

A Comparative Study of Electronic Health Record (EHR) Systems in US Healthcare – A Systematic Review

Mr. Mrinmoy Roy

Ph.D. Scholar, Mittal School of Business, Lovely Professional University
Associate Professor, PES University, RR Campus, Banshankari, Bangalore
Email id: mroy2612@gmail.com

Dr. Gyan Chandra Kashyap

Assistant Professor, Institute of Health Management Research, Bangalore; Email id:
gyan.ck@iihmrbangalore.edu.in

Ms. Preetha S

PGDM Health & Hospital Management, Institute of Health Management Research, Bangalore; Email id:
preethas.pgdm20@iihmrbangalore.edu.in

Abstract

Background: Electronic health record systems have given rise to a tremendous transformation in the US healthcare industry. They have showcased their importance in securely managing patient data and information by eliminating paperwork or manual documentation. A considerable leap occurred in the EHR era when the Health Information Technology for Economic and Clinical Health (HITECH) Act was converted into law in 2009 to encourage the adoption of EHR systems. The usage of EHR systems has decreased the occurrence of medical errors and improved the accessibility of secure patient data sharing. This has resulted in increased communication between providers and patients, resulting in better and smoother delivery of patient care. This study aims to understand the Electronic Health Record Systems in US healthcare with the help of a literature review. This study also aims to compare the top 5 EHR systems in the US and generate recommendations based on the same. A comprehensive literature search was done to study electronic health record systems from journals, articles, website blogs, and published papers on this topic. The criteria for the literature search were literature focusing on EHR systems in US healthcare and studies analysing the characteristics such as implementation risks, barriers, advantages, quality, and safety of EHR systems. The literature review highlighted some of the drawbacks and challenges in implementing EHR systems faced by US healthcare over several years. Some of them are high up-gradation costs, lack of standard interoperability, unreliable certifications, compromise in privacy and security, software errors and failures, lack of acceptance by physicians, and no user end support. The study also highlighted why EPIC EHR software is preferred and is at the topmost position, such as its high compliance and 3-way

interoperability, due to which large healthcare organizations prefer it. With the steady rate of spreading diseases, it is necessary for all healthcare facilities to be thoroughly prepared to deliver good healthcare and handle emergencies without compromising on patient safety. EHR vendors must divert their focus beyond accessibility and software problems and emphasize anticipating the needs of the patient's health. They also need to strengthen their technical capabilities so that we can achieve efficiency in delivering care and making healthcare affordable.

Keywords : Electronic Health Records, (EHR), US Healthcare, HITECH

Introduction:

Electronic health record systems have given rise to a tremendous transformation in the U.S. healthcare industry.^{1,2,3} They have showcased their importance in securely managing patient data and information by removing paperwork or manual documentation.^{4,5} The first EHR system developed was known as the Clinical Information System.^{6,7,8} In the mid-1960, Lockheed developed an EHR system which was handed over to Technicon. This EHR was then taken over by TDS HealthCare and Eclipsys, which is currently a part of Allscripts.

One of the earliest developers of the EHR system was the Department of Veterans Affairs in the U.S.⁹ Veterans Affairs had gone from a manual paper-based to a computer-based records system during the 1980s.¹⁰ It was called Decentralized Hospital Computer Program (DHCP).^{11, 12} This system was invented to bring uniform and standardised patient data into local centralised storage. A considerable leap occurred in the EHR era when the Health Information Technology for Economic and Clinical Health (HITECH) Act was converted into law in 2009 to encourage the adoption of EHR systems. After this conversion, the federal government planned to help healthcare centres with the adoption of a nationwide health information exchange system, and 300 million dollars was dedicated to this purpose. The Centers for Medicare and Medicaid offered thirty-five billion dollars through incentive payments.

