Investigating Factors of Interoperability of Electronic Medical Record Systems in Hospitals: A Narrative Literature Review

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Abstract

Background: Interoperable Electronic Medical Record (EMR) supports health information exchange from different service systems and provide convenient access to healthcare services. Despite these undisputable benefits, achieving interoperability between EMR systems has always been challenging. This study attempted to investigate factors that influence interoperability of EMR systems in hospitals.

Methods: The study employed a narrative review which involved a systematic search of articles from January 2010 to November 2020. Five electronic databases were searched, which are Science Direct, PubMed, Jstor, IEEE and Google Scholar. Data were analyzed using principles of thematic analysis.

Results: Using keyword search terms, 22609 articles were identified from database searching, whereby 565 articles were retrieved from databases after applying advanced search; the final review comprised of 17 articles which were then used for the study. Eight factors emerged (i) adherence to medical standards, (ii) the existence of medical terminologies and controlled vocabularies, (iii) the use of standardized data types, (iv) adherence to communication channels or protocols, (v) the influence of political supremacy (vi) existence of diverse social background, (vii) legal aspects, and (viii) availability of resources.

Conclusion: This review found that interoperability is possible given that actors will address these factors, which are both organizational and technical.

Keywords: Interoperability; Electronic medical records; Narrative review; Health information system inclusion and exclusion criteria

Introduction

Health Information System (HIS) is a system that manages health information on a national or sub- national scale. With the advent of technology, HIS uses computers to support the various processes involved in managing healthcare service delivery [1] including improved processing of data to deliver information useful for decision-making in the healthcare environments [2]. The major advantage of HIS, therefore, is to contribute to efficient and high-quality healthcare services [3]. In hospital settings, HIS are coordinated through Electronic Medical Record (EMR) systems [4]. These are HIS through which patient detailed information such as demographic, medical health history, and laboratory results are recorded by healthcare service providers [5,6]. EMR systems assist healthcare providers to streamline the flow of patients' information and its accessibility [7]. Hospitals which manage medical records electronically use different EMR systems [8]. These differences in EMR can be within one hospital where different sections like the outpatient department, reproductive health, pharmacy, and laboratory, all have different systems. Or it can be between hospitals, where one hospital has one system and a higher referral hospital has another. One of the key challenges standing in the way of reaping the benefits of EMRs is poor interoperability among different systems forming EMRs within a particular hospital or across related hospital units.

Many attempts towards interoperability have ended up in futility despite the agreed benefits of interoperability. Several researchers have therefore differently engaged the interoperability question. The field has therefore been under the attention of research over many years. For instance, [9] conducted a study on breaking the healthcare interoperability barrier in the healthcare system in Canada, and [10] did the study on technical interoperability solutions among electronic health record systems for public health organizations in Brazil.

Although these studies have given light upon factors that influence interoperability, there still lacks a comprehensive understanding of factors which influence the achievement of interoperable HIS, especially in the hospital settings. This study contends that there is a need to have a comprehensive understanding of what influences interoperability, both positively and negatively. The research question that is addressed is: "what factors influence the achievement of interoperability of electronic medical record systems?" The study engages this question through a narrative literature review to understand these factors. The study contributes to the discourses on interoperability by enhancing clarity on the relating components of interoperability, generally, and identifying factors for interoperability, in particular.

Literature Review

Interoperability and EMR systems

Several definitions exist on the term "Interoperability" depending on different contexts in different studies. Interoperability is the ability of different information systems, devices, or applications to cooperatively use and exchange health information and services that ensures continuity of care within and across organizations [9,11,12]. Further, Braa and Sahay define interoperability as the ability to exchange information between two or more systems [13]. In 1990, however, the IEEE defined interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [14].

Interoperable EMR systems are systems that allow information sharing, providing continuous workflow of service, integrated information flow, and enabling healthcare decision making, hence promoting wellness and improving health outcomes [15,16]. Interoperability, in the hospital settings, is the ability of heterogeneous EMR systems and computer applications to communicate and exchange information accurately, effectively, consistently, and use the exchanged information [3]. It is a key feature in the hospital HIS because in order to accomplish effectiveness, efficient, and coordinated care, information must be shared between healthcare organizations, doctors, pharmacists, nurses, and patients [17,18].

