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The Role of Electronic Medical Records on Aggregate Data Reporting and Use in the Tanzanian Health System

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Abstract
Background: Integrating routine data use into its health system is critical for informed decisions and better healthcare outcomes. Electronic Medical Records (EMRs) are crucial for this goal, particularly for individual data generation. While EMR adoption is growing, the effectiveness of EMRs in supporting the Health Management Information System (HMIS) for collecting, synthesizing, and reporting routine health data remains unknown. This study investigates how EMRs contribute to these HMIS functions. *Methods:* This study employed a descriptive qualitative approach to examine the implementation and usage of Electronic Medical Records (EMRs) in the Tanzania health system, using Dodoma and Bahi districts as case studies. The Task-Technology Fit (TTF) theory guided the development of key themes, focusing on how EMR functionalities support core Health Management Information System (HMIS) functions: data collection, synthesis, utilization, and dissemination. Data were gathered through key informant interviews with relevant stakeholders and a comparative review of EMR and HMIS monthly reports. *Results:* The study revealed that EMRs effectively manage individual patient data and primarily support direct patient care. However, their contribution to aggregate data reporting and use for broader health management is limited. This limitation is due to incompatible report formats, insufficient user capabilities, lack of interoperability, and the absence of aggregate data visualization dashboards and analytical tools, all hinder secondary data utilization and support for HMIS functions. *Conclusion:* This study emphasizes the need to address the identified challenges to realize the transformative potential of Electronic Medical Records (EMRs). By overcoming these obstacles, Tanzania's health system can effectively leverage EMRs for routine data reporting and utilization, leading to robust evidence-based decision-making and institutionalized data use.

Keywords: Electronic Medical Records (EHR); Health Information Systems (HISs); Integration and Interoperability; Task – Technology Fit (TTF) Theory.

Introduction

Effective generation and use of health data are essential for a well-functioning health system [1]. In a health system, data can be categorized into two, namely routine data and non-routine data [2]. Non-routine data is collected less frequently and often through special studies, censuses, surveys, or research projects. Routine data, on the other hand, is collected regularly and systematically through routine Health Information Systems (RHISs), also known as Health Management Information Systems (HMISs) [3]. As long-established by Lippeveld [2], routine data reports on service utilization, accessibility, morbidity, mortality, health resources, and the like, provide the

basis for informed decision-making. Reliable routine data systems are crucial for understanding health disparities across a population, planning, developing relevant policies, monitoring how well the system performs, and ultimately improving health outcomes [4-6]. However, many low- and middle-income countries lack robust health information systems (HISs) that can effectively collect, store, analyze, and synthesize data for better use [7]. This hinders evidence-based decision-making, potentially leading to suboptimal planning and resource allocation in these countries [8].

Routine health data collection, originating at primary (clinics, dispensaries, health centers) and secondary (hospitals) care facilities, has historically relied on paper-based methods [9]. This practice can contribute to poor data quality in terms of availability, completeness, timeliness, consistency, and reliability of reporting and so compromises the data cycle. Facilities often struggle with understaffing or lack of training, leading to inaccuracies or delays in data collection [10]. Additionally, unclear reporting requirements or cumbersome reporting formats create a burden and frustration for facility staff. In some cases, pressure to meet performance targets can incentivize facilities to over-report or under-report certain metrics, jeopardizing the overall data quality [11,12]. These issues hinder the effective use of routine data for decision-making at higher levels, as the data they rely on may be incomplete or unreliable [13].

But recently the global landscape of healthcare delivery has witnessed a change in thinking from traditional paper-based medical records to Electronic Medical Records (EMRs) [14]. An EMR is a digital version of a patient's paper chart [15]. It contains medical and clinical data collected within a single healthcare facility. This data includes patient demographics, medical history (diagnoses, medications, allergies, immunizations), laboratory and imaging results, treatment plans, and progress notes. This transition, driven by technological advancements has paved the way for EMRs to become an integral part of modern healthcare systems [4,16]. In the context of developing nations, including Tanzania, Kikoba and colleagues reported progressive integration of Electronic Medical Records (EMRs) into healthcare facilities. This integration is exemplified by the implementation of systems such as GoT-HOMIS, AfyaHMS, eHMS, and CTC-2, designed to support patient data management [11]. Despite the investment in EMR systems in developing countries like Tanzania, the extent to which these systems support the core functions of the national Health Management Information System (HMIS) specifically data collection, synthesis, and reporting of routine health information remains poorly understood [17]. The study contributes to the growing body of knowledge on the role of EMRs in strengthening health information systems in LMICs. Specifically, it seeks to assess how well the functionalities and characteristics of existing EMR systems align with the tasks and requirements of the Health Management Information System (HMIS) functions, utilizing the task-technology fit framework as an analytical lens.

Theoretical Literature Review on Task-Technology Fit Theory

Task-Technology Fit (TTF) theory offers valuable insights for designing better technology, training programs, and workflows, ultimately promoting effective technology implementation and positive user experiences [18]. As Goodhue and Thompson described in 1995 [19], the TTF focuses on the match between a task's requirements and a technology's capabilities. As illustrated in Figure 1, the TTF theory reasons that the success of technology hinges on its compatibility with users' tasks. Similarly, TTF posits that technology with features perfectly aligned with the specific demands of a task, its complexity, and required data processing, will lead to better user performance, satisfaction, and utilization [18]. While TTF focuses primarily on the individual user and their tasks, it acknowledges the influence of factors like user skills and even broader organizational contexts.