According to the American Hospital Association Annual Health Survey in 2009, only 12% of the hospitals had implemented a basic EHR system. The numbers then drastically increased to 83.8% by the year 2015.¹³ As per the recent report by Definitive Healthcare data from 2020, we can observe that more than 90% of all hospitals have implemented ambulatory and inpatient EHR systems in the US.¹⁴

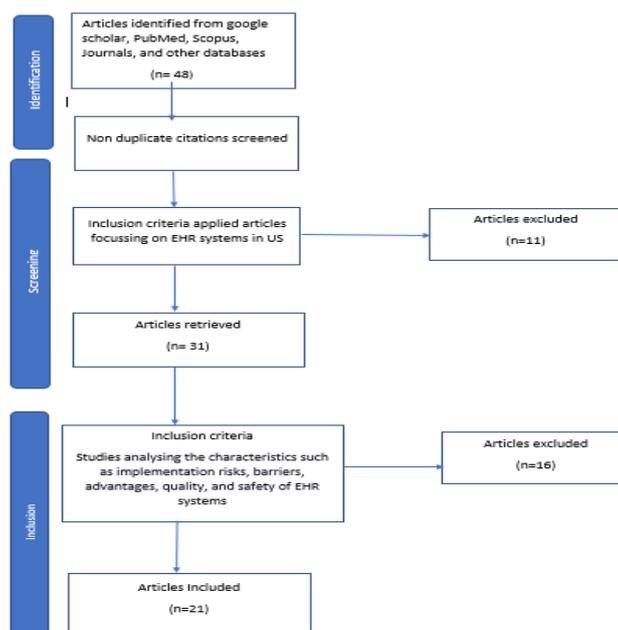
Although rural and critical access hospitals have always had a lower rate of Electronic Health Record adoption than all hospitals, these rates have significantly risen since 2011. From 20% rates of EHR adoption in 2011 critical access hospitals increased their rates to 80% in 2015. In the year 2020, it was recorded that nearly 95% of acute access hospitals had implemented EHR systems.¹⁵ EHR systems in U.S. hospitals are conquered by providers such as Epic, which holds almost 35% of the market share, followed by Cerner, with 23.7 % of the market share, Meditech has a share of 14.7%, weHReas Allscripts holds a share of 4.7%.^{16, 17}

The usage of EHR systems has decreased the occurrence of medical errors and upgraded the accessibility of secure patient data sharing.^{18, 19}. As a result, it has improved the communication between providers and patients, resulting in better and smooth EHR delivery of patient care.²⁰ This study aimed to systematically review the literature and a comparative study of the Electronic Health Record Systems used in U.S. Healthcare. Since we were concerned with identifying the gaps through mapping with the available evidence, a scoping review was based on these specific objectives: 1) To understand the Electronic Health Record Systems in U.S. healthcare from the literature review, 2) To do a comparative study on top 5 EHR systems in the U.S., 3) To generate recommendations based on the study.

Methods:

Study Design: A comprehensive literature search was done to study electronic health record systems from journals, articles, website blogs, and published papers. **Study Duration:** This study was conducted from Apr 15 – to May 31 2022. **Criteria for Paper selection:** The requirements for the passage of the articles were: Articles focusing on EHR systems in U.S. healthcare. Studies analysing the characteristics such as implementation risks, barriers, advantages, quality, and safety of EHR systems. To use the above criteria in the study, a preliminary reading of the title and summary of each article was carried out, through which it was possible to remove pieces that did not match the requirement. Then another EHR reading round was performed, and a sample of 21 papers was obtained for this study.

