REVIEW ARTICLE

Electronic Health Record Impact on Data Quality: An Integrated Review

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Abstract

Background: Few studies have assessed the impact of Electronic Health Record (EHR) on data quality and how it has impacted timeliness, accuracy, availability, integrity, consistency and uniqueness of health data. Assessing the current gaps between electronic health record utilisation in relation to enhancing data quality can help to identify and recommend key measures to improve healthcare delivery.

Objective: This review examines the impact of electronic health record on data quality, and proposes recommendations desirable to improving healthcare delivery.

Materials and methods: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Integrative Review Frameworks (IRF) were adapted as a sign post for the study. These frameworks guided literature search, data analysis and presentation of findings. Boolean AND/OR operators were combined with search terms to increase relevant search results. Six (6) electronic databases that were used for literature search are Scopus, Web of Science, Science Direct, PubMed, ProQuest and Google Scholar. Searched articles were between 2012 to 2022, with the exception of two articles on the Technology Acceptance Model (TAM) published in 1986 and 1975.

Results: EHR implementation impact key health outcomes and contribute to timely and complete data submission. Implementation of Electronic Health Systems (EHS) embellish consistency, completeness, accuracy and integrity of clinical data significantly through embedded interoperability solutions. By reducing the scope of manual reviews, integrating a technology that automates data integrity and quality checks into EHR may potentially lessen the strain of maintaining data quality.

Conclusion: Our findings depict that interoperability of clinical data sources will ensure consistent, timely and available health data when using EHR. The automated data integrity and consistency checks in the EHR improve data quality. The study contributes to advancing the theory of Technology Acceptance Model (TAM) in electronic health records and its impact on data quality in healthcare delivery.

Keywords: Electronic Health Record, Data Quality, eHealth, Health Data, Quality Healthcare

Introduction

Few studies have examined the impact of EHR on data quality (Kutney-Lee et al., 2019). There have been initiatives to mitigate data quality issues, yet, data quality issues remain unresolved due to data popularity and open data (Nikiforova, 2020). As postulated by Ali et al., (Ali et al., 2018), data that are relevant, accurate, valid, readable, trustworthy, complete, and available when needed by decision-makers for healthcare delivery and planning purposes are referred to as having high data quality. Health data use for decision-making in the health industry has been hampered by concerns about the quality of the information (Rumisha et al., 2020). Monitoring, analyzing, and optimizing the delivery of healthcare services and programs requires precise and reliable health information. (Mphatswe et al., 2012).

Paper-based record systems are prone to data quality defects, hence, the need to implement EHR to address these limitations (Adane et al., 2021). Low-and-medium-income countries (LMICs) are implementing EHR systems with the aim of enhancing quality of clinical data, which will improve health reporting and clinical practice (Ngugi et al., 2021). The implementation of these healthcare systems are mostly affirmed by the Technology Acceptance Model (TAM) proposed by Davis1 (Davis, 1986) as a well-known and well-accepted theory used to understand how new technologies and improvements in information and technology systems are accepted. Its elements are known to predict, explain, and govern acceptance in early TAM research (Fishbein and Ajzen, 1975). To support the idea of innovations, in healthcare systems researchers ultimately use the TAM model.

EHR adaption or adoption results in quality and safer care in hospitals (Kutney-Lee et al., 2019). Integrating data mining systems into electronic health records can ensure real-time access to relevant clinical information (Mohd Nor et al., 2019). Also, implementing electronic health record with standardised and structured recording of patient data may enhance data usability. It is essential to indicate that, standards set forth by the local government, such as data sharing protocols can affect data timeliness, which is a dimension of data quality (Tran et al., 2022). Electronic health record also has limitations that may influence the quality of health data (Makeleni & Cilliers, 2021). Lack of feedback from an electronic health record can lead to complacency at operational level, which may negatively affect data quality (Gumede-Moyo et al., 2019). Healthcare Professionals in high-income countries like United States of America find data entry and information retrieval using EHR as time consuming (Kutney-Lee et al., 2019). Funding gaps during implementation or post-implementation of electronic health record can result in data collection disparities, negatively affecting data completeness (Gumede-Moyo et al., 2019). Based on the above expeditions, this study seeks to examine the impact of electronic health record on data quality, and propose recommendations for improving healthcare delivery.

