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Understanding Challenges and Solutions with Systemigrams: Application to Electronic Medical Record Systems

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ABSTRACT

The medical field is becoming bigger and more complex in the 21st century, diseases both emergent and re-emergent are on the rise and are costing lives around the world. Evolution of many diseases has made people find a reason to seek medical care in healthcare centers. This has led to increased development of health care facilities as peoples' urge to get quality diagnosis and treatment rises. However, in the past patients ended up waiting a long time in their efforts to obtain these services. These wait times were due to the lack of proper documentation and recording of the personal information. Hospitals and health centers had to hire an increased numbers of health practitioners to handle the paper work as patient populations increased. Due to the massive amount of issues experienced and the patient agony, healthcare professionals were prompted to develop fast, reliable and efficient methods of handling large amounts of data within a short time. The rise of digital technologies enables the Electronic Medical Records (EMR) system to be utilized in the healthcare setting. This tool has revolutionized the whole spectrum of capturing and recording medical health data. Today, health care agencies and organizations can retrieve and store a patient's personal health information where physicians can readily access this information from their offices. Therefore, EMR is the real time solution to the health information management problem and through it there will be an improved patient experience in terms of wait time, diagnosis, and treatment. However, there are some challenges that come with the system that should be addressed to ensure efficiency. After a systemic review of the literature, we have used a systemigram approach and modeled the current challenges of EMR implementation and the related solutions to EMR system adoption.

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The objective of this study is to provide a systems-thinking approach to better contextualize the role of EMR in the complex system of healthcare from a multi-stakeholder perspective.

Keywords: Electronic Medical Records, Systemigram, Healthcare, Information System, Patient Information

INTRODUCTION

Electronic Medical Records (EMR) is a system devised for collecting and storing information in a digital manner about patients, according to HealthIT.gov. The system is composed of standard clinical and medical data collected from a health provider's office and is a system that enables providers to track patients' medical records. Therefore, EMR can be described as a digital model of the paper chart that comprises every patient's history regarding medical attendance in one practice (Siegler & Adelman, 2009). Most of the health providers who utilize EMR use it for medical diagnosis and treatment. Conceptually, this medical system of data collection and storage allows providers to share information among the staff, locations and departments (Randeree, 2007). This method is important and more efficient than paper records as it allows the data from patients to be available in real time from any location. As a result, data can be easily retrieved and stored in a more effective manner. Wallace, Maxey, & Iyer (2014) examined the implementation of EMRs within small- and medium-size physician practices, but focused only on a single physician practice. Winston and Medlin (2011) examined a medical practice that implemented EMR by reengineering its practice's processes.

The objective of our paper is to provide a foundation model of the ecosystem of EMR implementation through a systems-oriented approach that illuminates a deeper understanding of this system to allow practitioners to conceptualize solutions holistically. Our study uses the Boardman Soft Systems Methodology (Sauser et. al, 2011) to provide a holistic and integrated representation of the complex system of EMR implementation. (Engelseth et. al, 2020) explain that healthcare is inherently complex and illustrate healthcare examples using the Boardman Soft Methodology. Their paper suggests an alternative framework to studying healthcare that is motivated by an underlying paucity of studies researching healthcare from a systems approach. Lipper & Cloutier (2021) modeled technology domains by starting with the approach of "understanding the system." They state that "Good systems engineering cannot happen, however, if the domain being engineered for is poorly understood." Lipper & Cloutier (2021) use a

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systemigram approach to illustrate the complex nature of cyber warfare. Our study uses a similar approach to illustrate the complexity of an EMR hospital system.

Our literature review of EMR research confirms that traditional approaches of studying this topic are often limited by the numerous system interdependencies in the system (Nijor, Gokcen, & Lad, 2020). Our paper fills a research gap of providing a framework from which to study the infrastructure interdependencies of the structural complexities of EMR implementation. This framework is made possible by our development of a supporting systemic diagramming technique, that is, a systemigram, which based on our systematic literature review, has not been previously used to illustrate the complexities of an EMR hospital system. Our approach incorporates extensive information gathered from a literature-based foundation and a survey of technology-oriented healthcare websites (e.g., HealthIT.gov) to provide systemigrams to make possible an in-depth, multi-faceted understanding of the challenges and possible solutions faced by EMR implementation using real-life processes. Sauser, Mansouri, and Omer (2011) use a similar approach in a case study involving Homeland Security.

