time EHR systems will be tasked with recording vaccination results. As this process will likely take years to implement, electronic health records vendors are coming together and setting aside competitive differences for the good of the world. Several EHR manufacturers have joined the data-sharing coalition in an effort to hopefully fill the information void. There are currently dozens of health systems sharing their data and these numbers will only increase in the coming months. EHR vendors across the industry have been preparing their products and their healthcare provider organization users to make sure that when a patient receives this critical vaccination, it is recorded correctly, pushed to the necessary parties, and is accessible now and in the future by all the appropriate caregivers.\(^3^6\) However, the absence of interoperability is costing clinicians the opportunity to pool even larger datasets due to regulator practices that are affecting the EHR.

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industry. That failure to mine these oceans of invaluable data reflects the power of the vendors to prevent government requirements for data standards and interoperability.\textsuperscript{37}

When trying to observe how vaccine documentations are coming along, look no further than EHR giant Epic which recently put out a software update to deal with the influx of vaccinations being administered. Their EHR software now has the ability to track the amount of patients that have been vaccinated according to their records as well as those that still require to receive their dose of the vaccine. Patients would need to login to their MyChart, powered by Epic, to know when the second dose of the vaccine must be given. This timeframe would depend on the vaccine taken initially, of course, as Pfizer has a 21 day time period between doses whereas Moderna has a window of 28 days. Patients also have the ability to share their immunization status with healthcare providers, employers, schools and others. Regarding the aspects available for a clinician, they have the license to reach out to patients, send reminders, schedule appointments for vaccines, being notified of any side effects, and identifying patients that should be prioritized or vaccination or vaccine suppliers that may become recalled. Epic is at the forefront when it comes to public vaccination reporting. Epic software systems account for tracking large populations of vaccines and sharing vaccination data with other healthcare organizations that may have been involved in a patient’s vaccination. It’s safe to say the vaccine updates released by Epic has ultimately made the jobs of healthcare organizations that much easier.

With interoperability being critical to COVID-19 vaccination deployment, numerous health IT vendors such as Epic and Cerner began providing individuals with digital access to

their COVID-19 vaccination records. The group, known as the Vaccination Credential Initiative (VCI), developed a standard model for health organizations administering the COVID-19 vaccine. The vendors are prioritizing security and interoperability as digitalizing these documents can enhance patient matching and can expedite the time it will take for individuals to return to work, school, traveling, and extracurricular activities. COVID-19 has elevated the focus of software vendors dealing with electronic health records in applying more analytics and machine learning in discovering the path to early detection. There is certainly a sense of urgency in gaining a quicker understanding of a pandemic’s behavior within a given population, and therefore, faster and more comprehensive containment and/or mitigation interventions are possible.

**Overview of EHR Prototype**

Unfortunately, there is still a long way to go in supplying a fully-functional software system that is able to properly integrate patient information in systems across the country. During the pandemic, we have seen situations in which forms exchanged between hospitals and laboratories are often missing critical information, leading to delays in contacting patients and identifying people they had close contact with. In some states, demographic information on

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race and ethnicity is missing 85% of the time\textsuperscript{42} further highlighting how uncertain electronic health records can be at times.

The thesis project is centered around a software program assigned last semester and my attempts to try and tie that to a prevalent matter in COVID-19 that is currently affecting billions of people around the world. The prototype our group built contains the basics of what an electronic health record consists of. Our goal was to replicate an EHR software through the use of programming languages such as HTML, CSS, PHP, XAMPP, and MYSQL. Due to the time constraints of having a semester to present a functional EHR software, there are many features that can be further developed. We would have liked to provide key functionalities such as telemedicine and chatbots. Voice recognition software was another feature we planned on implementing in the future if groups down the line decide to take on the challenge of building upon our electronic health record. Clinicians would be able to speak into a microphone and have their words typed in real-time. Although the system is not perfect and errors in translation do occur, technological advances are making voice recognition more accurate and attuned to real-time voice detection thus speeding up medical visits.

