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Strategies for unlocking EMR Interoperability: A Narrative Review

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Abstract
Electronic Medical Records (EMR) is intended to solve many issues in patient care pathway besides the administrative roles which equally makes the hospital paperless, but they still face major interoperability issues. When there is no systematic connection between different healthcare providers, medical information pertaining to patients becomes fragmented, incomplete, and outdated. This study was undertaken to investigate the strategies used to overcome interoperability challenges by EMR implementors. A narrative review was conducted, and various keywords were used to search in EBSCO, Google Scholar, and pertinent healthcare informatics articles for papers published between 2012 and 2024. Drawing from a range of studies, the findings indicate that Machine learning and artificial intelligence, Standardization of Data Exchange Protocols, Blockchain technology, EHR-Agnostic Platforms, Training and Organizational Support, Government and Policy Interventions, social factors are the strategies that successful EMR implementers have employed to achieve EMR interoperability.

Introduction

Interoperability, sometimes called Health Information Exchange (HIE), refers to the data exchange between entities through different mechanisms. In healthcare, interoperability refers to the ability of different EMR systems to exchange, interpret, and utilise patient information flawlessly(Gordon & Catalini, 2018; Iroju et al., 2013).

Health information exchange (interoperability)has brought several benefits to the healthcare system, but providers still face hurdles in sharing information. Xu et al. (2024), in their study, note that multiple doctors raised the issue of hospital interoperability.

The most significant hurdle is the lack of clear and coherent standards for patient identification across the HIEs (Iroju et al., 2013). The lack of national identifier standards for patients poses a significant issue; numeric, alphanumeric, and alphabetical methods of registering patients are used in different forms by different entities across regions. This is a core issue and hinders the seamless access of patient-related information in the primary repositories.

Esmaeilzadeh and Mirzaei (2019) note that cross-provider sharing of patient health information is an intricate undertaking with the capacity to increase clinical effectiveness and research significantly. Firstly, healthcare institutions are usually highly reluctant to share patient data owing to privacy and confidentiality concerns, and they may shun sending information for fear that it will give the recipient

provider a competitive advantage. Secondly, there is no universal consensus regarding the technical infrastructure required to support sharing of data. Thirdly, sharing of data across institutions is a daunting process in itself, and there is a need for a mutual comprehension of both data structures as well as meaning.

Human and IT infrastructure is another hurdle affecting the implementation of interoperable electronic medical records. IT infrastructure, which comprises the composite hardware, network resources, software, and services needed for interoperability to work, is a significant determinant of its success. Nandikove et al. (2018) note that the technical aspects of ICT infrastructure determine the adoptability of EHRs and interoperability in developing nations such as Kenya. The infrastructure allows the organisation to collaborate and deliver IT solutions to its employees and partners. The interoperability landscape should comprise robust hardware resources, including computers, servers, data centres, hubs, switches, routers, etc. Software that can be integrated with other software is also a critical determinant of interoperability success.

Another significant challenge is the lack of involvement of the payers in sharing payers' patient data across entities. Payers have substantial amounts of data that would be significant to healthcare providers and would help enhance patients' outcomes (Rhapsody.health (2019).

Related Studies

Nsaghurwe et al. (2021), in their paper "One Country's Journey to Interoperability: Tanzania's Experience Developing and Implementing a National Health Information Exchange, documented the strategies that Tanzania implemented to achieve interoperability. Using the "Mind the GAPS (Governance, Architecture, Program Management and Standards)" framework, a five-step process, the paper highlighted how a country like Tanzania successfully developed an interoperable health system. Findings indicated that collaboration, designing the architecture for health system data exchange, putting a middleware interoperability layer in place to facilitate the exchange, and training to support system use were the strategies used. The study, however, did not indicate the user experience, long-term sustainability, and the impact on health outcomes.