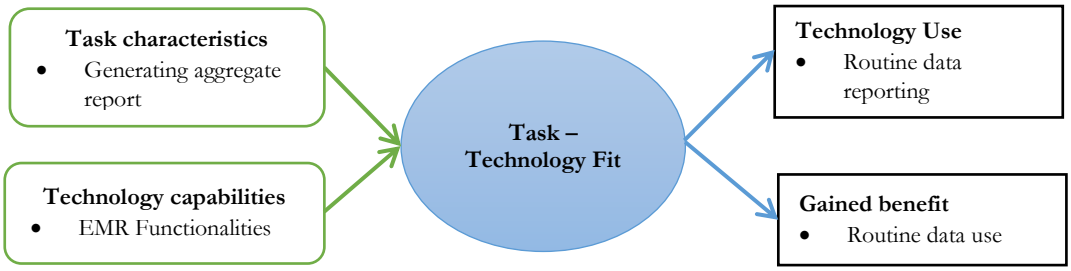


Figure 1. TTF framework, showing how task and technology best fit to produce the desired.

Empirical Literature Review on Tanzania HMIS

In Tanzania, routine data are collected under the unit called Health Management Information System (HMIS) also known as 'Mfumo wa Taarifa za Uendeshaji wa Huduma za Afya' (MTUHA) in Swahili [9]. The Health Management Information System is a unit in the Policy and Planning Department of the Ministry of Health that is responsible for routine reporting systems covering all health facilities and providing insights for management decisions [20]. The data collection tools used are register books that carry individual-level patient data, from which data are aggregated using tally sheets (counting books) and recorded into monthly summary forms or HMIS books [9]. Each month, facilities submit monthly summary forms to the council level, data are entered into the electronic system i.e. DHIS2, and from there, data can be accessible to regional, programs, and national. Such reporting from facilities to higher levels can be a troublesome process.

Hospitals have adopted and implemented electronic medical records to serve clinical operations. Studies have defined EMR as the computer systems that collect, store, and transmit clinical data [23]. Across developing nations, Electronic Medical Records (EMRs) have demonstrated efficacy in aggregating and synthesizing routine health data for informed decision-making. For example, Muthee et al. [24], in their assessment of routine data quality within Kenyan EMR systems, established a significant improvement in data quality and enhanced usability. Similarly, in Ethiopia, Medhanyie et al. reported the utilization of mobile solutions, specifically electronic forms, to enhance routine data collection quality [25]. The study documented a reduction in incomplete entries compared to paper records, attributed to the lack of standardized forms, with electronic forms improving data completeness by 8%. Consistent with these findings, a study in Nigeria evaluating the Electronic Nursing Process Form (ENPF), a form of nursing-specific EMR, indicated that ENPFs were perceived as superior to paper-based documentation in terms of usefulness [26]. The electronic forms generate primary data (individual-level data), which are later aggregated and become input for the hospital management reports. However, the rate of utilization of data generated from EMRs among health managers is not well-documented [16].

It is unclear how well EMR systems contribute to data aggregation and exchange with the District Health Information System 2 (DHIS2), which is the national health data warehouse. Therefore, this study aimed to investigate the specific contributions of EMRs to these critical HMIS functions within the Tanzanian health system. The study found answers to the following research question: "How do Electronic Medical Records (EMRs) influence routine data collection, synthesis, and reporting within the Tanzanian Health Management Information System (HMIS)?" Using the Task-Technology Fit (TTF) theory we examine current EMR implementation, data quality, and interoperability challenges, the study reveals the opportunities and obstacles to using EMRs in the institutionalization process of routine data use for effective evidence-based decisions in health care.

Materials and Methods

The study adopted a descriptive qualitative approach, whereby five tertiary-level hospitals were chosen as cases. According to Creswell et al. [27], a descriptive qualitative study helps explore the phenomena and gives a deep understanding of the problem, the details of the eventual design, and the lesson learned that might be of more general interest. Data collection was through key informants' interviews with health workers, facility in-charge, program coordinators, and the DHIS2 data officer. Also, a document review of the monthly HMIS reports was conducted.

Study Setting

This study was conducted within the Tanzanian health system from September to December 2024. Two distinct local government authorities were selected as case studies: Dodoma City Council, representing an urban setting, and Bahi District Council, representing a rural setting. Furthermore, the subnational findings were triangulated with findings from a previous study conducted by the research team involving the four most used EMRs from three regions, providing a comparative perspective on EMR implementation and impact at the national and

regional levels. This is because Tanzania's health sector follows a hierarchical structure with different levels of hospitals, each serving a specific population:

(1) Primary level, the most basic level of healthcare facilities constituting dispensaries and health centers found in villages and ward level, they provide services like outpatient care, family planning, and diagnostic tests.
(2) The secondary level serves as the first point of referral for primary facilities. They include district and regional hospitals offering more specialized care and have a wider range of specialists and equipment, offering services like surgeries, advanced diagnostics, and specialist consultations.
(3) The tertiary level, serves as the referral center for several regions, providing highly specialized care and treatment which includes, referral hospitals, special hospitals, and National hospitals, they provide the highest level of specialized care in the country, serving as a national referral center and teaching hospital.