An objective of EMR is to raise the standards of healthcare. The Affordable Care Act, referred to as Obamacare, and has yet to function as an effective system to lower costs and increase standards (Essounga-Njan, 2015) and EMR. Systemigrams are a holistic tool to capture the many aspects of complex systems and provide an enhanced insight into the assessment of systems characteristics. Gorod, Hallo, and Merchant (2020) illustrate the contribution that systemigrams make to complex healthcare systems in cancer treatment. The study in this paper also uses a systemigram approach to gain a better appreciation of the role of EMR in the medical profession. The systemigrams presented in this paper are the results of an integrated view of a multitude of medical healthcare publications (some of which are provided in the references of this paper) that extol the virtues of EMR. These diagrams are a contribution to the literature as they directly provide a visualization of influence paths to describe structure and behavior in an integrated manner.

EMR can also store data in the form of scans and images which gives medical attendants such as doctors and nurses a comprehensive overview of medical history of every patient. In addition, other essential information is also available to physicians including immunizations, allergies, current medications, previous diagnosis, tests and laboratory results, and all other important information (Kern, 2016).

Furthermore, the EMR system is crucial in allowing healthcare providers to better streamline and automate the organization while collecting data from the patients. The implementation of EMR systems provides health care organizations with

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information that helps providers produce sound decisions (Anderson, 1999). Therefore, the EMR system can be referred to as a game changer for healthcare organizations in terms of ensuring real time service delivery. Ultimately, when service delivery is fast, disease management should be improved, and patients should have a smoother experience while seeking medical care (Kern, 2016). However, because of current barriers to EMR, this is not happening, and it has resulted in a more fragmented and inefficient healthcare system which risks patient safety (Decker, 2012; Holden, 2011). Safety is part of the quality agenda and therefore a dimension of the quality culture, requiring broad commitment from both the organization and the community. The World Health Organization (WHO), which directs international health, is committed to enhancing the quality of health care, especially patient safety, another crucial element of that quality (http://www.euro.who.int/en/health-topics/Health-systems/patient-safety). Every point in the Process of care-giving contains a certain degree of inherent unsafety. Adverse events may result from problems in practice, products, procedures or systems.

In this study, we provide a framework consisting of systemigrams to address inherent challenges such as safety as well as barriers of EMR implementation. These systemigrams allow a researcher to seek solutions through the graphical associations that show the intricate relationships of the complexity of EMR implementation (Sauser & Boardman, 2015). Thus, this research attempts to provide a contribution in the field of EMR adoption and implementation by studying the current challenges and solutions of EMR through a systemigram lens. In the following sections, the major challenges affecting the overall usage of this system in the healthcare institution will be illuminated. Lastly, the advantage of a systems-oriented approach in providing practitioners with comprehensive insights to resolve challenges in EMR will be discussed. The contribution of this study and the conclusion will be the final sections discussed. This paper cuts across a broad spectrum of health care organizations and conceptually identifies the issues that medical practitioners are experiencing while using the digital technique of managing data and information.

BACKGROUND

Medical practitioners are expected to record any information they obtain as they interact with patients. This ensures that all critical data is captured from a patient that will enhance informed decision-making processes and that appropriate actions are taken. Documentation of this information is also essential for purposes of archival records that can be produced in case of disputes (Lærum, 2001). Physicians

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should focus their time on providing care to their patient, instead of spending excessive time in capturing information (Miller, 2004). Medical personnel also embrace the technique as it helps reduce duplication of tasks such as writing prescriptions on pads concerning ordered tests, x-rays, and laboratory tests which later have to be re-written in medical charts for effective recording. Communication among the medical practitioners is a challenge because many pieces of information are usually fragmented, voluminous, and frequently redundant. In addition, physicians are constantly coming across new information regarding patients and find themselves without appropriate tools to incorporate new treatments and techniques into their practices. With regard to this, physicians have been forced to store major experiences in their memories and others are made to turn many pages of documentation in efforts to getting essential information (Meade & Buckley, 2009; Ford, 2006).

As a concept of recording medical information from patients in an electronic mode instead of paper, EMR came into existence during the1960s. The idea was introduced by Larry Weed when he came up with the concept of a medical record that was problem oriented (Aronson, 2019). Since then doctors have been recording every bit of information concerning patient diagnosis and treatment. Later, the innovation brought forth a type of record that allowed third parties to verify the diagnosis provided. Nonetheless, the initial system for medical records was established by the Regenstrif Institute in 1972. The system was not very well received by the medical practitioners where many continued to operate without using it. In 1991, the United States Institute of Medicine recommended that by 2000, all medical physicians should be able to use computers in their work place in efforts to improve policy recommendations and patient care (Meade & Buckley, 2009).As of 2017, 94 percent of hospitals implemented an EMR system to enhance hospital documentation.