Methods

PRISMA and IRF were adopted to guide this study. These frameworks guided literature search, data analysis and presentation of findings. Boolean AND/OR operators were combined with search terms to increase relevant search results. Six (6) electronic databases that were used for literature search are Scopus, Web of Science, Science Direct, PubMed, ProQuest and Google Scholar. These databases were selected due to their reliability, the amount of data they keep, and the importance of the articles they contain with reference to data quality management and electronic health records. Several features of data collected in the healthcare sector are still obscure, and research expertise on its influence on data quality is still being developed. Quantitative, qualitative and mixed-method studies, which were published in peer-review journals that focused on the themes: electronic health record, health data, data quality, eHealth and healthcare were downloaded.

Text Selection

Searched articles were between 2012 to 2022, with the exception of two articles on the Technology Acceptance Model published in 1986 and 1975. After a meticulous search from six databases 1258 studies were identified. Mendeley reference management system was used to eliminate 563 duplicate papers. The inclusion criteria of the study were applied to screen the title, keywords and abstracts of the remaining 695studies. Post screening, 113 articles remained for full text evaluation. The inclusion criteria were that, literature must be:

- published between the periods of 2012 to 2022, except articles on TAM.
- relevant to study title, keywords and objectives.
- written in English Language.
- a peer-review journal paper.

Twenty-eight articles were selected, after 85 articles failed to meet the inclusion criteria. Table 1 shows the chosen databases, number of identified studies, number of included studies and the various percentages from the chosen databases. Figure 1 also shows the PRISMA flow for the process of selecting articles with the inclusion and exclusion criteria.

Table 1: Databases, Number of Identified and Included Studies, and Percentages of Included Studies

Electronic Databases	Number of Identified Studies	Number and Percentage of Included Studies
Scopus	304	9(32)
Web of Science	111	4(14)
Science Direct	102	3(11)
PubMed	191	5(18)
ProQuest	209	3(11)
Google Scholar	341	4(14)

Methodological Quality of Studies

To determine the quality of a selected study, five questions were posed requesting 'Yes' or 'No' response such as:

i. Has the objective of the study been clearly stipulated?

ii. Does the article address any thematic area of this study?

iii. Will inclusion of this article help attain the objective of this study?

iv. Were the findings of the study well elaborated?

v. Were data analysis adequately robust?

The quality assessment studies based on the criteria identified 28 studies as shown in table 2.