Sampling

The study purposively selected twelve (12) health facilities from both Bahi and Dodoma, i.e. six facilities from each. The criteria used for selection were the availability of fully functional EMRs and the District Health Information System (DHIS2). Among the selected facilities, four were secondary level (hospitals), and 8 were primary level i.e. (health centers and dispensaries). For triangulation purposes, four more hospitals from the tertiary level in Dodoma, Coastal, and Dar es Salaam regions were selected. The selection criteria for selection being the most used EMR in the country, where:

- **GoTHOMIS:** The most used EMR at the subnational primary and secondary level of care, and the primary EMR under study setting. GoTHOMIS serves as the primary Electronic Medical Record (EMR) system implemented across the majority of subnational healthcare facilities, including hospitals, health centers, and dispensaries, within the two local government authorities under study [28].
- **eHMS:** The most used EMR at the tertiary level, involving most regional referral hospitals.
- **CTC2:** A care and treatment database a primary data collection system for the HIV/AIDS Programme.
- **Jeeva:** An EMR for the national hospital to capture national perspective.
- **Care2x:** Mostly used in private facilities

The selected hospitals were urban and geographically diverse to capture potential variations in EMR implementation and utilization across regions of Tanzania. Key informants consisting of health workers, program coordinators, administrators (facility in-charge), and DHIS2 (Data) officers were selected. While the findings from this sample may not be generalizable to all healthcare facilities in Tanzania, they provide valuable insights into the specific context of tertiary hospitals with EMR systems.

Data Collection Methods

A mixed-methods approach was used to collect data, combining qualitative data from semi-structured interviews with quantitative data from a document and system review. This approach allowed for a comprehensive understanding of how Electronic Medical Records (EMRs) aggregate data reporting and use within the Tanzanian health system.

i. **Semi-Structured Interviews.** Qualitative data was collected through key informant interviews using semi-structured interview questions developed by the B.K. According to Creswell et al., a key informant is a person having firsthand knowledge, experience, or a unique perspective on the research topic who is willing to share insights with the researcher [27]. In this study, 32 interviews were conducted with key informants selected based key, informants were selected based on experience involved in Health Management Information Systems (HMIS) and EMRs at the selected hospitals, this included health workers, facility in-charge, program coordinators, and DHIS2 data officer:

- **Facility in charge:** Individuals responsible for overseeing facility welfare including data collection, quality control, and reporting within the hospital.

- **Program coordinators**: Personnel responsible for overseeing the performance of the specific program, such as the Malaria coordinator, ANC coordinator, and CTC coordinator. These coordinators have a role in collecting and analyzing program-based data for quality improvement purposes.
- **DHIS2/HMIS focal person:** Staff involved in the management and maintenance of routine data both electronic (in the DHIS2) and paper-based forms, from both facility and council level.
- **Health worker**: Clinicians who utilize the EMR system for patient care and may contribute to aggregate data generation.
- **EMR implementer**: Individual responsible for overseeing EMR implementation at the ministry level, specifically from the Ministry of President's Office of Regional Administration and Local Government (PORALG) implementer of the GOTHOMIS.
- **HMIS focal form Ministry of Health (MoH):** Responsible for overseeing DHIS2 data are reported from the facility to the ministry level.

The summary of the interview conducted is presented in Table 1.

Table 1. Summary of data collection participants

Research question	Activities	Dodoma CC	Bahi DC
What is the contribution of EMRs in routine aggregate data reporting and use?	Key informant interview (KII)	6 HMIS focal person	5 HMIS focal person
		4 health facilities in charge or representative	5 health facilities in charge or representative
		2 Program coordinators (Immunization and Malaria)	2 Program coordinators (HIV and Malaria)
		2 EMR implementers from four EMRs (GOTHOMIS, and eHMS)	1 hospital IT system administer
		3 health workers	2 health workers
		1 HMIS focal form Ministry of Health (MoH)	
	Total interviewees	**17**	**15**

The interviews were conducted using a pre-developed interview guide with open-ended questions designed to explore the process of generating aggregate data from EMRs, the use of EMR-generated data, HMIS reporting, and the utilization of aggregate data for decision-making at the hospital and higher levels. Interviews were conducted face to face by the researcher (BK) where feasible, in some cases mobile phone calls were used with participant consent. Interviews were audio-recorded and transcribed verbatim to ensure accuracy and facilitate detailed analysis.

ii. **Document and System Review.** To complement the qualitative data and provide a quantitative perspective, a document review of monthly HMIS reports generated by the selected hospitals was conducted. The review focused on reports generated during a defined period (e.g., the past 12 months) to capture the latest trends and patterns in aggregate data reporting. The document review aimed to assess the availability and completeness of reporting forms, where the Outpatient department (OPD) and Inpatient department (IPD) data sets were used, and examine the format and consistency of reporting across different months and hospitals. Then, identify any discrepancies or inconsistencies between data reported through the HMIS and data potentially available within the EMR systems. Data extracted from the HMIS reports were entered into a spreadsheet for quantitative analysis, allowing for descriptive statistics and comparisons across hospitals.

Data Analysis

Qualitative data gathered through key informant interviews and observations were analyzed thematically. Figure 2 presents the theoretical framework of Task-Technology Fit (TTF) utilized to formulate themes for data analysis exploring the alignment between the functionalities of the EMR system and the information needs and tasks of healthcare professionals, as shown in Figure 2. Data extracted from the HMIS reports and EMR reports were entered into a spreadsheet for quantitative analysis, allowing for descriptive statistics and comparisons for data validation.