EMR hospital implementation is used in improving the quality of the documentation process 82 percent of the time with patient safety improvement occurring 81 percent of the time and organizational performance enhancement

77 percent of the time (https://www.healthit.gov/sites/default/files/page/2019-04/AHAEHRUseDataBrief.pdf). However, many medical facilities are unable to endorse the digital record management system due to huge costs of executing the technology (O'Malley, 2010).

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MODELLING CURRENT SCENARIO OF CHALLENGES OF EMR

Many tools are available to model systems-oriented methodologies. This research uses the software tool SystemiTool (https://sercuarc.org/serc-tools/) to showcase the results of numerous healthcare related articles studying EMR to achieve quality improvement in healthcare practices. While EMR possessesmany useful features to help streamline healthcare processes, some people find the whole system overly complex and believe they could take good care of patients even without it. But when implemented properly, EMR serves as a great tool to preserve critical medical information and increase workflow efficiency. Yet, there are a number of challenges present that need to be addressed if one wants to reap the full benefits of EMR.

Two current mainstream barriers to EMR implementation are: Interoperability and Variation in Workflow (Kruse, Kristof, Jones, Mitchell, & Martinez, 2016).

These are outlined below and modeled using a systemigram in figure 1. The red color-coding indicates challenges and barriers to EMR.

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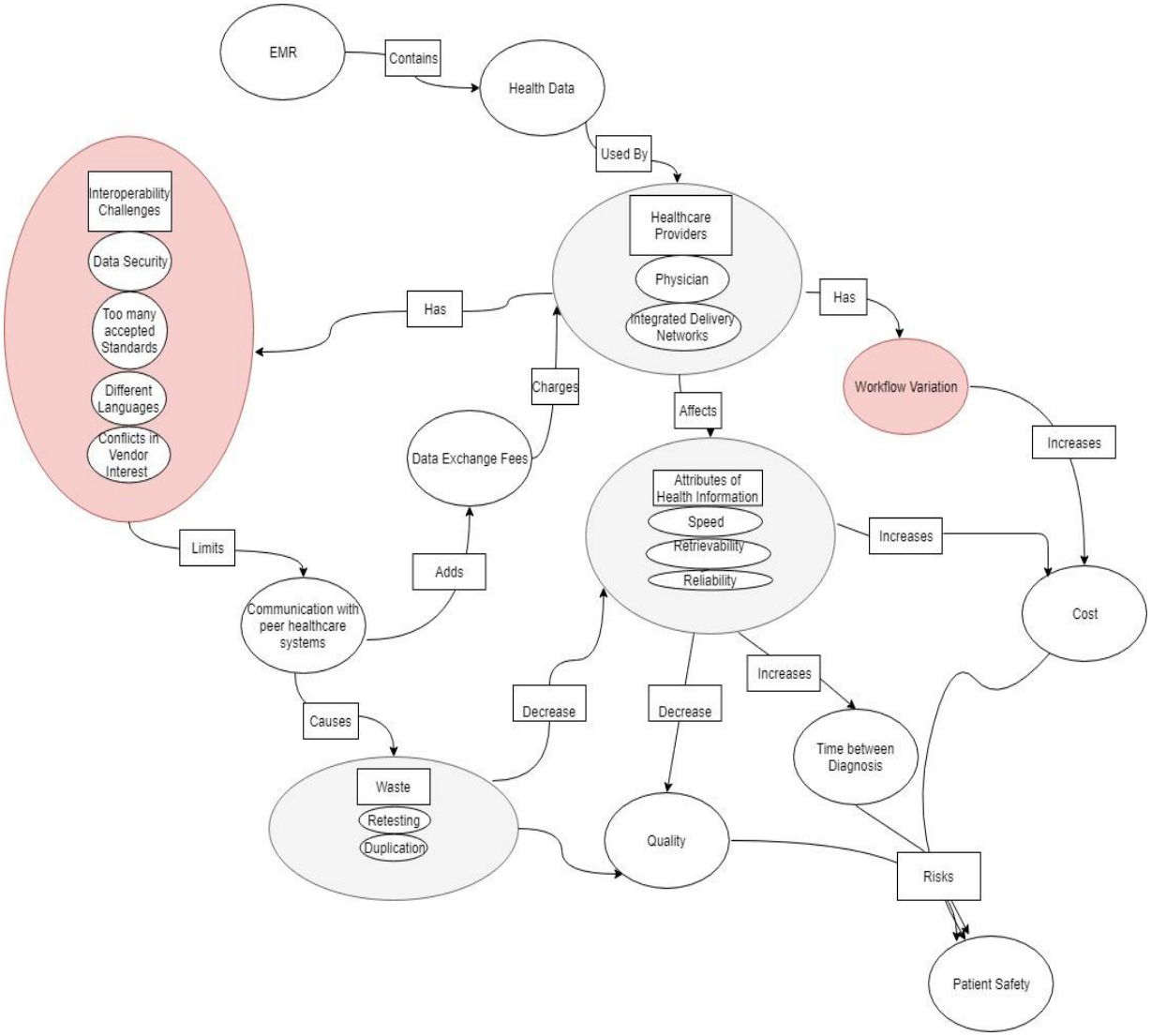
Figure 1. EMR Challenges