Gaynor et al. (2014), in their study entitled "A General Framework for Interoperability with Applications to Healthcare", presented a methodology for designing and analysing interoperable systems in healthcare with a focus on creating modular flexible systems that adapt to evolving standards and technologies. They propose a formalised method that integrates graph theory and system modularity; however, the research falls short of providing a thorough answer to interoperability due to its limited real-world applications and shallow investigation of technical challenges. Social technical issues have not been addressed yet, but they are vital for successfully implementing EMR interoperability (Garlapati and Biswas, 2011).

In their paper, Kasthurirathne et al. (2015) made a valuable contribution to EMR interoperability by showing how Fast Healthcare Interoperability Resources (FHIR) based API can improve the integration of healthcare systems like OpenMRS with other applications. A solid foundation for further exploration of standards-based APIs in healthcare and a roadmap towards better interoperability was stated. One limitation of this study was security. Even with plans to use OAuth for authentication in the future, the implementation indicated that it utilises less secure BASIC authentication. The absence of a thorough explanation of security protocols cannot be ignored since healthcare data interoperability depends heavily on security, and secure data has received more attention.

In their study "Interoperability of Heterogeneous Health Information Systems: A Systematic Literature Review",Torab-Miandoab et al. (2023) discussed the standards, challenges and technologies associated with Health information systems interoperability while focusing on semantic

interoperability. Interoperability was covered widely, addressing standards while also including real-world examples. However, the literature included is up to 2022, which can leave out recent developments in the rapidly growing health IT and interoperability. Also, the absence of quantitative data leaves a gap in assessing the effectiveness of various interoperability frameworks and standards.

This study was done to identify what successful implementers are doing to address the challenge of interoperability and provide a road map to achieve improved patient outcomes, long-term sustainability in the healthcare system, and operational effectiveness.

Methods

This paper adopted a narrative review approach to assess secondary data on successful EMR interoperability implementers' strategies. The scoping was from documents between 2012 and 2024 concerning the strategies used by successful interoperable EMR implementers. The keywords Interoperability, EMR (Electronic Medical Records), Electronic Health Records, Health information exchange, and successful implementation strategies were used. Electronic databases were searched, including EBSCO, Google Scholar, and pertinent healthcare informatics articles. Studies were included in the analysis if they reported interoperability barriers, interoperability opportunities and implementation of interoperable Electronic Medical Records or Electronic Health Records. Studies that were not published in English, before 2012 and those that were out of context and irrelevant to the topic were excluded.

Results and Discussion

It has been shown that interoperability can be successfully implemented using machine learning and artificial intelligence applications. Machine learning has been gaining a lot of traction owing to the ability to sift through vast volumes of low-quality data. It is easier to map complex and intricate interoperability data and their associated terminologies through machine learning. According to Lehne et al. (2019), artificial intelligence is a treasure trove for handling massive data in healthcare interoperability settings. Finding correlations and patterns in high-dimensional interoperability datasets can help clinicians and researchers when looking at high-volume patient data. Ratwani et al. (2018) state that new efforts in healthcare interoperability focus on a handful of well-defined web APIs, including Reusable Technologies (SMART) on FHIR, which leverage machine learning. According to Dunskiy (2024), AI and Machine Learning systems can help process the ever-increasing flow of clinical notes, patient forms, and clinical notes. This helps address most of the healthcare interoperability-related challenges. Additionally, AI can help provide real-time insights regardless of the data source.

Another critical factor in ensuring interoperability is the standardisation of data exchange protocols. Globally, standards such as HL7 (Health Level 7), FHIR (Fast Healthcare Interoperability Resources), DICOM (Digital Imaging and Communications in Medicine), and ICD-10 (International Classification of Diseases) provide the framework for the exchange, integration, sharing, and retrieval of electronic health information(Ndlovu et al., 2021).