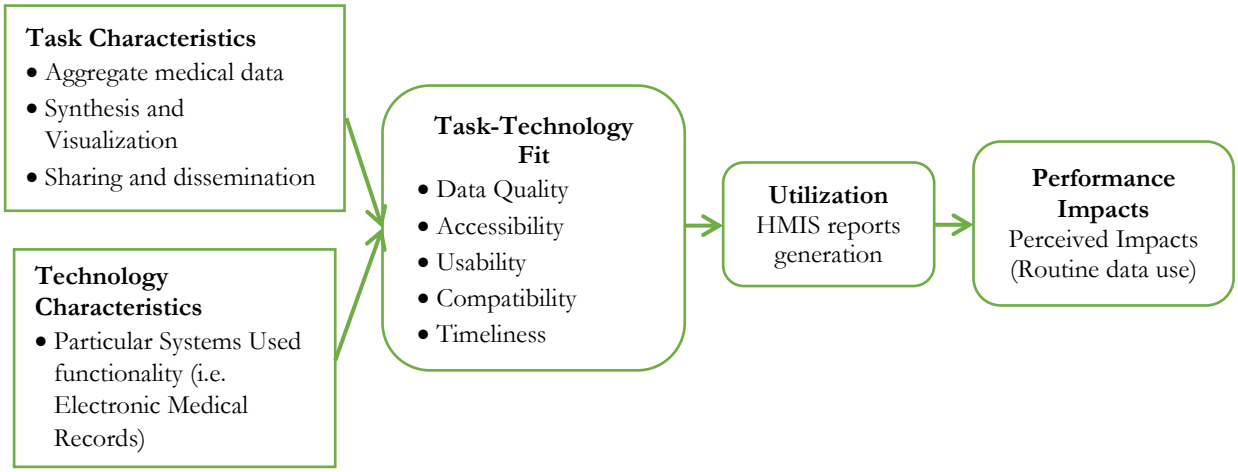


Figure 2. Data analysis themes following TFF Theory.

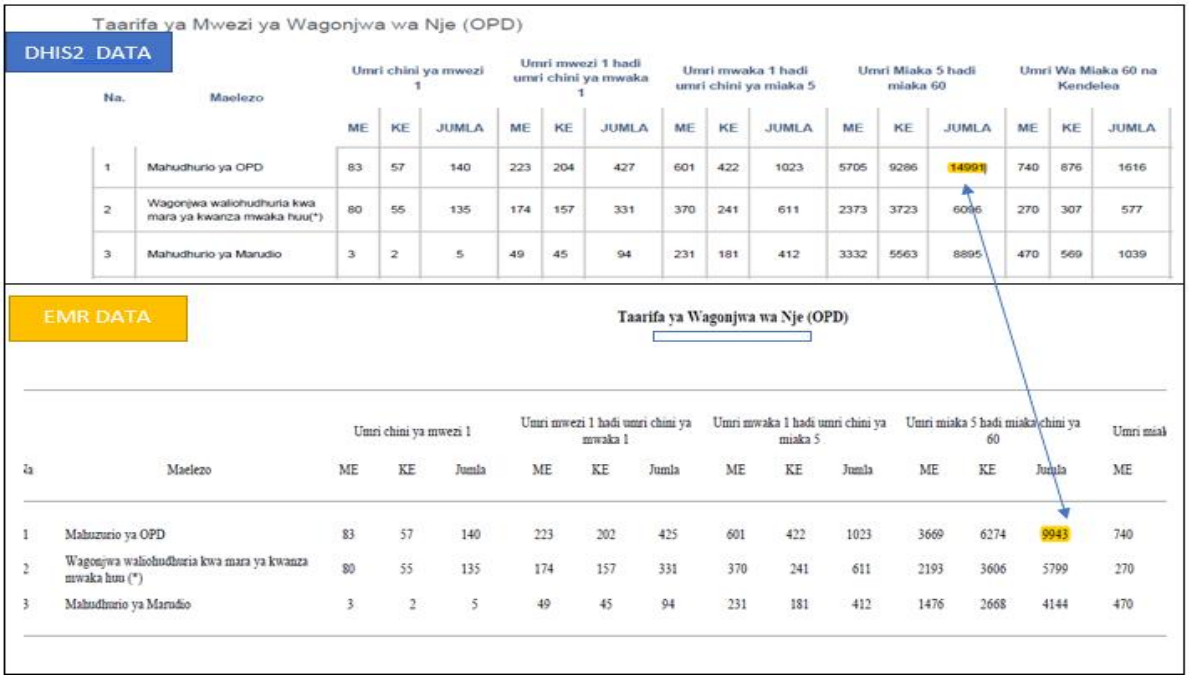
Results

The findings detail aggregate data flow, EMR-DHIS2 interoperability and accessibility, reporting practices, and challenges associated with the reporting practices.

Individual to Aggregate Data Flow

It was observed that most of the facilities have digitized patient treatment modules, where individual patient data flows smoothly from registration to discharge. The specific flow may vary depending on the type of patient (i.e. inpatient (IPD) and outpatient (OPD)), technology used, and local routines. For instance, in Hospital A, where GOTHOMIS has been implemented, it was observed a seamless data flow from registration, diagnosis, and treatment, billing to referrals or discharge. In an interview with a GOTHOMIS implementer from the local government ministry (PORALG), he gave the following remark "*In recent years we have managed to distribute computers to almost 80% of hospitals and health centers in the country and trained healthcare workers on how to use the system for patient treatment. We are still working on the remaining dispensaries and clinics which are the majority of healthcare facilities in the country*" (GOTHOMIS implementer, from PORALG)

During the system review, it was noted that the system has integrated an HMIS-like module, that generates reports and analytics based on MTUHA reporting forms. Also, there is a comprehensive report that does not resemble the HMIS format, which uses the International Classification of Diseases, Tenth Revision (ICD10) coding, which is being updated to the Eleventh version. However, at the facility, although some EMRs like GOTHOMIS and eHMS have implemented electronic HMIS modules, it was found that these reports are not used in preparing monthly summary data for DHIS2 reporting. It was observed that the facility still maintains a record/copy of services provided using an HMIS register (a different data collection tool). It was further learned that HMIS focal are not allowed to use them for official reporting because the EMRs are not reliable due to usability issues such as power cuts and some health workers neglecting to use the system. Using the EMR-generated forms could impact the quality of data submitted for use. Such argument seemed evident during forms comparing, where data in EMR showed few records compared to reported data in DHIS2 as shown in Figure 3, where two forms were generated from DHIS2 and EMR respectively of the same month.