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Interoperability

Many benefits have been realized with the use of EMR systems in healthcare institutions. However, lack of proper interaction with other information systems in the healthcare organization is a big challenge. This can result in errors which jeopardizes the integrity of EMR information (Bates, Goldman, & Lee, 1991). When there is little interaction with other information systems in a healthcare center, there will exist cases of poor diagnosis and treatment due to unavailability of some essential data (Reardon, 2007). The healthcare institutions must transition to systems that are more technology-based that provide financial rewards for increasing the availability of information and reducing redundancy. EMR has the potential of increasing quality by having a patient's information follow the patient regardless of changes in medical modalities. Four sub-challenges that are included in interoperability are as follows: data security, lack of commonly accepted healthcare standards, different languages and format, and conflicts in vendor interest.

Data Security

Maintaining private and secure medical records is a top priority for many healthcare organizations. Although, EMR implementation has proven to increase efficiency, data security has been a barrier to EMR adoption for some healthcare organizations (Kruse et al., 2016). With the proven benefits of EMR, there are still data safety concerns that must be addressed to continue increasing the number of healthcare facilities utilizing EMR systems. Data breach events are not reported often within the healthcare field. However, approximately 53% of the users in an EMR study indicated they had experienced a serious occurrence where patient data had been compromised within the last five years (Menon et al., 2014). As a result, it is imperative that EMR tools have the added technology and safety measures in place to ensure data safety for the patients and providers involved.

LACK OF COMMON ACCEPTED HEALTHCARE STANDARD/DIFFICULTY MATCHING PATIENT RECORDS

Research suggests that most healthcare institutions spend a lot of time and finances mitigating the duplicated patient information records. For instance, on a weekly basis, approximately 72% of the health records managers are editing medical records to reduce unnecessary duplication (Simborg, 2008). The major challenges that were identified include the lack of unfamiliar terminologies or language

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barriers among medical practitioners, lack of enough resources for ensuring there is good development of information in hospitals and lack of executive and governance policy support.

Different Languages and Formats

Apart from being unable to share data of patients in an efficient manner, many EMR systems fail to interface with others. Major factors contribute to the interoperability of the EMR system. Technical variations make it hard to develop a one standard data sharing format. For instance, there are diverse service models, capabilities and technology architectures which make it hard to choose the best model (Phillip, 2008).

Conflict of vendor interest

This is a huge issue that is preventing effective data exchanges among the different providers. Major factors contribute to the interoperability of the EMR system. Resistance from vendors is of critical importance. For instance, medical associations, physicians, and politicians are key in identifying some of the vendors who are thought to engage in the blocking of information (Kemper, 2006). The reason some medical professionals block information is to deny others access and in turn charge fees for exchanging the same information. Expensive data exchanges and language barrier is another factor affecting EMR interoperability. For instance, some vendors charge 5000 to 50000 dollars to set up data sharing connections (Phillip, 2008). This is harmful as every EMR system contains its own data sharing system.

There are also technical variations that make it hard to develop a one standard data sharing format. For instance, there are diverse service models, capabilities and technology architectures which make it hard to choose among the best model. The challenge is also exasperated by vendors who fail to offer technical support and training of EMR systems (Simon, Kaushal, & Cleary, 2007). Lack of trustworthy vendors reflects directly on the healthcare system when it becomes difficult for some physicians to adopt the system. Expert support is an issue that derails the process of adopting the technology. Physicians may be able to learn from their fellow physicians and from clinical staff. This ensures that those who have adequate skills about the technology educate others (Kern, 2016).

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Physicians are required to possess fast pace, varied skills while treating multiple patients of diverse age groups, making diagnosis and keeping comprehensive records using different sources. These duties make some physicians find it hard to adopt the EMR technology due to its time-consuming nature and multitasking aspect (Meinert, 2004).

Reliability is another issue that makes healthcare systems find it challenging to adopt the digital technology. Reliability can be described as the dependability and sustainability of the technology that houses EMR. For instance, as more EMR vendors get into the lucrative medical care market, there is a tremendous rise in the competing systems (Farsi, 2006).