At the moment, our software is capable of searching for patients, showing a list of patients that is stored in a database, and adding new patients into the system. Users can view patient insurance information, set up payments using our billing transaction system, upload a patient profile picture, and have access to medical diagnostic codes which is a table containing accurate medical codes and descriptions linked to patient diagnoses. Once directed to the home screen after logging in, users have access to the patient chart which displays medical history, any

lab work, immunizations, vitals (blood pressure, body temperature, heart rate), medications, documents, office visits, and hospitalizations. If a user has follow-up questions for a patient, the navigation bar placed at the top of the page contains a gmail icon to send email inquiries and directs the user directly to gmail. Additionally, if a user decides to go on a lunch break or needs to leave the desk for any reason, the information being viewed can be hidden by clicking on the “Lock Screen” button at the top. My main priority was on setting up the backend of our software and creating mock data to test the usability of our software.

When creating our EHR software, my objective was centered around features that many EHR providers do not implement or offer to their customers. I would have liked to process and filter out important patient data for software users as it is in line with my research findings. If a clinician searches a patient, the software should be capable of outputting an up-to-date history such as recent visits or any diagnosis that may be relevant. Our software prototype allows medical professionals to identify risk factors at an earlier stage, due to all the information being present on a single page. By using our cloud-based EHR solution, medical professionals can easily access records from any device.
While we constantly ensured the software was running the latest version and made sure authorization was in place to prevent unauthorized individuals from accessing patient data, there was not enough expertise and experience from our group to efficiently store patient health information on internal systems protected by firewalls or anti-solutions to block malware. The tech industry is evolving each year and individuals looking to commit malicious activities on digital systems or networks are becoming more clever in their attempts to take advantage of vulnerabilities on software systems. Amplifying the security of an electronic health record is much more than disaster recovery, blocking spam emails, websites, and malware, or encrypting messaging within the software platform. As a result, EHR vendors should recognize the

Figure 5. Use Case Diagram of EHR Prototype
importance of constantly overseeing update policies and procedures, reviewing security controls, and upgrading to better defense solutions when possible. This thesis can serve as a guide for our group in expanding and building upon the points presented in this paper.

Conclusion

Electronic health records play an essential role in clinical research, both as a supplement to existing methods, but also in the growing domains of outcomes research and analytics.\(^{43}\) Even with all the extensive data and analytics involved in EHR software, the system still has its limitations, particularly in the form of interoperability. The ability of EHRs in efficiently aiding COVID-19 detection and treatment will require a collaborative environment for both IT and business to work closely and quicken delivery. Disasters such as COVID-19 will always overwhelm healthcare systems and technologies in the short term. While these pandemics will not always be detected early, individuals do, however, have the ability to control the response time to an outbreak. A rapid response is critical to containment. The coronavirus pandemic exposed the need for a value-based care model which ensures patients are given the correct treatment and the general population remains protected from massive infection spreads. If this pandemic has taught us anything regarding our healthcare system, it is the lack of a cohesive data model for patients in most electronic health records — an intuitively patient-centric construct that allows clinicians to start with a patient and trace back to their signs, symptoms, and diagnostic tests.\(^44\)

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There are over 75% of office-based clinicians and 96% of hospitals in the United States using an EHR system. Electronic health records are currently in 11% of the hospitals nationwide while also being operated by 12% of clinicians. The U.S. government has made encouraging efforts to promote electronic health records as a way to improve patient care. The figures above display the need for improving the efficiency and use of EHRs. Granted, healthcare systems are at an early stage when it comes to the advanced capabilities of electronic health record utilization. New designs are constantly being implemented and achieving the intelligent, plan-centric health care platform will require a level of industry cooperation that is unlike, and in some ways antithetical to, the way we’ve always done things.\footnote{EHRIntelligence. “How a Total EHR System Overhaul Can Support Value-Based Care.” \textit{EHRIntelligence}, 28 Sept. 2020, ehrintelligence.com/news/how-a-total-ehr-system-overhaul-can-support-value-based-care.}

The question is still debatable whether the whole world will move towards the implementation of the electronic health record. The impact of EHR systems has been evident throughout the pandemic and it is no surprise to see the improved diagnostics & patient outcomes found in health corporations that have adopted EHR software in comparison to those that do not. Of course, it is important to note that less fortunate practices may not have the luxury to afford the costs of implementing an electronic health record for their medical group. The rollout of EHRs was a target on President Obama’s agenda in terms of setting up the “investment necessary to ensure that within the coming years, all of America’s medical records are computerized.” It’s difficult to say whether or not EHRs will be more advanced in the next couple of years, but the pandemic has made the deficiencies of EHRs glaringly apparent.
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