Results

In all, twenty-eight articles were included in this study. The included articles were categorised into four themes, excluding the two articles on TAM included in the introduction. Six articles representing 23% elaborated on
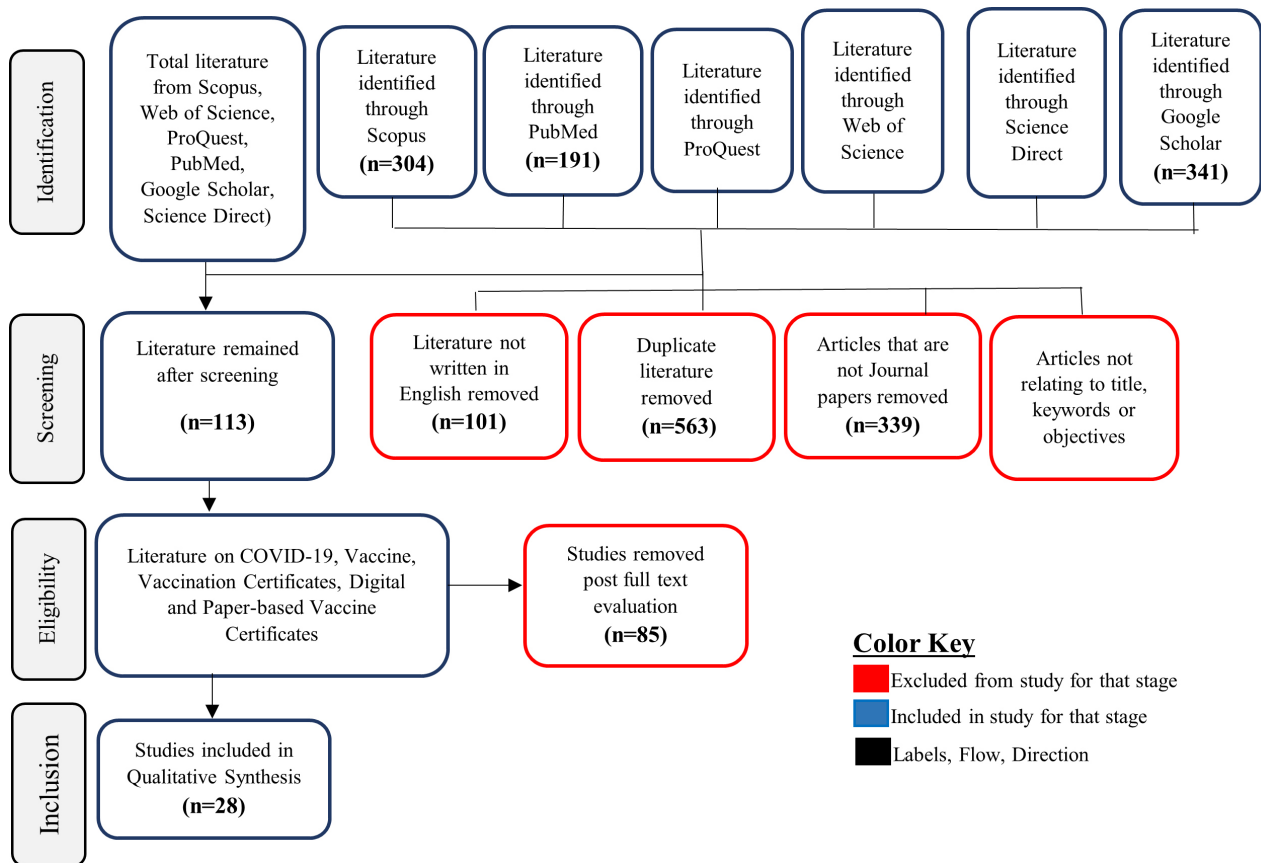
Figure 1: PRISMA Flow for Process of Article Inclusion and Exclusion

Table 2: Methodological Quality of Studies

	Studies	i	ii	iii	iv	v	Scores
1	(Nikiforova, 2020)	Yes	Yes	Yes	Yes	Yes	5/5
2	(Rumisha et al., 2020)	Yes	Yes	Yes	Yes	Yes	5/5
3	(Mphatswe et al., 2012)	Yes	Yes	Yes	Yes	Yes	5/5
4	(Adane et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
5	(Ngugi et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
6	(Kutney-Lee et al., 2019)	Yes	Yes	Yes	Yes	Yes	5/5
7	(Shiferaw et al., 2018)	Yes	Yes	Yes	Yes	Yes	5/5
8	(Ali et al., 2018)	Yes	Yes	Yes	Yes	Yes	5/5
9	(Atinga et al., 2020)	Yes	Yes	Yes	Yes	Yes	5/5
10	(Agniel et al., 2018)	Yes	Yes	Yes	Yes	Yes	5/5
11	(Tizifa et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
12	(Tian et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
13	(Makeleni & Cilliers, 2021)	Yes	Yes	Yes	Yes	Yes	5/5
14	(Kpobi et al., 2018)	Yes	Yes	Yes	Yes	Yes	5/5
15	(Artis et al., 2017)	Yes	Yes	Yes	Yes	Yes	5/5
16	(Gumede-Moyo et al., 2019)	Yes	Yes	Yes	Yes	Yes	5/5
17	(Tran et al., 2022)	Yes	Yes	Yes	Yes	Yes	5/5
18	(Roomaney et al., 2017)	Yes	Yes	Yes	Yes	Yes	5/5
19	(Hutchinson et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
20	(Moukénet et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
21	(Joukes et al., 2019)	Yes	Yes	Yes	Yes	Yes	5/5
22	(Monda et al., 2012)	Yes	Yes	Yes	Yes	Yes	5/5
23	(Mohd Nor et al., 2019)	Yes	Yes	Yes	Yes	Yes	5/5
24	(Walcott-Bryant et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
25	(Thuraisingam et al., 2021)	Yes	Yes	Yes	Yes	Yes	5/5
26	(Bhattacharya et al., 2020)	Yes	Yes	Yes	Yes	Yes	5/5
27	(Davis, 1986)	Yes	Yes	Yes	Yes	Yes	5/5
28	(Fishbein and Ajzen, 1975)	Yes	Yes	Yes	Yes	Yes	5/5