Therefore, as vendors compete there will be aspects of compromised reliability and quality in the implementation of EMR tools. Organizational and in-house training is important to reduce redundancies in the implementation efforts. Performing redundant tests is costly and may lead to false-positive results, which will then lead to evidence that there is negative association between diagnostic testing and the use of an EHR and/or its components.

VARIATION IN WORK – FLOW

In the initial implementation of the EMR system, research suggests that productivity was noted to reduce gradually (Miller, 2004). For instance, the implementation of the digital system saw the physicians' productivity fall from 33% to 25%. However, this drop was expected from the initial stages as the physicians were reluctant in embracing the technology. The staff and the physicians had a difficult time while learning the technology initially. After one month of using the technology, they appeared more comfortable and over time the productivity began to increase again. However, the improvement was not uniform among all the healthcare staff and physicians and their expertise levels varied from office to office (Loomis, 2002). Some groups of physicians showed even worse adaptations and productivity than others. For instance, the physicians practicing in the internal medical units were able to comfortably adjust to the digital technology and slight improvement in productivity was observed in the next few months. On the other hand, there was a huge contrast as family practice and pediatricians were not able to return to their initial levels of productivity and experienced even worse levels compared to their earlier productivity state (Meade & Buckley, 2009).

The variation in the workflow indicates that different groups of physicians require special care while undergoing training of EMR tools. Furthermore, there is no specific method which is better that can be used in handling aspects of medical documentation even with the latest technology. As a result, optimal ideal

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technology models should be implemented, assessed, and re-designed since workflow demands vary dramatically depending on the medical treatment as well as on the experience of the physician.

MODELING THE FUTUR STATE OF EMR SYSTEMS

Electronic medical record systems integrated with proposed solutions can improve quality of care, contain costs and reduce overtreatment (Ludwick, 2009). A well-integrated network of interoperable healthcare provider's system will provide an unprecedented access to management and collection of information about healthcare quality. Figure 2 illustrates a systemigram that shows proposed solutions for challenges that were mentioned before. Color coding – green shows the proposed solutions. Individual scenes can be found in the appendix.

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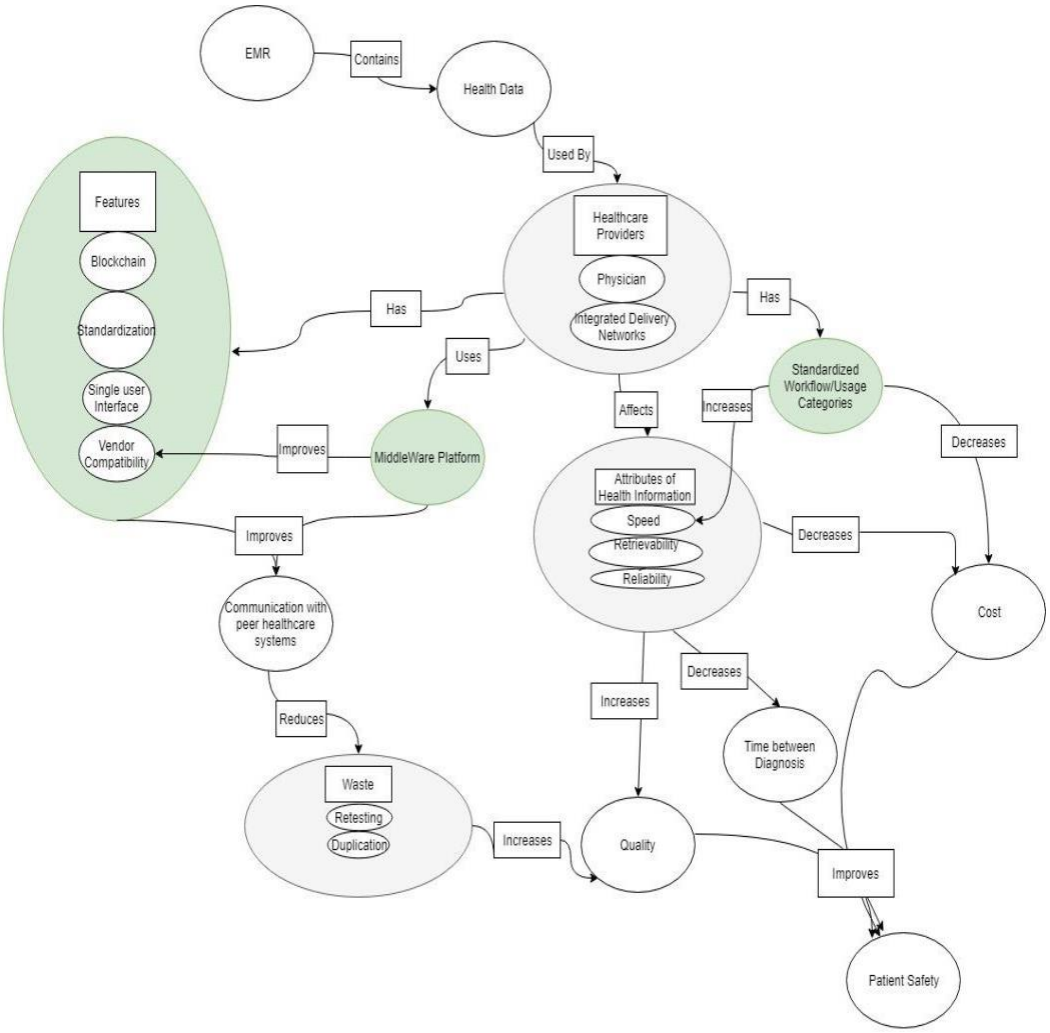
Figure 2. Solutions for EMR challenges