In the health sector generally and the EMRs in particular, interoperability is a significant endeavor because the sector is relatively more complex and highly politicized [19]. This complexity and politicisation mean several electronic systems serving related purposes [20]. Interoperable systems, therefore, provide a common view of important information for a patient to any healthcare provider involved in the circle of care [9]. Interoperable EMR systems lead to the provision of high-quality health information as they cover information across a wide range of systems, and provide fast and convenient access to healthcare services and cost reduction [21,22]. Interoperability of EMR has many advantages such as contributing to appropriate decision-making that in turn improve the health of clients [18,20,23]. Additionally, there is saving of time, reduction of costs, increased transparency and improved quality of the service offered [3,24,25]. This also includes better compilation of a patients' information such that an overall health status of the patients is observed [21,26], hence enabling different EMR systems from different providers to communicate and share resources [26].

Narrative literature review

A narrative literature review is a research strategy in which previous research is systematically gathered and synthesized [27,28]. The narrative review reports the author's findings in a condensed manner that summarizes the contents of the reviewed articles, with the goal of objectively presenting the current state of knowledge on a topic, based on previously published research [29]. The integration of findings and viewpoints from various empirical discoveries results in a more efficient manner of answering research issues, which is accomplished through already published publications. The advantage of a narrative review is that it enables a researcher to save time when examining or seeking information [28,30,31]. In narrative review, a researcher has the advantage to read the reviewed articles rather than wasting time going through a large volume of literature. It also provides information for decision-makers and researchers who utilize narrative reviews of literature to find, justify, and develop ideas, as well as recognize and avoid previous research pitfalls. Additionally, a narrative literature review can be used to validate assumptions, get insight into the dynamics that underpin other studies' conclusions, and provide more conclusive results than a single primary research study.

A typical narrative literature review comprises the following structure [28]: (1) Literature search, (2) Search terms, (3) Selection criteria (4) Critical assessment and (5) Writing the review. The literature search phase specifies search databases to employ in the search and defines the selection bias. Appropriate search terms are identified in such a way that they allow selection of all relevant articles while also excluding those that are not. Inclusion and exclusion criteria for literature selection can support in focusing on the research relevance to the topic during the selection criteria phase. The exclusion criteria are determined based on the relevance of the search target, whereas the inclusion criteria establish the key elements of the review. Critical assessment evaluates the articles according to key results, limitations, suitability of the methods used to test the initial hypothesis, quality of the results obtained, interpretation of the results, and impact of the conclusion in the field [28]. This article's Materials and Methods section explains how each of these processes was accomplished.

Materials and Methods

Literature search

To investigate what influences interoperability of EMR in hospitals, a literature search was carried out from August to November 2020. The last search was done on 26th November 2020. The search was performed from the following electronic

databases: Google Scholar, PubMed, Jstor, Science Direct and IEEE as indicated in Table 1. These electronic databases were chosen because they provide health informatics databases including EMR systems, and offer a set of search options for enhancing reference retrieval. The search used the terms ("electronic medical records" OR "electronic health records" OR "patient health records" OR "Hospital Information System" OR "Health Information System") AND (interoperability OR interoperable) and advanced search was such that the article title should include the term/keyword ("Interoperability").

Table 1: Literature search factors influencing interoperability of EMR.

Name of Search Engine	All Hits	Advanced Search Title Include (Interoperability)	Matching Titles	Matching Abstract
Science Direct	2752	88	23	11
Pubmed	1099	212	63	22
Jstor	473	19	1	0
IEEE	685	131	33	18
Google Scholar	17600	115	77	31
COUNT	22609	565	197	82

Inclusion/exclusion criteria

Search terms were identified to formulate the most inclusive search. The retrieved literature was screened for eligibility according to pre-specified inclusion and exclusion criteria as shown in Table 2.

Table 2: Inclusion and exclusion criteria.

Inclusion	Exclusion
Articles published in English between 2010 and 2020	Grey literature, thesis, and dissertation
Articles whose titles include interoperability	Commentaries, conference abstracts, editorials, opinions, perspectives, and peer reviews.
Articles titles specifically related to health	Articles without abstract