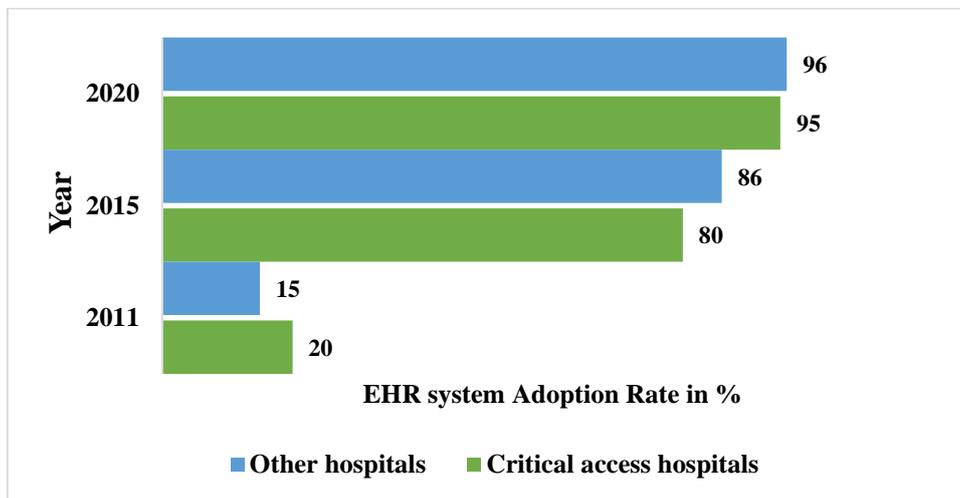
PRISMA Flow chart



Results: According to the American Hospital Association Annual Health Survey in 2009, only 12% of the hospitals had implemented a basic EHR system. The numbers then drastically increased to 83.8% by the year

2015. As per the recent report by Definitive Healthcare data from 2020, we can observe that more than 90% of all hospitals have implemented ambulatory and inpatient EHR systems in the U.S.

Figure 1: A comparison of EHR adoption among critical access hospitals and other hospitals (%)



Authors and year	Title	Country	Key ideas
A. Jay Holmgren, N. Lance Downing, David W. Bates (2021)	Assessment of Electronic Health Record Use Between U.S. and Non-US Health Systems	US, Canada, North America, Europe, Western Europe, the Middle East	<ul style="list-style-type: none"> U.S. Clinicians spent more time (90 min) handling the EHR than non-US Clinicians (58 min). More time Longer spent on taking notes instead of automated text generation. This process of a more extended hour with EHR systems leads to Physician burnout.
Ross Koppel, Christoph U Lehmann (2015)	Implications of an emerging EHR monoculture for hospitals and healthcare systems	The U.S.	<ul style="list-style-type: none"> Epic EHR advantages- User formats are standard, user interface requires less maintenance, and training needs are less. Disadvantages include upgradation costs as 40–49% of the system's initial cost.

Davis, Minal Thakkar and Diane C (2006)	Risks, Barriers, and Benefits of EHR Systems: A Comparative Study Based on Size of Hospital	The U.S.	<ul style="list-style-type: none"> • 37% of the respondents of this study indicated they currently used some components out of all the eight core functionalities identified by IOM. • Barriers preventing the usage of EHR were the privacy of data, software cost, lack of acceptance by the physicians, and funding.
Jeffrey A. Linder, Jun Ma, David W. Bates (2007)	Electronic Health Record Use and the Quality of Ambulatory Care in the United States	US	<ul style="list-style-type: none"> • EHR was used in only 18% of the estimated 1.8 billion ambulatory patient visits in the U.S. between 2003 and 2004. • They were functionally essential EHRs, needing more clinical decision support and focused on improving quality widely used.
Reisman, Miriam (2017)	EHRs: The Challenge of Making Electronic Data Usable and Interoperable	The U.S.	<ul style="list-style-type: none"> • The financial costs of implementing EHRs are the main barrier to their adoption. • Diverse clinical terminologies, technical specifications, and functional abilities make it difficult to achieve interoperability.
Raj M. Ratwani, Erica Savage, Amy Will, Allan Fong, Dean Karavite (2018)	Identifying Electronic Health Record Usability and Safety Challenges in Pediatric Settings	US	<ul style="list-style-type: none"> • EHR and Medication issue accounts for 56.4 % of the events in this study • The main contributing factor was the usability and safety issues, accounting for 63% of the above. • TEHR may be a risk to the Patients due to usability challenges.
Authors and year	Title	Country	Key ideas
A Jay Holmgren, Julia Adler-Milstein, Jeffrey McCullough (2017)	Are all certified EHRs created equal? Assessing the relationship between EHR vendor and	The U.S.	<ul style="list-style-type: none"> • Epic was positively linked with 3 criteria (medication CPOE, VDT available for patients, and VDT used by patients). • Cerner was linked with 1 criterion (VDT used by patients) instead of 3, and tEHR