Taarifa ya Mwezi ya Wagonjwa wa Nje (OPD)

DHIS2 DATA

Na.	Maelezo	Umri chini ya mwezi 1			Umri mwezi 1 hadi umri chini ya mwaka 1			Umri mwaka 1 hadi umri chini ya miaka 5			Umri Miaka 5 hadi miaka 60			Umri Wa Miaka 60 na Kendelea		
		ME	KE	JUMLA	ME	KE	JUMLA	ME	KE	JUMLA	ME	KE	JUMLA	ME	KE	JUMLA
1	Mahudhurio ya OPD	83	57	140	223	204	427	601	422	1023	5705	9286	14991	740	876	1616
2	Wagonjwa waliohudhuria kwa mara ya kwanza mwaka huu(*)	80	55	135	174	157	331	370	241	611	2373	3723	6096	270	307	577
3	Mahudhurio ya Marudio	3	2	5	49	45	94	231	181	412	3332	5563	8895	470	569	1039

EMR DATA

Taarifa ya Wagonjwa wa Nje (OPD)

ła	Maelezo	Umri chini ya mwezi 1			Umri mwezi 1 hadi umri chini ya mwaka 1			Umri mwaka 1 hadi umri chini ya miaka 5			Umri miaka 5 hadi miaka chini ya 60			Umri miak
		ME	KE	Jumla	ME	KE	Jumla	ME	KE	Jumla	ME	KE	Jumla	ME
1	Mahuzurio ya OPD	83	57	140	223	202	425	601	422	1023	3669	6274	9943	740
2	Wagonjwa waliohudhuria kwa mara ya kwanza mwaka huu (*)	80	55	135	174	157	331	370	241	611	2193	3606	5799	270
3	Mahudhurio ya Marudio	3	2	5	49	45	94	231	181	412	1476	2668	4144	470

Figure 3. Screenshot of the DHIS2 report and EMR report from Hospital A, in the same month.

The data collection tools used for the HMIS register are paper-based and used to collect summary data at the facility level:

(i) Registers; various programs have specific registers such as Expanded Program of Immunization (EPI), antenatal care (ANC), family planning (FP), tuberculosis (TB), HIV/AIDS, etc.

(ii) Tally sheets are summary forms where records with a mark and with no patient identification.

(iii) Reports (summary forms), contain the selected indicator (as per services provided), which can be used to inform action at the facility or are sent to the district for further use.

A response at one of the facilities in Dodoma city council reported a tiring double work of filling both electronic and paper-based forms. Also, supported by an interview response from the HMIS focal person at the hospital in Bahi said;

"The paperwork involved can be overwhelming. Keeping track of numerous forms and documents is not only tedious but also poses a risk of misplacement or loss of important data" (HMIS focal person)

Explaining the impact of these manual forms, a health worker at Hospital C, responded:

"The lack of automation means that our staff spends a large portion of their time on data entry and record-keeping, which could otherwise be allocated to more impactful activities such as direct patient care and community outreach" (Health worker at Hospital C)

Electronic Medical Records to District Health Information Software v2 Interoperability and Accessibility

It was observed that there was no direct integration/interoperability between the two data systems. Although all facilities had DHIS2 units, aggregate data entry was done manually within the facility. This was complemented by interview findings from the ministry, where it was found that more than 85% of hospitals and health centers in the country have access to DHIS2 at their premises. Explaining the interoperability challenge, a system administrator at Hospital B, said:

"The biggest headache is getting the data to flow smoothly between the EMR and DHIS2. The two systems speak different languages. The EMR might record patient information and generate a report in different code formats, while DHIS2 has its summary form formats that do not match the EMR report format. So, we end up having to manually re-enter a lot of data, which is time-consuming and prone to errors" (Information Technology (IT) system administrator at Hospital B)

Reporting Practice at the Facility with Electronic Medical Records

It was observed lack of uniformity and standards across facilities even with the same EMR implemented, on how and what to extract from the EMRs. Different EMRs generate different formats of monthly reports with different datasets/indicators based on the level of services and EMR design. For instance, in the GoTHOMIS system, it was observed in Facility B there are empty HMIS forms without data values. Other EMRs used in tertiary hospitals produce a comprehensive report with more data elements coded using the International Classification of Diseases, Tenth Revision (ICD10), for instance, the eHMS system at Hospital C. This varies with the report format used for the HMIS summary reports. For example, it was found that 34 datasets were reported at Hospital A, 12 datasets were reported at Hospital B, and 30 datasets at Hospital C. The good thing, for the shared data sets, is that they have the same data elements. For instance, in eHMS the OPD monthly report generated in the EMR has 232 data elements, while the HMIS reporting form has only 90 dataset fields. To compile an aggregate report for monthly utilization, the data officers must manually aggregate the 232 data elements into 90 data elements by combining the related disease names. A respondent in an interview had this to say:

"The systems just don't talk to each other at all, and we have to create workarounds, like exporting data from the EMR and then importing it into DHIS2, which is not ideal. It would be so much better if there was a seamless, automated way to transfer the data." (HMIS Focal person at Hospital B)

In some facilities, like Chamwino and Kikuyu in Dodoma, the DHIS2 monthly report is generated from both paper-based summary forms and electronic provisional reports from the EMRs. The reports consist of mixed data sets, most of which are unwanted or need to be combined to form one element to be reported. For example, for hospital A, an OPD provisional report generated from EMR consists of more than 200 elements coded from ICD-10. During reporting these data are to be aggregated and selected to fit into 90 data elements needed for reporting into DHIS2. The job of aggregating and selecting indicators to report is done manually by the personnel responsible. You find a printout of the provisional and diagnosis report from EMR trying to match the corresponding disease register found in DHIS2. Figure 4 shows the OPD-reported data extracted in DHIS2 and EMR for the same facility in December 2024 during monthly reporting.