Search results and study selection strategy

The initial search yielded 22609 articles from database search. The statistics of the search from the databases was based on the search criteria used. However, these results needed to be screened to remove all articles that were irrelevant to the study. By applying advanced search criteria, a total 565 articles were retrieved from databases. Out of those, 368 articles were excluded by the title criterion, while 115 articles were excluded by the abstract criterion. The remaining 82 articles were considered for the study, and 9 articles were added from other sources, hence making a total of 91 articles. From the 91 articles, 5 articles were theses/dissertations, 4 articles were editorials/opinions/perspective/peer review, and 3 articles had no method defined; 11 articles were duplicates and 51 articles were found not to be relevant to the study. Thus, 17 articles were included in the analysis. Figure 1 depicts the search process.
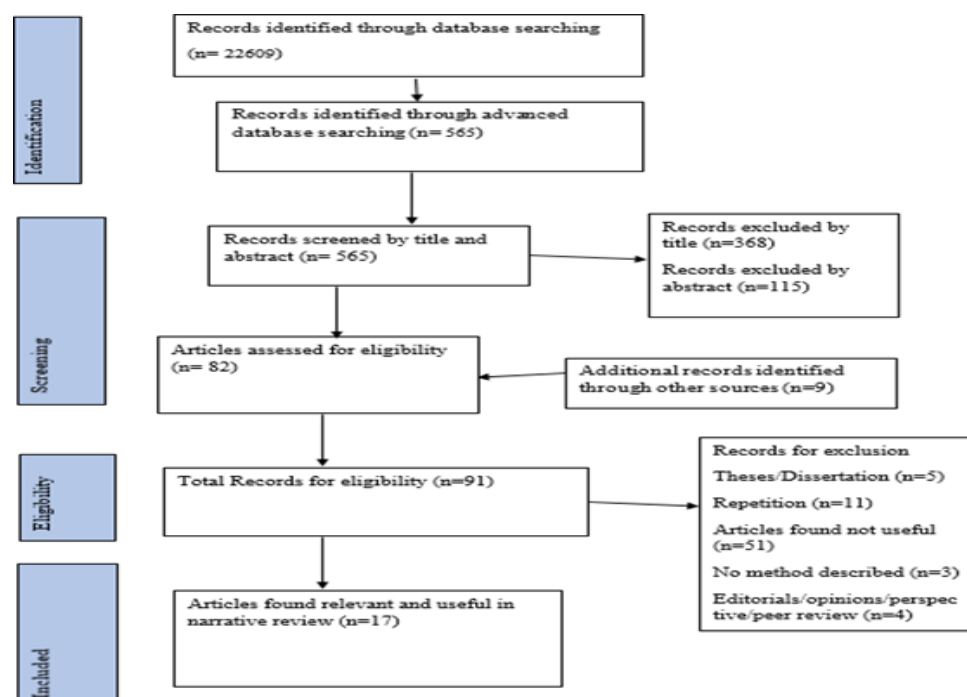

Figure 1: Flowchart of the literature search process.

Result

Seventeen (17) articles were found to be relevant to the study, in which eight (8) were empirical studies and nine (9) were non-empirical studies. Hence, factors that influence interoperability were derived from these 17 articles from the reviewed literature. Initial results show that authors have categorized interoperability based on different layers: technical, semantic, organizational, and legal layers. Hence, from the identified articles, two (2) considered the technical layer; five (5) considered the semantic layer; and only two (2) focused on semantic and technical layers. However, one (1) article considered semantic, technical, organizational, and legal layers, while six (6) articles combined semantic, technical, organizational, and legal layers, including other generic factors such as cultural and resources. Table 3 presents the matrix of the different interoperability layers reported by respective authors. The different interoperability layers are hence described in Section 4.1.

Table 3: Identified interoperability layers by authors.

Interoperability Layer	Author (Year)
Semantic	1. Ojeda-Carreño et al. [40]
	2. Adel et al. [42]
	3. Janaswamy & Kent [50]
	4. Hammami et al. [44]
	5. Naveed et al. [49]
Technical	1. Souza et al. [10]
	2. Frisse [47]
Semantic and technical	1. Sachdeva & Bhalla [37]
	2. Adel et al. [45]
Semantic, technical, organisational, and legal	1. Botts et al. [61]
Technical, organisational, and legal	1. Edmunds et al. [8]
Semantic, technical, organizational, legal, and generic factors (cultural and resources)	1. Hammond [48]
	2. Atalag et al. [34]
	3. Kobusinge [38]
	4. Soceanu et al. [62]
	5. Beštek & Stanimirović [39]
	6. Barbarito et al. [60]

Layers of interoperability

Health organizations and researchers have defined interoperability layers in different ways. Kuziemsky [32] and Benson [33] report three layers of interoperability: technical, semantic, and process interoperability. European Interoperability Framework (EIF) breaks down interoperability into four layers; semantic (information and service sharing), technical (data and message exchange), organizational (business unit), and legal layer, which ensures that organizations operating under different legal frameworks, policies, and strategies can work together [18]. The Healthcare Information and Management Systems Society (HIMSS) defines "interoperability as the ability of health information systems to work together within and across organizational boundaries to advance the health status of, and the effective delivery of healthcare for, individuals and communities" [34,35]. HIMSS defines three layers of health information technology interoperability; foundational, structural, and semantic interoperability [36].