the introduction and background of electronic health record and data quality. Articles that expounded on the positive impact of electronic health record on data quality were 6 (23%). Again, 7 (27%) of the total included papers scrutinised limitations of electronic health record with regards to data quality. Also, the remaining 7 (27%) of the papers proposed recommendations to mitigate the identified limitations of electronic health record with regards to data quality.

Included articles in the summary characteristics were from 19 different countries. Table 3 shows the distribution of countries with included studies.

All chosen articles for the study had similar characteristics, this has been summarized in Table 4 with the captions, year of publications, citation of authors, study location, title of the articles and some key findings identified in each article. The various articles have also been segmented based on a colour code system in the table.

Table 3: Distribution of Included Studies Based on Themes (Excluding Articles on TAM)

Colour Key	Description	Number of Included Studies (%)
	Introduction and Background to Electronic Health Record and Data Quality	6 (23)
	Positive impact of Electronic Health Record on Data Quality	6 (23)
	Identified Limitations of Electronic Health Record with regards to Data Quality	7 (27)
	Recommendations to mitigate the limitations of Electronic Health Record with regards to Data Quality	7 (27)

Table 4: Distribution of Countries of Included Studies in the Summary Characteristics

Countries	Included Articles	Countries	Included Articles
South Africa	4	Vietnam	1
United States of America	3	Zambia	1
Kenya	3	China	1
United Kingdom	2	Australia	1
The Netherlands	2	Malaysia	1
Ethiopia	2	Chad	1
Ghana	1	Pakistan	1
Tanzania	1	Latvia	1

Table 5: Summary Characteristics of Studies Included

Year of Publication	Author Name	Study Location	Title	Key Finding
2020	Nikiforova,	Faculty of Computing, University of Latvia, Latvia.	Definition and evaluation of data quality: user-oriented data object-driven approach to data quality assessment.	Data quality issues have existed since 1960's. Data Quality issues remain unresolved due to data popularity and open data.
2020	Rumisha et al.,	National Institute for Medical Research, Tanzania.	Data quality of the routine health management information system at the primary healthcare facility and district levels in Tanzania.	Data utilisation for decision-making in the health industry has been hindered by worries about the accuracy of health information.
2012	Mphatswe et al.,	Department of Paediatrics and Child Health, University of Kwazulu-Natal, South Africa.	Improving public health information: a data quality intervention in Kwazulu-Natal, South Africa.	For the purposes of monitoring, assessing, and improving healthcare service delivery and programmatic initiatives, accurate and reliable health information is crucial.
2021	Adane et al.,	Ethiopian Pharmaceutical Supply Agency, Addis Ababa, Ethiopia.	Exploring data quality and use of the routine health information system in Ethiopia: a mixed-methods study.	Paper-based record systems are faced with issues like availability of register books, variations in choice of denominators based on population estimates, hence, the need to implement EHR to address these limitations.
2021	Ngugi et al.,	Institute of Biomedical Informatics, Moi University, Kenya.	Development of standard indicators to assess use of electronic health record systems implementation in low-and medium-income countries.	Low-and-medium-income countries (LMICs) are implementing EHRs with the aim of enhancing quality of clinical data, which will improve health reporting and clinical practice.
2019	Kutney-Lee et al.,	Center for Health Outcomes and Policy Research, University of Pennsylvania, USA.	Electronic health record adoption and nurse reports of usability and quality of care: the role of work environment.	Few studies have examined the impact of EHR on data quality. EHR adoption results in safer and quality care in hospitals.