These are three main solutions for EMR solutions which the systemigram in Figure 2 supports:

1. Introduction of Middleware software
2. EMR usage categories.
3. Blockchain Technology

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MIDDLEWARE

Middleware is the software that connects more than one diverse software application. The software is currently in use to connect software tools that are not related yet transforms them into a single user interface that can connect emerging technology and legacy systems. Further, the middleware is an innovation of the mainframe systems, which involves integration and data that comes from exporting and importing data in a standardized manner (Kern, 2016).

The Middleware software ensures there is real-time delivery of information to physicians when they are in need of it (Kern, 2016). Real-time information is essential in time of emergencies, when making office decisions, and while in operating rooms. It is thus essential to utilize the software for the purpose of quality, cost effective care and patient safety. To achieve this, there should be approaches in place to guide the provider (Voltz, 2015). The data fragments collected from every patient should be put in a single or in a tightly coupled database or even the development of an interface to EMRs would be beneficial. The decision of storing this data safely should be critical as there are many potential inherent risks and also the unforeseen impacts that can develop as physicians and staff scale up data (Boonstra & Broekhuis, 2010).

Health care response to the initiation of new technology is an issue of concern (Asaro & Boxeman, 2008). In the modern day world, there are huge amounts of information that can be stored. Sometimes data may be misinterpreted or handled in an improper manner, which can result to misdiagnosis. Therefore, it is essential to retrieve the original source of information for quality services (Meade & Buckley, 2009). Middleware is simple to use in connecting previous systems that are disconnected. The software has demonstrated great value while applied in other institutions that are more complex than the healthcare sector. Thus, this software is ideal as a synergistic tool in health care to assist systems in multiplying their productivity. The utilization of Middleware has demonstrated the ability to reduce costs as well as reduce the risks that are present in many healthcare institutions (Kern, 2016).

Healthcare facilities are still at the early stages of embracing the overall cycle of EMR systems. Though many government institutions are utilizing the technology, there is still a struggle in identifying the effective and efficient means of using the system (Kemper, 2006). With time, ideally these systems will be utilized fully as healthcare systems continue to look for appropriate methods of addressing the challenge of providing quality services to the ever-expanding population of patients (Boonstra & Broekhuis, 2010). In addition, middleware improves interoperability with other healthcare facilities, and provides data in a standardized format. Collaboration among healthcare professionals will also help develop a scalable

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remedy to the lack of standards challenge (Ajami & Bagheri-Tadi, 2013).

Encountering the challenge of different language usage via the Middleware technology has been present as well. The software will ensure that all the large data from the providers is handled in a simple manner. The software will also merge in a systematic manner the different data fragments from patients to bring out a meaningful line of information. Middleware will also allow fast sharing of data that will eliminate all the vendors that compromise data sharing (Voltz, 2015).EMR usage categories

In an attempt to address this challenge, research indicates that it is essential to breakdown EMR system usage into manageable categories. Two major categories were proposed, one being information review and the second being information entry (Jha et. al, 2009). These two categories can appropriately handle the challenge of introducing the physicians into EMR and at the same time improve their workflow. By separating into two categories, physicians can better delegate tasks, reduce their administrative load, and focus more on patients, thereby increasing their productivity and ultimately their delivery of better patient care.