Although these layers can slightly be different across definitions, they generally follow a distinction between lower-layer technical components and higher-layer organizational components. In line with this conceptualization, [25] defines four layers of interoperability which are technical, syntactic, semantic, and organizational aspects of interoperability. Thus, the identification of factors that influence interoperability in this study mainly adopts EIF because it covers all layers addressed by other health organizations and researchers. Layers of interoperability defined include; technical layer, semantic layer (which covers both semantic and syntactic aspects), organizational layer, and legal layer.

Critical analysis of results

It was found from the articles that interoperability of EMR systems can be based on different layers. While one author may place a factor under a certain layer, another author places the same factor under a different layer of interoperability. Moreover, other scholars have grouped such factors like medical standards, medical terminologies and controlled vocabularies, data types, communication channels, and communication protocols as standards [34,37], standards which further subdivided into:

i.   Message or interface standards: Health Level 7(HL7) [HL7 2010]; Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT); and Digital Imaging and Communications in Medicine (DICOM).

ii.   Content-oriented standards: Logical Observation Identifiers Names and Codes (LOINC); The International

Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10); International Classification of Procedures in Medicine (ICPM).

iii. Hybrid standards: CEN 13606 and open EHR.

It was also found from the study that some scholars have identified factors that influence interoperability without addressing the layers of interoperability [8,38,39]. These factors are referred as general factors or generic factors that influence interoperability. Hence, this study revealed that factors that influence interoperability may be associated with both the layer concept as well as with generic factors. From the reviewed literature, the study takes on the combination of findings in terms of layers of interoperability and generic factors. Factors that influence interoperability from the identified articles are presented in Table 4.

Table 4: Factors that influence interoperability from articles reviewed.

Article Name	Factors That Affect Interoperability
1. Atalag et al. [34]	1. Business drivers and leadership
	2. Organisational and legal
	3. Social and political
	4. Standards
2. Sachdeva & Bhalla [37]	1. Message or interface standards (HL7)
	2. Content-oriented standards (ICD 10)
	3. Hybrid standards (openEHR).
	4. Data types and messaging formats (XML, ASCII, integer, string) and shared coding
	5. Medical Terminologies
3. Barbarito et al. [60]	1. Medical standards
	2. Political and guidelines
	3. Technological infrastructure for data sharing
	4. Organization and law
4. Soceanu et al. [62]	1. Medical standards
	2. Political context and strong government
	3. Policy and regulations
5. Botts et al. [61]	1. Policies and organization
	2. Medical terminologies
	3. Communication standards
6. Hammami et al. [44]	1. Existence of many terminologies
	2. Lack of uniform data standards
7. Edmunds et al. [8]	1. Technical
	2. Legal, and organizational
	3. Financial and cultural factors
8. Janaswamy & Kent [50]	1. Standards
	2. Differences in formats, data types, programs, and DBMS
9. Ojeda-Carreño et al. [40]	1. Medical standards (HL7 and DICOM)
	2. Medical terminologies and controlled vocabularies (ICDx)
10. Beštek & Stanimirović [39]	1. Standards (FHIR and Open EHR)
	2. Medical terminologies (ICD10)
	3. Political, and regulatory
11. Frisse [47]	1. Communication protocols (HTTP, SOAP, REST)
12. Hammond [48]	1. Medical terminologies and controlled vocabularies (ICD, SNOMED-CT)
	2. Medical standards (HL7, SMART® on FHIR, CDS Hooks)
	3. Organizational, and policies
	4. Governance
13. Naveed et al. [49]	1. Medical Terminologies
	2. Interoperability standards
14. Souza et al. [10]	1. Interconnection between systems
	2. Interoperability standards

15. Adel et al, [42]	1. Communication protocol
	2. Medical terminologies and controlled vocabularies
16. Adel et al. [45]	1. Differences in standards, programs, and DBMS
17. Kobusinge [38]	1. Interoperability standards
	2. Contextual factors (Policy and Resources).