2018	Shiferaw et al.,	Addis Ababa University, Ethiopia.	Designing mHealth for maternal services in primary health facilities in low-income setting: lessons from a partially successful implementation.	Implementation of EHR can impact key health outcomes and contribute to timely and complete data submission.
2018	Ali et al.,	Mercy Corps, Pakistan.	Data quality: a negotiator between paper-based and digital records in Pakistan's TB control program.	Digital records have minimal data quality issues as opposed to paper-based records that have relatively higher data quality issues. More useful information for decision-making can be delivered by maximizing mobile data capture using continuous EHR data quality assessment.
2020	Atinga et al.,	University of Ghana, Ghana.	E-health usage and health workers' motivation and job satisfaction in Ghana.	Electronic health usage in Ghana has led to timely access to health information, such as patients' and administrative records, and diagnostic and treatment records.
2018	Agniel et al.,	Department of Biomedical Informatics, Harvard Medical School, USA.	Biases in electronic health record data due to processes within the healthcare system: retrospective observational study.	Electronic health record ensures real-time big data availability.
2021	Tizifa et al.,	Department of Infectious Diseases, University of Amsterdam, The Netherlands.	Leveraging phone-based mobile technology to improve data quality at health facilities in rural Malawi: a best practice project.	Electronic health system implementation improves consistency, completeness, and accuracy of data significantly.
2021	Tian et al.,	College of Biomedical Engineering and Instrument Science, Zhejiang University, China	Application of open EHR archetypes to automate data quality rules for electronic health records: a case study.	Some EHRs have integrated Data Quality Rules (DQRs), which measures data quality level of each indicator (accuracy, timeliness, consistency, completeness, integrity) and replaces the traditional time-consuming mode of assessing data quality.
2021	Makeleni & Cilliers,	Department of Information Systems, University of Fort Hare, South Africa.	Critical success factors to improve data quality of electronic medical records in public health institutions.	EHRs offer advantages to medical facilities that effectively deploy and use the system, but they may also introduce their own flaws that could impair the quality of the data.
2018	Kpobi et al.,	Alan J. Flisher Centre for Public Mental Health, Stellenbosch University, South Africa.	Challenges in the use of the mental health information system in a resource-limited setting: lessons from Ghana.	The success of a new system is not guaranteed by its setup. An electronic health record's usefulness depends on its appropriate setup and upkeep.
2017	Artis et al.,	Department of Medicine, Oregon Health and Science University, USA.	Accuracy of laboratory data communication on ICU daily rounds using an electronic health record.	Post EHR implementation, there can be inaccuracies and omissions in patient data, which highlights patient safety issues.
2019	Gumede-Moyo et al.,	School of Public Health., University of Zambia, Zambia.	A qualitative inquiry into implementing an electronic health record system (SmartCare) for prevention of mother-to-child transmission data in Zambia: a retrospective study.	The absence of feedback from an electronic health record might cause operational complacency, which can result in poor data quality.
2022	Tran et al.,	Oxford University Clinical Research Unit, Vietnam.	Digital Health Policy and Programs for Hospital Care in Vietnam: Scoping Review	Local governments' requirements and regulations such as data sharing protocols can affect data timeliness, which is a dimension of data quality.
2017	Roomaney et al.,	South African Medical Research Council, South Africa.	Availability and quality of routine morbidity data: review of studies in South Africa.	The elements that make up data quality are mainly shared across frameworks used to analyze health information systems.
2021	Hutchinson et al.,	London School of Hygiene & Tropical Medicine, United Kingdom.	Opening the 'black box' of collaborative improvement: a qualitative evaluation of a pilot intervention to improve quality of malaria surveillance data in public health centres in Uganda	It is important to address data quality issues associated with EHR because, incomplete, inaccurate, or delayed data restricts the data's reliability and usefulness.