BLOCKCHAIN TECHNOLOGY

The mitigation of EMR data security concerns occurs through the implementation of blockchain technology. Blockchain helps provide a shared and transparent account of all transactions while building applications with trust and accountability (Dubovitskaya et al., 2017). Maintaining the privacy and confidentiality of patient information is of critical importance to both healthcare providers and healthcare delivery systems, and there are many benefits of blockchain technology in place to help achieve this (Rifi et al., 2017). A survey of U.S. adults concerning privacy resulted in 65% of patients feeling uneasy about the leakage of sensitive health information (Shah et al., 2014). Through attaining data sustainability, data stability, and data security, blockchain technology has the potential to revolutionize healthcare operations (Roman-Belmonte et al., 2018).

New research studies have emerged that focus on EMR sharing models using blockchain technology (Wu & Du, 2019). These models prove how achieving both security and efficiency in EMR systems is possible through utilizing blockchain resources. Data security, management, and accessibility continue to be the forefront concerns for EMR systems. However, many studies have proven that the implementation and integration of blockchain technology can help eliminate and address many of these concerns (Shahnaz et al., 2019).

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DISCUSSION

In modeling the future state of EMR systems, this research is proposing different feasible solutions to address the barriers to EMR adoption. The proposed recommendations identified are not only workable resolutions, but as mentioned previously have proven to provide significant benefits to a variety of settings. From Middleware software, EMR usage categories, to Blockchain Technology these options provide the pathway to better understanding EMR systems and EMR implementation. For many sectors, healthcare included, understanding how a system works is a critical first step in the ongoing consistent usage of such system. System integration is necessary in EMR systems and this study has shown how fragmented systems can communicate using Middleware for physicians to provide a coordinated collaborative medical care plan for patients. In addition, physician burnout happens and as a result is a leading cause of medical error (Nijor et al., 2020). EMR usage categories, proposed in this study, can help with physician workflow and task delegation. Lastly, blockchain technology adoption is increasing in multiple fields in addition to healthcare.

This study has indicated how blockchain technology could offer significant benefits to the implementation of EMR systems in healthcare facilities.

CONTRIBUTION TO LITERATURE

Healthcare is often analyzed conceptually. This paper uses systemigram to communicate the whole system of EMR implementation. The systemigram condenses the research and literature review of the components that comprise an EMR system. The conceptual model presented in this study triggers a critical assessment of EMR and promotes information coordination among professionals in the healthcare ecosystem. EMR's benefits, namely, transparency and efficiency, allow for increased quality as well as robust research data.

The medical information system in the United States is fragmented because a large percentage on medical professional are not on fully on board with the value of EMR (Rao, 2011). Our paper fills a research gap of providing a framework from which to study the infrastructure interdependencies of the structural complexities of EMR implementation. This framework is made possible by our development of a supporting systemic diagramming technique, that is, a systemigram, which based on our systematic literature review, has not been previously

To address interoperability challenges, we have adopted system thinking methods. As mentioned earlier, our literature review demonstrates a need for a holistic

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systems thinking approach to EMR and that our paper fills this gap by leveraging a systems thinking approach through the use of systemigram. When EMR implementation is viewed as a system, instead of silos, several important gaps were revealed that can be helpful in solving problems related to EMR implementation. By systems-oriented review of the literature, we were able to find one such gap – interoperability, and its solution is introduction of middleware. When viewed from a lens of systemic thinking we can now have a clear picture of how it is linked to the entire system and how it affects the system. By following the systemic thinking method, we have a conceptual model that can be tested. Future research should be carried out to test the assumption that middle ware improves communication and collaboration between hospital system. This will increase speed, quality and reduce cost of transferring healthcare information. Ultimately, it results in better and affordable healthcare.

MANAGERIAL IMPLICATIONS

EMR can reach its optimal capacity when the above challenges are addressed. Over the past two decades, medical facilities have been using ERP system to manage their supply chain. However, initially, it was focused only on transaction tasks such as order management and invoice matching (*http://healthcare-executive-insight.advanceweb.com/Archives/Article-Archives/Linking-Technology-and-Supply-Chain.aspx*). The reason for this initial focus relates to the healthcare system's typical pattern of lagging behind industry in terms of information technology advancement. There is a learning curve. In 2000, only 5% of primary care providers in the U.S. were using EMR systems (Bates, Gotlieb, Zapp, & Mullins, 2003)

Now, ERP integration in the healthcare field has made tremendous strides in healthcare efficiency and EMR is on a similar path. EMR now provides multiple core functionalities besides the capture of health information. For example, EMR allows for better management of orders and routine procedures, administrative processes, data interchange, and patient reports.