	hospital meaningful use performance		vendors had mixed results.
Sally L Baxter, Nate C Apathy, Dori A Cross, Christine Sinsky, Michelle R Hribar (2021)	Measures of electronic health record use in outpatient settings across vendors	The U.S.	<ul style="list-style-type: none"> • Vendors were in the early stages of development, and differences between vendor-provided and proposed measures are significant for performance and cross-vendor comparison. • Three vendors offered measures and well-developed platforms; the remaining must develop or are still developing standards.
Vikas N. O'Reilly-Shah, Katherine R. Gentry (2020)	The COVID-19 Pandemic Highlights Shortcomings in U.S. Health Care Informatics Infrastructure: A Call to Action	US	<ul style="list-style-type: none"> • Lack of data infrastructure inhibits communication; hospitals depend on interpersonal communications rather than working from a readable multi-organisational playbook. • Interoperability challenges exist within hospital systems or single hospitals.
Evans, R. S. (2016)	Electronic Health Records: Then, Now, and in the Future	The U.S.	<ul style="list-style-type: none"> • The need exists for developing flexible EHR structures that can operate seamlessly within the workflow of a healthcare environment. • More research is required to incorporate the EHR into patient encounters effectively.
Beauvais, Bradley, Kruse, Clemens Scott, Fulton, Lawrence (2021)	Association of Electronic Health Record Vendors with Hospital Financial and Quality Performance: Retrospective Data	US	<ul style="list-style-type: none"> • All the top 3 EHR vendors achieved equal and good efficiency scores. • Epic has become more effective because of its users who want to explore more than the primary user training in the areas of TPS. • The EHR systems of Hospitals have more user experience and become more efficient than new users.

Comparison of Top 5 EHR systems used in U.S. healthcare

Product Details		Software Features									Compliance				Certification	
Vendor	Market Share	Delivery Platform	Appointment Management	Charting	E prescribing	E/M Coding	Patient Portal	Voice Recognition	Insurance and claims	Handwriting Recognition	HIPAA Compliant	ICD-10	CPT	HL 7	Meaningful Use Certified	NC ATCB Certified
Epic	34.05%	Cloud Based	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cerner	23.71%	Cloud Based	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓
MEDITECH	14.67%	Cloud Based	✓	✓	✓	✓	✓	X	✓	X	✓	✓	✓	✓	X	X
Allscripts	4.68%	Cloud Based	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	X	✓
athenahealth	1.31%	Cloud Based	✓	✓	✓	✓	✓	X	✓	X	✓	✓	✓	✓	X	✓

Source - (EHR in Practice)

Discussion

The above table compares the top 5 rated EHR systems in 2021 in the US.²¹ Though the above table may indicate that all the EHR systems offer similar solutions, their purpose of serving the organisations and workflow experiences provided changes. Cerner is a more dependable choice regarding ambulatory services in U.S. healthcare. Epic is mainly used to assist large and complex organisations. EHR selection for an organisation also highly depends on its budget allocation. The pricing for the Epic system starts from \$200 per month and can go up to \$35,000 per month. The cost of the software depends on the additional features offered. This includes setup and training costs, but some vendors may charge separately for training. Cerner's price is less when compared to Epic. It starts at \$25.00 per year. To implement the Epic EHR system, healthcare centres must select and convey their goals, strategies, and planning within their organisation.²² It has been found that clinicians in the U.S. spent more time (90min) handling the EHR compared to non-US Clinicians(58min). Most of the time, longer hours are spent on the taking notes function instead of using automatically generated text, and these lead to physician burnout.^{23, 24} Four common themes on successful EHR implementation arose while semi-structured qualitative interviews conducted amongst Family physicians, primary healthcare providers, preliminary healthcare information and operations management delivery teams such as expectations of EHRs, time and training required to implement and adopt the software, the emergence of an EHR champion or problem solver, and the readiness of health care providers to accept the system.²⁵ Although the top 3 EHR vendors are equally proficient in achieving good efficiency scores, users are more willing to discover outside the basic user training has caused Epic to be more effective in the areas of TPS. Even it found that hospitals that have been using the EHR over many years have been more efficient than hospitals that have only recently started using or changed their EHR system.²⁶