Year	Authors	Affiliation	Title	Key Finding
2021	Moukénet et al.,	Malaria Consortium Chad Country Office, Chad.	Health management information system (HMIS) data quality and associated factors in Massaguet district, Chad.	Workload is linked to a higher likelihood of inaccuracy. Moreover, lesser inaccuracy was linked to the availability of dedicated workers and health technicians.
2019	Joukes et al.,	Department of Medical Informatics, University of Amsterdam, The Netherlands.	Impact of electronic versus paper-based recording before EHR implementation on health care professionals' perceptions of EHR use, data quality, and data reuse.	Organising pre-implementation data recording practice can positively influence quality of clinical data post EHR implementation.
2012	Monda et al.,	School of Medicine, Moi University, Kenya.	Data integrity module for data quality assurance within an e-Health system in Sub-Saharan Africa.	Integrating a tool that automates data integrity and quality checks into EHR will reduce potential burden of maintaining data quality by limiting the scale of manual reviews.
2019	Mohd Nor et al.,	Department of Surgery, University Malaya Medical Centre, Malaysia.	Development of electronic medical records for clinical and research purposes: the breast cancer module using an implementation framework in a middle-income country –Malaysia	Integrating multiple clinical visit data sources into Electronic Health Record may provide comprehensive, accurate and real-time update of patient record.
2021	Walcott-Bryant et al.,	IBM Research Africa, Kenya.	Addressing care continuity and quality challenges in management of hypertension: case study of the private health care sector in Kenya.	Digital health data interoperability solutions can enhance data consistency and maintain data integrity.
2021	Thuraisingam et al.,	Department of Surgery, University of Melbourne, Australia.	Assessing the suitability of general practice electronic health records for clinical prediction model development: a data quality assessment.	Data accuracy and completeness exceeds just EHR implementation. Health staff and clinicians must have the ability and competence to effectively use the EHR system.
2020	Bhattacharya et al.,	Department of Disease Control, London School of Hygiene & Tropical Medicine, United Kingdom.	Improving the quality of routine maternal and newborn data captured in primary health facilities in Gombe State, Northeastern Nigeria: a before-and-after study.	The correctness, completeness, and internal consistency of data can be improved after the deployment of an EHR by assuring regular self-assessments of data quality, peer-review and feedback, workshops, and work planning for improvement.

Discussion

This review examines the impact of electronic health record on data quality, scrutinises the limitations of electronic health record with regards to data quality, and proposes recommendations to the identified limitations.

Impact of Electronic Health Record on Data Quality

Electronic Health Record implementation can impact on the key health outcomes and contribute to timely and complete data submission (Shiferaw et al., 2018). Agniel et al., (2018) elaborates that, electronic health record ensures real-time big data availability as a result of easy filing and retrieval of clinical or patient record. As postulated by Ali et al., (2018), digital records have minimal data quality issues as opposed to paper-based records. Ali et al., (2018) further expounds that, electronic health record can deliver more meaningful information for decision making by maximising its mobile data capture and continued data quality assessment features. In Ghana, electronic health system usage has led to timely access to health information such as patients' and administrative records, and diagnostic and treatment records (Atinga et al., 2020). Implementation of electronic health systems

embellish consistency, completeness, accuracy and integrity of clinical data significantly through embedded interoperability solutions (Tizifa et al., 2021; Walcott-Bryant et al., 2021). Some electronic health record systems have integrated Data Quality Rules (DQRs), which applies automation to measure data quality level of each indicator (accuracy, timeliness, consistency, completeness, integrity) and replaces the traditional time-consuming mode of assessing data quality (Tian et al., 2021).

Although electronic health records provide benefits to health facilities that successfully implement and utilise these systems, it may also introduce its own limitations that may affect data quality (Makeleni & Cilliers, 2021). Patronising a new electronic system does not warrant its success (Kpobi et al., 2018). Even after implementation of electronic health record, there can be inaccuracies and omissions in patient data if clinicians and health staff are not well oriented on how to effectively use the system (Artis et al., 2017). Even in high-income country like the United States of America, nurses and other healthcare professionals find data entry and information retrieval as time consuming and expressed doubts in the ability of electronic health record to enhance patient care (Kutney-Lee et al., 2019). Accuracy and completeness of health data

can be negatively affected when there is no feedback from the EHR. This is because, lack of feedback from the system results in complacency at operational level (Gumede-Moyo et al., 2019). Frameworks that analyse health information systems mostly overlap, affecting integrity and consistency of data in electronic health records (Roomaney et al., 2017).