FHIR leverages the latest web standards and focuses significantly on the capacity for implementation. FHIR is a standard used in health information technology introduced in 2011 by the Standard Developing Organization, Health Level Seven International (HL7). Braunstein et al. (2018) state that FHIR is based on previous HL7 standards (HL7 versions 2 and 3 and Clinical Document Architecture) and combines their advantages with established modern web technologies such as a Representational State Transfer (REST) architecture, application programming interface (API), XML, and JSON formats; and authorisation tools (Open Authorization). In FHIR, all exchangeable content is defined by distinct basic building blocks—referred to as resources which determine the content and structure of information and can refer to each other using reference mechanisms. The base FHIR specification

serves as a foundation providing basic resources, frameworks, APIs, and a platform in which different solutions can be implemented. To cover information not included in the basic resources, FHIR provides a built-in extension mechanism that can be adapted for specific use cases while ensuring interoperability.

A more recent strategy to address the interoperability challenge is the development of EHR-agnostic platforms. These systems are designed to integrate with multiple EMR solutions, regardless of vendor-specific differences (Latrella & Baldasare, 2024). This reduces the need for healthcare providers to adopt a single EMR system and instead promotes using platforms that can seamlessly interact with various existing solutions. In their study, Latrella and Baldasare (2024) established that to manage its value-based patients in the post-acute situation, St. Joseph's Health established a post-acute nurse navigator, social worker, and care manager roles in addition to implementing a data analytics platform. As a result, a significant reduction in readmission rates was realised, underscoring the importance of interoperability for improved patient outcomes. In their study, Solomon et al. (2023) also confirmed that integrating EHR agnostic platforms enhances interoperability.

Blockchain Technology is another strategy that can be seen as a solution to EMR interoperability and security issues. Kamau et al. (2018) aver that Blockchain offers a decentralised, peer-to-peer solution that could provide seamless interoperability between disparate health systems, enabling efficient data sharing across stakeholders such as hospitals, insurance companies, and researchers. They further state that Blockchain's decentralised nature and cryptographic techniques ensure enhanced security for EMR systems. It can provide secure, verifiable records through a distributed ledger, reducing data breaches or unauthorised access risks. The study advocates for adopting blockchain technology to solve EMR system challenges, especially in developing countries, and focuses mainly on enhancing interoperability, security, and patient empowerment. Schmeelk et al. (2022) also stated in their study that "Our research showed promise in implementing blockchain technology associated with EHRs, especially with Health Information Exchanges". Patil et al. (2024) demonstrated how Hyperledger Fabric was employed in a healthcare system to enhance security and interoperability, enabling different stakeholders to access the same patient data without risking security breaches.

Government regulatory interventions also play an essential role in overcoming interoperability challenges. Governments have begun implementing incentives and regulatory frameworks encouraging healthcare providers to adopt interoperable EMR systems. Such policies promote the adoption of universal standards and provide financial incentives for compliance (Rwegasira et al., 2024). Rwegasira et al. (2024) discuss how government-led initiatives in Tanzania have driven the adoption of integrated EMR systems, significantly improving patient care and data sharing across healthcare facilities. (Gellert et al., 2024) state that the U.S. Health and Human Services developed new incumbrances for information blocking in late 2023, penalising actions that could endanger patients or interfere with healthcare provision. As per the regulations, a hospital may not be eligible for incentives under the Medicare Promoting Interoperability Program, the Quality Payment Program, or the Medicare Shared Savings Program if the Office of Inspector General finds that the institution participated in information blocking.

Social factors such as training are considered a strategy to successfully implement Interoperable Electronic Medical Records. Nsaghurwe et al. (2021) note that extensive training programs were implemented for health workers and technical staff to operate and manage the Health Information Exchange system. This was done to ensure that the government could maintain and expand the system independently.

The figure below presents strategies successful implementers of interoperable Electronic Medical Records (EMRs) use.