Findings

The study identified eight (8) factors in the category of technical and non-technical factors as per summarized in Table 5. These factors are: adherence to medical standards, the existence of medical terminologies and controlled vocabularies, the use of standardized data types, adherence to communication channels or protocols, political contexts, the existence of diverse social background, legal aspects (law, policy, rules, and regulations) and availability of resources. Table 6 shows the linkage between the Categories, EIF layers and factors that influence interoperability.

Table 5: Technical and non-technical factors that influence interoperability.

Category	Factors that Affect Interoperability
Technical	1. Adherence to medical standards
	2. The use of medical terminologies and controlled vocabularies
	3. The use of standardized data types
	4. Adherence to communication channels or protocols.
Non-Technical	1. The influence of political supremacy
	2. Existence of diverse social backgrounds (customs, constructs, beliefs, desires, and practices among people)
	3. Legal aspects (Law, Policy, Rules, and Regulations)
	4. Availability of resources (money, time, and labour)

Table 6: Categories, EIF layers and factors that influence interoperability.

Category	Eif Layers	Factors that Affect Interoperability
Technical	Semantic	1. Adherence to medical standards
		2. The use of medical terminologies and controlled vocabularies
		3. The use of standardized data types
	Technical	1. Adherence to communication channels or protocols.
Non-Technical	Organizational	1. The influence of political supremacy
		2. Existence of diverse social background (customs, constructs, beliefs, desires, and practices among people)
		3. Availability of resources (money, time, and labour)
	Legal	1. Legal aspects (Law, Policy, Rules, and Regulations)

Description of factors that influence interoperability

Adherence to medical standards: Medical standards provide a common language and a common set of expectations that allow interoperability between systems and/or devices [33]. Medical standards are defined as standards used in the medical industry to store or communicate information to other systems [12]. Medical standards are approved by a recognized body, which contains repeated practice, rules, and guidelines in a medical setting [4,40]. Adherence to medical standards ensures the communication is faultless and uniform as medical information is shared from doctors and nurses, laboratories, pharmacies, billing departments, insurance companies, and from one hospital to another hospital [12,33,41]. Also, the implementation of common standards has been suggested to facilitate different levels of interoperability within or across health care settings [22]. On the other hand, failure to adhere to medical standards results in a lack of interoperability of EMRs since EMRs rely greatly on medical standards [9,42]. Examples of medical standards are Health Seven Level (HL7) and DICOM.

The existence of medical terminologies and controlled vocabularies: Medical terminology and controlled vocabulary play a major role in the interoperability of EMRs between hospitals and hence facilitate sharing of medical information. Shared medical terminologies refer to establishing a shared vocabulary for the interchange of medical information [37,43]. Medical terminologies allow for representing medical statements in a formalized way and are vital for implementing automated search and medical processing; for example, drug interaction check, medical/workflow controlling, reporting, payment, search/index/query [43]. Medical terminology is defined as a set of classes each representing a concept in the medical arena. A class may also be called a term or vocabulary (sets of terms and meanings) [43]. According to Hammond, lack of medical terminologies and controlled vocabularies may result in ineffective communication between EMR since communication between EMR relies on medical terminologies and controlled vocabularies. Therefore, failure to adhere to medical terminologies results in poor interoperability between EMR systems [22,44]. Some common vocabulary standards currently used in the marketplace

include SNOMED-CT, LOINC, and ICDx, where x can be version 9 or 10 [45]. The definitions of these common vocabulary standards are:

i. ICD-10 and ICD-11: The International Statistical Classification of Diseases and Related Health Problems (ICD) is a medical classification list by the World Health Organization (WHO). It contains codes for diseases, signs and symptoms, abnormal findings, health management, complaints, social circumstances, and external causes of injury or diseases [12]. According to the WHO, the 11th revision will replace the ICD-10 in January 2022 [46].

ii. Logical Observation Identifiers Names and Codes (LOINC®): A universal code system for identifying health measurements, laboratory observations, and documents [12]. These codes represent the "question" for a test or measurement [47]. LOINC codes can be grouped into laboratory and clinical tests, measurements, and observations [48].

iii. Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT): A comprehensive clinical health terminology product. It enables a consistent and processable representation of clinical content in electronic health records (EHRs) [12]. These codes often represent the "answer" for a test or measurement to the LOINC "question" code [47,49].

The use of standardized data types: Data types refer to the categories of data exchanged by EMR systems. Interoperability requires EMR systems to share data types on different messaging formats, for example XML and ASCII; programming languages, for example integer and string, and different database management systems [37,42,50]. The use of standardized data types supports interoperability of EMR systems, hence enables sharing of medical information, while unstandardized data type leads to a lack of interoperability, hence transferring of medical information from one system to another becomes a challenge [51]. Information stored in an EMR system may be either medical or non- medical data, hence EMR systems must have the ability to contain both structured and non- structured data [42,52].