With the promise of substantial benefits such as better care and decreased healthcare costs, EHR system implementation brings on severe unintended consequences due to poor EHR system design and improper use, causing EHR-related errors that jeopardise the integrity of the information in the EHR, leading to errors that endanger patient safety or decrease the quality of care. These unintended consequences also may increase fraud and abuse and can have severe legal implications.²⁷

Presently Electronic Medical Records (EMR) adoption and usage tripled in Canada over the last seven years from 2014, when the National Physicians Survey was taken online, and 65% of physicians responded that patient care becomes much better when EMR is used. However, over 30% of Doctors in Quebec, New Brunswick, Newfoundland, and Labrador still use paper charts exclusively.²⁸

Apart from the following potential benefits of EHR adoption such as i) Clinical outcomes (Improved Quality with reduced Medical Errors), ii) Organisational outcomes (Financial & Operational Benefits), iii) Societal outcomes (Improved ability to conduct research, improved population health with reduced cost) the following drawbacks such as high upfront acquisition costs, ongoing maintenance costs, and disruptions to workflows that contribute to temporary losses in productivity etc. Moreover, EHRs are associated with potential perceived privacy concerns among patients, which are addressed legislatively in the HITECH Act.²⁹

As per the national survey conducted in U.S. Hospitals during Feb/ Mar 2005 to identify the status of EHR systems regarding the core implemented functionalities as determined by the Institute of Medicine, 37% of participated hospitals have all core components, and 27% have some of the core functionalities. There was a significant relationship between some perceived benefits and barriers to adopting EHR systems based on the size of the hospital. Regarding perceived benefits, a significant correlation was found between the “medical staff’s work efficiency and time management” and the size of the hospital.³⁰

EHR and Clinical Decision Support Systems (CDSS) have the potential to enhance antimicrobial stewardship. Lots of EHRs & CDSSs are potentially available to empower clinicians and Antimicrobial Stewardship Programs (ASPs) to review pharmacy, microbiology, and clinical data.³¹

Family medicine residents spend a significant amount of time completing EHR data entry after their working hours which causes physician burnout; this can be avoided with objective EHR data to devise interventions to decrease inefficient use of EHR, decrease after-hour EHR use, and improve well-being.³²

During 2003-2004, only 18% of EHR were used in an estimated 1.8 billion ambulatory visits in the United States. Most are more basic, lack clinical decision support, and need to be focused on quality improvement.³³ With the increase in medical knowledge, more investigative and treatment options are available. But a family physician cannot know ‘everything’; to adequately address patients' complex needs, there is a need for EHR & its associated Information Technology to transform the entire healthcare system.³⁴

A multi-centre study on ‘A usability and safety analysis of Electronic Health Records’ emphasises that 56.4 % of the events were related to EHR and medication issues. Of this, nearly 63 % had a usability issue³⁵ as a contributing factor to the safety issue, and 36% had a usability issue contributing to the medication event.³⁶ Patients may be put at risk because of usability challenges. The financial costs of implementing EHRs are the main barrier to their adoption. Diverse clinical terminologies, technical specifications, and functional abilities make it difficult to achieve interoperability.³⁷ The Pros of Epic EHR- standard user formats, less maintenance user interface, and less training needs. Cons is upgradation costs are 40–49% (as a percentage of the system's initial cost).³⁸

EHRs built with the cloud computing model can achieve good privacy and security through business associate contracts with cloud providers that specify compliance requirements, performance metrics and liability sharing.³⁹

Lack of data infrastructure inhibits communication; hospitals depend on interpersonal communications rather than working from a readable multi-organisational playbook. During COVID-19 Pandemic, this shortcoming is evident in U.S. Healthcare Informatics Infrastructure, and Interoperability challenges exist within hospital systems or single hospitals.⁴⁰