Recommendations to mitigate limitations of electronic health record with regards to data quality

According to Moukénet et al., (2021), a study with data sources from paper-based records and health management information systems (HMIS), there is a correlation between workload and increased probabilities of inaccurate data. From this, it can be inferred that, reducing workload of health staff may also reduce data inaccuracies. Also, lower inaccuracy was correlated with having a dedicated team and health technician. (Moukénet et al., 2021). Organising pre-implementation data documentation practice can positively influence post implementation data quality (Joukes et al., 2019). Integrating a tool that automates data integrity and quality checks into EHR system will reduce potential burden of maintaining data quality (Monda et al., 2012). Integrating multiple clinical data sources into a single electronic health record system may provide comprehensive, accurate and real-time update of patient record (Mohd Nor et al., 2019). Also, digital health data interoperability solutions can enhance data consistency and maintain data integrity (Walcott-Bryant et al., 2021). Orienting health staff and clinicians on how to properly document health data can enhance their ability and competence to effectively use the EHR system (Thuraisingam et al., 2021). In addition, the accuracy, completeness, and internal consistency of health data can be improved through routine self-evaluation of data quality, peer review, and feedback, supportive supervision, workshops, and work planning for improvement (Bhattacharya et al., 2020).

Conclusion

In two different ways, our investigation advances the theories (Technology Acceptance Model-TAM) in electronic health records and its impact on data quality in healthcare delivery. Firstly, our study contributes to the emerging field of technology acceptance theory of interoperability on clinical data sources to ensure consistent, timely and available health data when using electronic health record. In this regard, we assert that only adaptive EHR systems with the desired network and appropriate data managing tools that fits the healthcare industry should be introduced to healthcare professionals. The impact of the EHR system and data quality would facilitate working processes and help make rapid informed decision.

Secondly, our study contributes to TAM theory of automated data integrity and consistency checks in EHRs, which improves data integrity, accuracy and completeness. Electronic health record requires that stakeholders in the health industry develop strategies that go beyond mitigating damages when crises such as difficulty in obtaining patient data occurs. Healthcare facilities must include the development of a robust and continuous

information sensing system; that can constantly feed healthcare facilities with complete, timely, accurate, consistent and relevant updates that has the potential to predict threats to healthcare stability. These will be fruitless if there are no intense orientation and periodic training for operational level health staff before, during and after implementation of electronic health record. The study also contributes to advancing the frontiers of healthcare technologies.

Quintessential of academic studies, there were some limitations to this study. For instance, only six databases were used to gather the studies for the literature search. This might imply that all other research that weren't based on these sources were disregarded. The results of this research could be limited by the few papers (28) that were included. As a result, other articles with relevant material were ignored and devalued due to the strict inclusive and exclusive criteria used. The results of this study are severely constrained by the methodological shortcomings of the parent studies, namely the sampling methods used to choose reviewed materials in primary investigations. This is because the majority of these studies did not explicitly state how participants were chosen and recruited, which may restrict the generalizability of their findings.

This review largely contributes to the understanding of the overall effects of EHR on the quality of the data in particular databases. The proposed integration of electronic healthcare systems must be further investigated in order to determine whether it will have a positive impact on the future quality of healthcare data. In order to comprehend the many scenarios of EHR efficacy and efficiency on data quality based on historical records and future projections, this study needs more primary-based data that can be simulated.

Declarations

Author Contributions

Conceptualization, JK, and CA formal analysis, investigation, and data curation, JK, and CA,. formal data analysis and results interpretation, JK, and CA. writing, original draft preparation, JK and CA; writing, review and editing, JK,CA, TA and AAK. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate:

Not applicable

Consent for publication

All authors have provided their consent for the manuscript to be submitted for review and publication

Availability of data and materials:

Pieces of Literature analysed during the current study are available online and can also be made available through the corresponding author upon request.

Conflicts of Interest:

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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