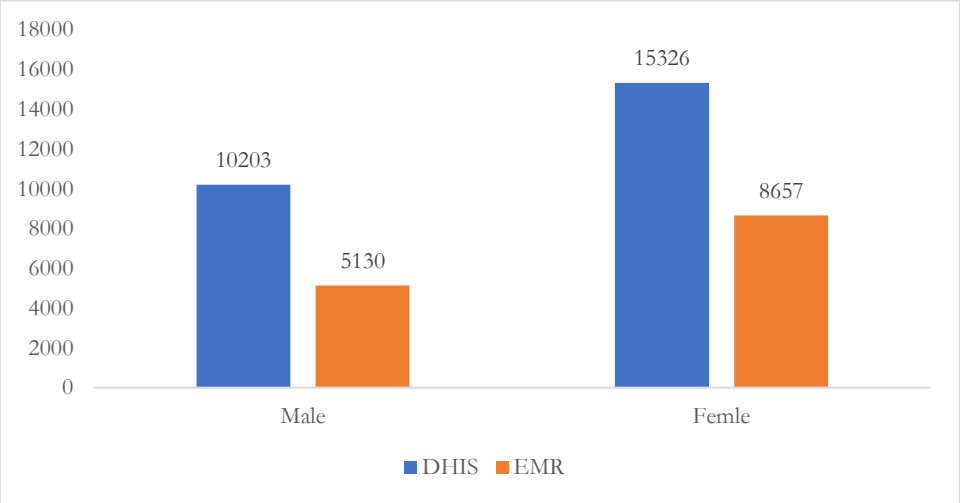


Figure 4. Data inconsistency between DHIS2 and EMR was reported in December 2024 at Hospital A.

Responding to the value differences in the two databases, the health worker reported that:

"Sometimes data focal person has to rely on the extracted report however the disease codes in EMR and DHIS2 do not match, and as a result, there are errors in counting and aggregating the data into more abstract forms used by the HMIS unit." (Hospital C, December 2024)

Comparison between Facility Levels

Data aggregation practices exhibit variability across different levels of healthcare facilities. At the primary care level, facilities often engage in redundant data entry, performing patient registration both within the electronic system and in manual HMIS registers. Conversely, tertiary-level facilities do not typically employ such dual documentation methods as illustrated in Figure 5. A respondent from a national hospital reported the presence of

a dedicated statistics section responsible for generating data reports through direct extraction from the Jeeva EMR system. These disparate practices contribute to inconsistencies in routine data reporting procedures across various levels of healthcare delivery. In response to inquiries regarding these practices, a facility in charge at a health center in Dodoma stated:

"We at the lower level are underprivileged, we are forced to do double work of recording in electronic system and paper forms, we should choose one, and I think we should use the digital system only, the paperwork should be for backup purposes in case of a power cut or system failure"

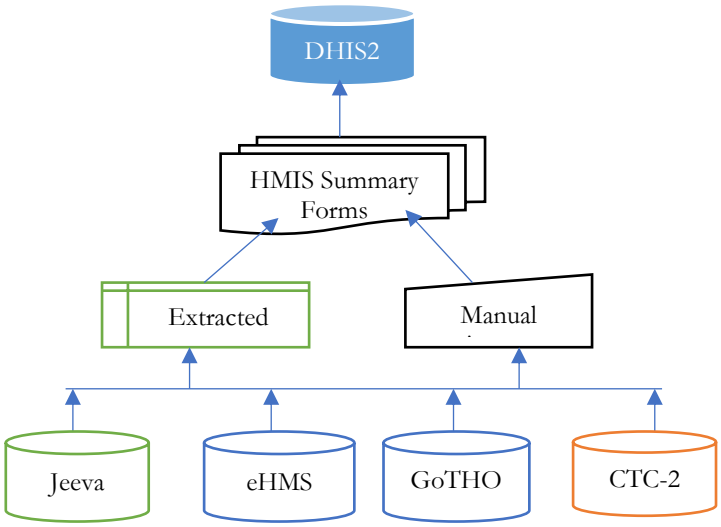


Figure 5. Variations in data reporting across EMRs used at different levels.

Furthermore, it was noted a disparity in supportive interventions across health facilities was identified, as reported by Bahi District health officials. This study revealed an unequal distribution of resources, with some facilities possessing significantly more tools than others. For instance, a dispensary was observed to have a single tablet computer in use, while three additional tablets remained in storage awaiting GoTHOMIS and other system installations. In contrast, higher-level facilities, beyond tablet availability, were equipped with printers, facilitating the direct printing of reports from EMRs for subsequent re-entry into DHIS2. Disparities extended beyond equipment to encompass human resources. Hospitals at higher levels typically employed designated HMIS personnel for data reporting and analysis within DHIS2, whereas the majority of health centers and dispensaries relied on co-opted health workers to fulfill these responsibilities. This practice resulted in a substantial workload overhead for the health workers.

Electronic Medical Records Data Use

It was observed that most generated data in EMR are used primarily for patient care i.e. patient consultation during treatment. Also, other systems such as GOTHOMIS have referral modules, facilitating individual patient data sharing from lower-level facilities to a higher level. The patient data captured within the EMR, including medical history, diagnoses, treatments, and lab results, enables clinicians to make more informed decisions at the point of care. Also, the EMR are used to improve diagnostic accuracy and better monitoring of patient progress especially for the inpatient department. In Hospitals B and C, it was observed that EMRs streamline clinical workflows, where a patient queue mechanism was implemented for patient-doctor allocation.