Comparing paper-based Health Records and EHR leaders shows different priorities, such as improved technical training and ongoing technical support, sufficient protection of patient privacy, and open recognition of physician resistance, especially for those loyal to a legacy EHR. Compared to paper-based practices, EHR-based leadership believed that comfort level with I.T. and adjustments to workflow changes would be easy challenges to overcome.⁴¹ A lot of things need to be considered before the implementation process. Though Epic implementation is a massive task, if you are considering the best and most comprehensive EHR resolution for a large organisation, then this is one of the best choices. Cerner and Epic EHRs vary by small software features. Epic EHR offers CRM and dental services which are not found in Cerner. Cerner offers real-time data access and consultation, which is not present in Epic. Also, though the EPIC EHR template may need to be better-looking to view when compared to Cerner, studies have shown that users prefer EPIC over Cerner because of its user-friendly ness and less necessity for training.

Additional benefits of Epic EHR are that it allows interoperability in 3 ways compared to Cerner's single interoperability. Healthcare providers can access patients' data without connecting to Epic EHR. Epic is the most preferred choice of EHR in the U.S. healthcare industry. Most top U.S. hospitals, such as Rochester, Cleveland Clinic, Ohio, and even Mayo Clinic, have chosen Epic EHR System to maintain their patient records. OtEHR EHR systems mentioned in this study have a lower market share and are affordable and preferred by smaller organisations.

Critical issues with the EHR usage

The benefits associated with EHR usage are Standard formats. User's face requires less maintenance, lesser training needs, improved standardised care across the facilities, access to real-time data, reduction in product interoperability difficulties, remote access to patient data, medication error alerts and reminders for preventive care, provision of treatment goals or signs to remind providers, increased revenue & decrease in billing errors, improved legal and regulatory compliance, improved ability to conduct research, and increased satisfaction among physicians.

Drawbacks with the EHR usage

EHR costs are high; upgradation costs are 40–49% (as a percentage of the system's initial cost), loss of revenue in the initial stage when physicians are learning how to use the software, difficulty in creating one standard interoperability format for data sharing, usability challenges arising from the design, EHR certifications are not reliable, errors in the system compromise patient safety, and privacy and security concerns.

Challenges in implementation

Lack of acceptance by the physicians, lengthy process, lack of funding, lack of technical expertise, highly complex software, and software failures tend to compromise patient safety, customisation issues and lack of support for the end-users

Conclusion: EHR in U.S. healthcare has undergone significant evolution over the decades. From a basic model to the recent cloud-based models used by large healthcare organisations, EHRs have undergone many changes and upgrades. Though their usage has potential benefits for the healthcare service provided, we can observe that many drawbacks still need to be addressed. With the constant rate of diseases spreading, it is the need of the hour for all healthcare facilities to be fully prepared to deliver good healthcare and handle emergencies without compromising on patient safety. EHR vendors must increase their focus beyond accessibility and software issues and emphasise anticipating the needs of the patient's health. They must try to make the system user-friendly to the maximum extent so that physicians spend less time working on functionalities and concentrate on patient care. They also need to strengthen their technical capabilities so that we can achieve efficiency in delivering care and making healthcare affordable. This study highlights the current state of EHR in the U.S., and based on these, strategies can be formulated to fill the gaps in existing EHR systems.

Recommendations: Create a standard basic design that is user-friendly so that it prevents healthcare professionals from spending more hours on EHR handling and offering Free Pre-recorded Demo sessions to Physicians that are accessible by them at any time. Implementing technological advancements such as voice recognition and digital scribe in every system model, regardless of the software price, motivates more healthcare organisations to implement EHR systems and speed up the entire documentation process. It offers free implementation assistance on purchasing EHR. Implement regular safety check features in EHR to prevent errors related to the system from interfering with patient care and harming them.

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Informed Consent

Not Applicable

Ethical Statement

The study is based on a secondary source of information (Literature Review). Therefore, the ethical statement is not applicable.

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