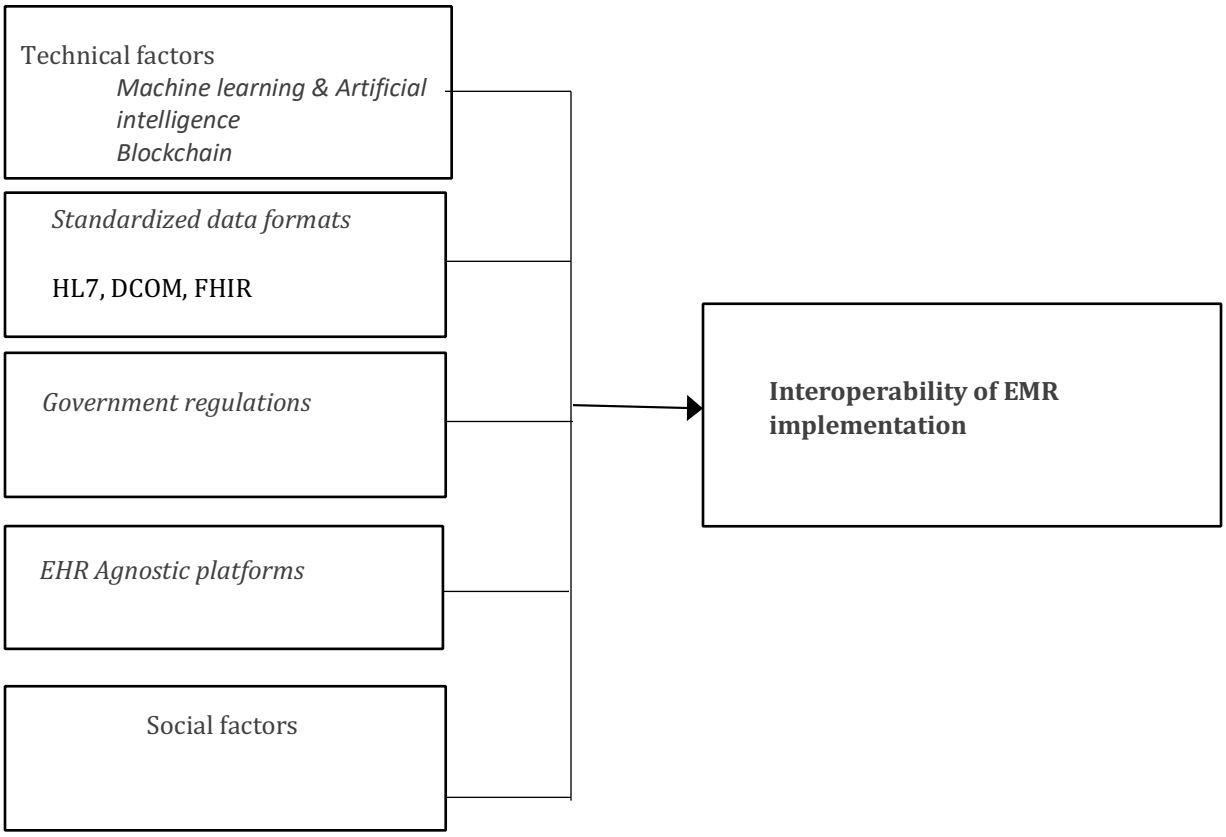

Figure 1: Strategies used by successful implementers of interoperable EMRs (Source: Author, 2024)

Limitations

The authors purposed to do a narrative review. While this is limiting compared to a systematic review, it was agreed that it would still meet the threshold required of the study. A systematic review or scoping review would probably reveal more than stated. Additionally, the study relied on just a few databases, meaning that other databases and repositories could uncover additional studies and offer a more comprehensive reflection of strategies used by successful implementers of EMR interoperability.

Conclusion

Attaining interoperability in EMR systems requires coordinated efforts across technology, organisation, regulatory and social factors. Successful implementers have demonstrated that healthcare systems can overcome integration barriers by adopting standardised protocols, leveraging emerging technologies like blockchain and machine learning, and fostering organisational and policy-level support. As the healthcare landscape evolves, these strategies will be crucial in ensuring that EMR systems fulfil their potential to improve patient care.

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