However, the study found low potential EMR data for secondary use (i.e., public health surveillance, and quality improvement initiatives). These applications are currently less developed and utilized. There are challenges related to data aggregation, synthesis, and visualization. There is no synthetic dashboard for secondary data use, the available dashboard is for primary patient care. Most of the summary reports produced with the EMR do not confirm the reporting requirement of the HMIS, and so affect its usability. In hospital C for instance, the HMIS reporting forms designed in the system are static and does not fetch/query timely data. In responding to this, some health workers responded>

"Our system lacks visualization tools for aggregate data, as you know effective dashboards help for interpreting and analyzing aggregate data. Without these, healthcare providers find it challenging to extract meaningful insights from raw data" (Health worker at Hospital A)

Also, the interoperability and low analytics of the system were reported as challenges to secondary data use, where variability in data entry practices and data quality issues further complicate the use of EMR data:

"The lack of interoperability and analytics between these systems hinders the ability to aggregate data seamlessly, this has been due to lack of resources to invest in these capabilities" (DHIS2 officer at Hospital C)

Challenges Associated with Reporting and Use

Due to manual reporting processes, the study identified several associated challenges:

- *Mismatch of reporting tools.* There are mismatches between the produced EMR reports and the HMIS reporting tools. The mismatch of tools increases the burden on the data officers, who are the health workers too. There are approximately more than ten registers plus disease-specific registers which need to be filled by one or two health workers who also have clinical duties.
- *Cumbersome reporting procedure.* Procedures of recording, tallying, and reporting are too complex. Data is to be recorded on a patient register, then tallied on a tally sheet before being aggregated to the summary form, then HMIS books, and finally data entry into the DHIS2 database. This process increases the burden on health workers who are already overwhelmed by clinical duties. HWs need to record each data on all those tools as a result most of them are not correctly filled. The aggregation is error-prone because they are not given calculating machines for aggregating.
- *Duplication of reports.* Data is recorded multiple times within different registers. For example, OPD and IPD data sets consist of data elements from other specific registers such as RCH, and have to be reported in both forms. There is a need to unify data reporting forms to reduce duplication of reporting of the same data element.
- *Parallel reporting.* In some cases, the study noted parallel reporting influenced by donor needs. There is a tendency when donors and other health partners to need data beyond available HMIS tools. Hence, they bypass the HMIS books and request hospitals or health facilities to report on their independent forms, which hardly differ in fields and data elements from the official format of the HMIS tools. Vertical programs, such as Malaria, HIV, and TB have their reporting manual and request independent reports in their format.

Factors Limiting Electronic Medical Record Use for Data Aggregation

Despite the capability to produce a comprehensive report, still in some facilities, the reports are not used, instead, manual registers are preferred. The main reasons for limited use are as follows:

- *Computer illiteracy*: It was found that medical record personnel cannot print electronic reports from the computer. Some reports are available in the system but they cannot access it because of computer use barriers. At some point, they use a screen capture function to snap the data entry page instead of printing a complete report.
- *Poor system designs:* Some EMRs have incomplete functionalities with most of them lacking reporting modules even the available ones are not user-friendly. The reporting forms do not resemble the HMIS tools which are the standard reporting tools, there are guidelines to follow when developing and implementing the EMR, but most of the implemented systems don't align with it.
- *Incomplete functionalities and data.* Some electronic systems have missing values that lead to neglected use of it. reading to a health worker forced to record irrelevant data Example, in Hospital D, a patient is diagnosed with a disease that is not coded into the database as a result a doctor uses any available code to check out the patient. This increases wrong recording and leads to the unrealistic prevalence of disease.
- *Power supplies.* In the local hosted system (LAN) Electricity is an issue, there is frequent cutoff of power reading to delay service. For example, when visiting one of the facilities, it happens electricity cut off although the hospital had a backup generator it took more than 30 minutes before the system was up and running.

- *Parallel EMR systems*: With more than one EMR system running parallel at the same facility, there are duplications and silos of systems at the hospitals, each vertical program is running its independent system, and confusing which one to rely on when it comes to data reporting. For example, CTC2 and eHMIS, or AfyaPro and GoT-HOMIS, the challenge comes with what EMR to use for HMIS data reporting.

Discussion

The study has shown hospitals with EMR have successfully automated clinical operations as previously reported in the scientific literature [28,29], but with little contribution toward aggregate data reporting and use. There is a disconnect between the potential of Electronic Medical Records (EMR) and their current role in supporting routine aggregate data reporting and use, which is the result of mismatching of the system functionalities. Facilities still rely much on paper-based data collection tools i.e. registers, tally sheets, and summary forms, which are proven to be more error-prone and subjected to wrong data being reported [5,6,7]. This limitation stems from several factors, including incompatible report formats, insufficient user capabilities, a lack of interoperability, and the absence of aggregate data visualization dashboards and analytical tools, all of which impede secondary data utilization and support for Health Management Information System (HMIS) functions.

The finding of our study also highlights a gap in the analytical capabilities of current EMR systems within Tanzanian health facilities, directly hindering the utilization of routinely collected data. Unlike the national health information system, DHIS2, which boasts robust analytics features such as scorecards and customizable dashboards for visualizing aggregate performance data [12,13], it was observed the EMRs largely lack these crucial functionalities. This deficiency means that while valuable patient-level data is being captured, the ability to readily aggregate and visualize this information in a meaningful way for performance monitoring and informed decision-making at both the facility and council levels remains severely limited. Consequently, healthcare workers and decision-makers are unable to easily identify trends, and pinpoint areas requiring intervention directly from their EMR systems, thus undermining the potential of these digital tools to drive data-driven improvements in healthcare delivery.