Now three-fourth of primary care providers and healthcare systems use some form of EMR. According to a survey conducted in 2014, only 25% of hospital were using electronic means to integrate their supply chain (Kumar et al., 2008). The healthit.gov website shows that that as of 2017, approximately 85.9% of the hospitals use some form of electronic health records. Integrating EMR with other information systems, results in better inventory management and supply chain management. According to an article published by Health IT, integrating immunization information systems of government with EMR have played an important role in purchasing and inventory management of vaccines between

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providers, states and federal government (https://www.healthit.gov/buzz-blog/electronic-health-and-medical-records/immunization- information-systems). Healthcare systems are very dynamic with high stakes, so accurate and timely information is critical. Another key use of EMR is data capture. Providers need accurate and timely data in order to ensure the right product is delivered at the right time and suppliers need to be ready to provide the right product (Ross, 2009).

Healthcare systems can capture the use of device and medical products used during patient procedure, which can then be populated into other information systems. Middleware facilitate interchange of data between EMR and hospital system and this can result in better supply and demand forecast. In conclusion, EMR results in enhanced supply chain management that ultimately reduces the cost and improves quality of healthcare. Studies indicated that coordinated sharing of supply and demand information with supply chain partners reduced cost and shortened order cycle time (Strader et al., 1999). In a dynamic environment like healthcare where demand is volatile increase in information sharing results in better supply chain responsiveness (Lee et al., 2000) and enhanced operation, product and delivery flexibility (Sezen, 2008). EMR provides data collection, data cleaning, and data storage with quality reporting and allows for decision-making opportunities that are more holistic.

Inclusion of the patient in information sharing results in transformation of care provider to facilitator of care that together with patient is involved in development of new programs and services. The information sharing and collaborating results in new innovative ideas and the provider can achieve a better picture of demand and can adjust services accordingly. Patient value co-creation significantly influences health care outcomes, whether by reducing medical service costs, yielding better clinical outcomes, improving patients' psychological well-being, or increasing patients' satisfaction with their physicians (Ashcroft et al., 1986; Fallowfield et al., 1990; Gill et al., 2011; Martin et al., 2005; McColl-Kennedy et al., 2012; Randeree, 2007).

CONCLUSION

Both interoperability and variation in workflow are identified as key components to addressing the efficiency of an EMR system. Interoperable electronic medical records improve the ease with which doctors provide care even when patients are moved across a variety of healthcare facilities. Workflow redesign can maximize efficiencies. This study makes a unique contribution to the EMR literature by providing a system-thinking approach to the understanding of the role of EMR in the complex system of healthcare by leveraging the methodology of systemigram to evaluate the EMR system. In this paper, the discussion has focused on several

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challenges and solutions associated with EMR adoption in healthcare institutions. Many of the solutions accrue to patients and physicians overall (Zhao et. al, 2015). For the identified solutions to be realized, the federal government has to embark on a journey to transform a maximum number of physicians and staff towards EMR adoption and use in a meaningful manner. Due to lack of ubiquitous utilization of the EMR system, experts have a belief that many United States healthcare objectives cannot be realized. The HITECH Act (https://www.healthit.gov/topic/laws-regulation-and-policy/health-it-legislation) has been awarded financial incentives that aim at defraying some of the costs that come with adoption of the EMR, especially for the small organizations where costs are a big barrier. There are also programs which provide an incentive to HITECH, which helps in protecting against misalignment that is associated with EMR.

LIMITATIONS

EMR adoption has proven to be significantly beneficial for many healthcare facilities and systemigram analysis have proven to be useful in understanding systems in variety of settings; however, there are limitations of the systemigram presented in this study. The research performed focused only on the mainstream barriers to EMR implementation, Interoperability and Variation in Workflow. However, there are other dynamics preventing healthcare facilities from adopting EMR systems, such as economic and knowledge barriers (Paré et al., 2014). A research study went on to determine there are four different categories of barriers preventing EMR utilization in private practice settings (Paré et al., 2014), and these categories are as follows: behavior, knowledge, technological, and economic. This study did not investigate how each of these barrier categories can be addressed using the systemigram technique. However, this is a future research task to occur beyond this study.

The EMR is the best digital tool for the healthcare sector that will help change the manner in which health institutions are operated. For instance, the increase in world population has resulted in too many patients in hospitals, which mean health care professionals have to handle huge volumes of data. This is difficult especially when using the traditional paperwork method. EMR has come to replace the traditional method and improved effectiveness and efficiency in the healthcare sector. With the system, physicians can now collect, store and retrieve patients' information from their officers. Diagnosis and treatment will improve and patients' satisfaction will be achieved.

However, there are many challenges surrounding the use of the EMR system that should be addressed to ensure positive results are achieved. For instance, there are additional costs that come with using the software including security costs. Also,

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there are issues where physicians oppose the digital technology. Appropriate solutions should be embraced including adoption of the Middleware software to handle voluminous data (Meinert, 2004).

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