Adherence to communication channels or protocols: Adherence to communication channels or protocols enables EMR interoperability [47]. According to Lehne M et al. [25] moving health information from one point to another requires communication channels and protocol for health information transmission. Emerging and widely used standards for the communication of health information include HL7's Fast Healthcare Interoperability Resources (FHIR) and Open EHR for the structured exchange of health information [53]. Open EHR defines medical content using the so-called architecture or models and specifications of clinical concepts based on an underlying reference model. Interoperability architectures are models which make use of different technologies and standards. Failure to adhere to architectures that provide a communication channel for health information leads to lack of interoperability among EMR systems [10].

There are communication standards outside the healthcare space that are also useful [12], for example, Application Programming Interfaces (APIs) which allow users to enable data transfer and workflows. Many web-based applications support APIs for information transfer and interoperability. Fast Healthcare Interoperability Resources is an API for exchanging health- related information. Different types of API styles that can use to integrate digital health information include SOAP (Simple Object Access Protocol), REST (Representational State Transfer) and GraphQL [12,36].

The influence of political supremacy: Political contexts play a major role in influencing interoperability since it is necessary for successful planning and interoperability implementation [12]. Without considering political supremacy as a factor that influences interoperability will lead to difficulty in approval of interoperability medical standards and communication standards [12]. Also, political contexts include the need for EMR systems to be designed in accordance with national directives and manners that drive HIS initiatives [32]. Political participation involves individuals or parties who have authority in an organization, hence they determine policy decisions on EMR interoperability, the direction and strategies of the organization [54].

Existence of diverse social background: The existence of diverse social mores, customs, constructs, beliefs, desires, and practices among people in a certain community affect the ability of hospitals to achieve complete interoperability [55,56]. Social aspects have a great influence on EMR systems interoperability [9,33,57]. Social aspects include the underlying cultural issues about hospital-to-hospital and hospital-patient health information sharing [8,20]. Social aspects influence how information is acquired and used in a healthcare setting [32], building relationships and agreement across stakeholder groups about which health information should be collected and what formats should be used [58]. However, social aspects behaviors can be regulated using law [34].

Legal aspects (law, policy, rules and regulations): Legal factors have a great influence on interoperability and can become an obstacle in any interoperability initiative [54]. Organisations are subjected to certain laws, rules and regulations that govern them. These laws could be in the form of policies since a policy, regardless of its scope, expresses a clear rule of law [59]. Policies concern with systems development, system integration and interoperability, health information sharing, and privacy of sensitive health data, among others [60]. Such policies, once established, could help direct EMR interoperability implementations within a country [38]. Discussions on legal structures for a standard are arguably as important as discussions about the appropriate choice of a standard [61]. A governing body that builds interoperability standards must ensure that it complies with the regulations and privacy requirements [9,62]. Interoperability standards need to be managed and legally enforced by the governing body or leadership responsible for the healthcare system. It is believed that strong leadership results in better standards with complete applicability [34].

Availability of resources: Resources that influence EMRs interoperability include money, labour (skilled human resources), and time, among others [63]. Availability of these resources greatly

influences interoperability and lack of such resources leads to difficulty in achieving EMR interoperability [38]. According to Edmunds M et al. [8], implementation of interoperable EMRs between hospitals should be aligned with financial incentives because they have to invest in systems that will make it easier for others to achieve cost savings. EMR interoperability reduces duplicative tests and procedures and thereby reduces healthcare costs; hospitals would likely lose revenue when duplicative tests or procedures were avoided [8].

Conclusion

This narrative review of literature has sought, retrieved and described factors that influence interoperability of EMR systems in hospitals. Interoperability of EMR systems support the flow of health information which greatly contribute to appropriate decision-making that will in turn improve the health of citizens. Based on the findings of the review, factors that influence interoperability are necessary to be considered to support interoperability efforts and contributions to their success. These factors are: adherence to medical standards, the existence of medical terminologies and controlled vocabularies, the use of standardized data types, adherence to communication channels or protocols, political contexts, the existence of diverse social backgrounds, legal aspects (law, policy, rules, and regulations) and availability of resources. The findings of this study add to the literature, and contribute to the body of knowledge on interoperability of EMR systems.

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