Unlike Tanzania, experiences in other developing countries contrast, EMRs have shown greater success in aggregating and synthesizing routine data for informed decision-making [30]. For instance, in Ethiopia, Medhanyie et al. demonstrated the effectiveness of mobile solutions, specifically using electronic forms, in enhancing routine data quality during collection and reporting. The study reported addressing the issue of incomplete entries in paper records due to a lack of standardized forms, by introducing electronic forms, which improved data completeness significantly and drove data-driven decision-making. Similarly, Muthee et al. (2018) in Kenya found that EMRs significantly improved the quality and usability of routine data [24]. The paper stresses enhancing the quality of data captured within Electronic Medical Record systems in a resource-limited setting like Kenya, which has implications for better reporting, utilizing, and ultimately, improved healthcare service delivery. In Nigeria, the Electronic Nursing Process Form (ENPF) was perceived as superior to paper-aided documentation, further highlighting the potential of EMRs to enhance data quality and utility. The learning experience from these countries underscores the importance of context-specific implementation strategies. The challenges observed in Tanzania, such as incompatible report formats and insufficient user capabilities, suggest a need for more development of standardized, interoperable EMR systems and robust training programs. The EMR system should be redesigned to support aggregate routine data generation and sharing into the national HMIS. Furthermore, the absence of aggregate data visualization dashboards and analytical tools highlights the need for advanced analytical tools to compensate for EMR limitations as suggested by Gifu's to utilize Soft Sets Extensions is particularly relevant [31]. Soft sets offer a valuable toolkit for addressing uncertainty and variability, especially in healthcare claims data analysis, which encompasses details about treatments, providers, costs, and prescriptions. This approach could be instrumental in extracting meaningful insights from EMR data, even when faced with data inconsistencies and limitations.

Generally, in the effort to institutionalize routine data use practices at lower levels, we argue that HMIS units should take a step forward in recognizing and strengthening EMR as a primary source of routine data since the adoption of EMR in health facilities is higher [14,30]. As previously argued by Kikoba et al; (2019) data that are

shared electronically from EMR directly to DHIS2 improves data completeness and eliminates delays and aggregation errors [11]. However, we recommend that integrating the two needs to be taken with caution addressing the usability aspect of EMR by health workers. If not well addressed, could affect the accuracy and quality dimension of data. The usability of EMR affects the inconsistency and quality of data residing in the systems. Also, common report formats need to be designed and agreed upon by stakeholders. For instance, the HMIS could make use of ICD 10 and 11 in coding their data set to align with the data generated in EMRs. The act of relying on registers and HMIS books is long gone, as they increase the burden on health workers instead of concentrating on the main clinical activities. The recognition of EMR as a primary source of data will improve not only the accuracy of reporting, but also enhance effective utilization of routine data, and reduce the HW burden of aggregating data based on registers. This should go together with health workers' training on the proper use of EMR as also recommended by Jawhari et al. [30].

The present study, while providing valuable insights into the role of EMRs within the Tanzanian health system, acknowledges the following limitations. Firstly, the study's focus on two subnational case studies (Dodoma City Council and Bahi District Council) and the triangulation with a previous study involving only five tertiary hospitals inherently limits the generalizability of the findings to the entire Tanzanian health system. Secondly, the qualitative nature of the study, relying primarily on key informant interviews, provides rich contextual data but may not capture the breadth of experiences across all health personnel. While purposive sampling was employed to select key stakeholders, the sample size within each council and the five tertiary hospitals was relatively small and may not fully reflect the complexities of EMR implementation and utilization across all levels of the health system. Consequently, the country-specific context and limited sample size underscore the need for further research with larger, more representative samples and quantitative methodologies to validate and expand upon these findings.

Conclusions

The study has illuminated a disconnect between the potential of Electronic Medical Records (EMR) and their current role in supporting routine aggregate data reporting and use within the Tanzanian health system. Despite the investment in EMR systems, our key finding reveals a persistent reliance on traditional paper-based registers as the primary source for aggregate data. This parallel system creates a demonstrable double workload for already burdened healthcare workers, diverting valuable time and resources from direct clinical care. The limited utilization of EMR for aggregate reporting is a multifaceted challenge, stemming from critical limitations within the EMR systems themselves, including insufficient analytical capabilities for generating structured datasets and a lack of seamless integration with the national data warehouse, DHIS2. Furthermore, the effectiveness of EMR adoption is hampered by gaps in health worker knowledge and skills in utilizing these systems effectively, compounded by the unreliable nature of the EMR infrastructure, particularly concerning power supply. Addressing these challenges is crucial for Tanzania to fully leverage the benefits of its EMR investments. Moving forward, targeted interventions are needed to enhance the analytical and interoperability functionalities of existing EMR systems, coupled with comprehensive training programs to empower healthcare workers with the necessary skills. Simultaneously, efforts to ensure a more reliable EMR infrastructure are paramount. Only through these concerted efforts can Tanzania transition towards a more efficient, accurate, and less burdensome system for routine aggregate data reporting and use, ultimately strengthening evidence-based decision-making and improving the overall health outcomes within the nation.

List of Abbreviations: CTC2- Care and Treatment Center; eHMS- Electronic Hospital Management System; DHIS2- District Health Information Systems version 2; EMR- Electronic Medical Records; GoTHOMIS- Government of Tanzania Hospital Operation Management Information System; HMIS- Health Management Information Systems; HW- Health Workers; RHIS - Routine Health Information Systems; TTF- Task-Technology Fit Theory.

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