

**AN ARCHITECTURAL DESIGN FOR AGGREGATED HEALTHCARE
REPORTING FROM ELECTRONIC MEDICAL RECORD SYSTEMS TO THE
NATIONAL ELECTRONIC HEALTHCARE REPORTING SYSTEM: A CASE
STUDY OF UGANDA MINISTRY OF HEALTH**

EMMANUEL OGWANG

KS22M10/001

**A DISSERTATION SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND
TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD
OF THE MASTER OF SCIENCE OF INFORMATION TECHNOLOGY OF UGANDA
CHRISTIAN UNIVERSITY**

June, 2025



**UGANDA CHRISTIAN
UNIVERSITY**

A Centre of Excellence in the Heart of Africa

DECLARATION

I, Ogwang Emmanuel, affirm that this report is entirely my original work, free of any plagiarism, and has not been previously submitted to any other institution for any purpose or award.

Signature:  _____

Date: 11th June 2025

“I certify that both the study and the report were conducted by the candidate under my supervision.”

Arinaitwe Irene



23.06.2025

Name and signature of immediate Supervisor

DEDICATION

I dedicate this work to my beloved parents, my father, Canon William Ongeng, and my mother, Imat Molly Ongeng, whose unwavering support and encouragement have propelled me to pursue knowledge. To my dear wife, Caroline Ogwang, and my siblings, Mr. James Alot, Ms. Sarah Ruth Auma, Ms. Racheal Akica, Miss. Jenny Mirriam Atedo and my cousin brothers (Mr. Otidu Morrise, Mr. Raymond Ojok, Mr. Paul Ayo, Mr. Walter Ongeng and Mr. Ramos Okori), for your encouragement has inspired me to strive for excellence.

I would like to also acknowledge Mr. Isaac Ogwal, for following my academic journey right from secondary school. A special acknowledgment to my father for instilling in me the value of higher education, igniting my passion for continuous learning. And finally, to the Anglican Christian community.

Thank you.

ACKNOWLEDGEMENT

I humbly acknowledge the Almighty God, the highest and most merciful, whose grace enabled me to successfully complete this course of study. He possesses all knowledge, known and yet to be discovered by humankind.

My deepest gratitude goes to the team of facilitators, Dr. Otto Francis (PhD), Dr. Irene Arinaitwe (PhD) and Ms. Justine Mukalere, whose unwavering guidance and support were instrumental from the beginning to the end of this endeavor.

I extend my appreciation to the head of the department and all participants in the postgraduate mentorship program in the Department of Engineering, Science, and Technology, whose invaluable support and guidance were pivotal throughout this journey.

I express heartfelt thanks to all the lecturers across various departments for imparting their knowledge during my studies.

Special recognition goes to the finance office for their flexibility in allowing tuition payments in installments, easing the burden of combining work and study.

I am grateful to Smart Applications International for their understanding and support, enabling employees to pursue education while maintaining a flexible work schedule.

Thank you.

ABSTRACT

In Uganda, there has been notable adoption of Information and Communication Technology (ICT), especially Electronic Medical Record (EMR) systems. Pilot studies have paved the way for the implementation of UgandaEMR, primarily used by government healthcare providers for disease surveillance and electronic reporting to DHIS2, the national electronic healthcare reporting system. Despite strong endorsement by the Ministry of Health (MoH), private healthcare providers have been slow to adopt UgandaEMR, citing diverse requirements, notably advanced financial capabilities.

A major challenge with alternative EMR systems is their inability to directly exchange routine aggregate healthcare data with DHIS2, a functionality already achieved by UgandaEMR. This gap leads to reporting delays to the MoH, negatively impacting disease surveillance and resource allocation.

This study addressed three key objectives: understanding challenges in aggregated data reporting from diverse EMR systems to DHIS2 and identifying architectural needs, designing an application architecture for data exchange between alternative EMR systems and DHIS2, and implementing this design for proof-of-concept.

Through an inductive approach, a survey of 20 purposively selected healthcare providers was conducted using questionnaires, with descriptive statistics used for analysis. The analysis revealed numerous challenges in report aggregation, including spending more than three hours consolidating reports, duplicate entries, data incompleteness and inaccuracy, and reliance on unreliable data sources such as simultaneous paper and EMR system usage.

To enhance EMR system capabilities, several strategies were identified, including developing an auto-synchronization service for report automation, integrating MoH report formats into EMR systems, and adopting interoperability standards for seamless data exchange.

A prototype was developed to demonstrate these strategies' effectiveness, showing that enhancing alternative EMR systems' capabilities enabled timely submission of aggregate healthcare data to the MoH, thereby improving disease surveillance and resource allocation efficiency.

TABLE OF CONTENT

DECLARATION.....	i
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENT.....	vii
LIST OF TABLES.....	xi
LIST OF FIGURES	xiii
LIST OF ACRONYMS AND ABBREVIATIONS	xiv
CHAPTER ONE.....	1
INTRODUCTION.....	1
1.0 Introduction	1
1.1 Background.....	1
1.2 Statement of the problem.....	4
1.3 Objectives	6
1.3.1 General Objective	6
1.3.2 Specific Objective.....	6
1.4 Research Question	6
1.5 Scope.....	7
1.5.1 Geographical Scope	7
1.5.2 Content Scope	7
1.5.3 Timeline	7
1.6 Significance / Justification of the study.....	8
1.6.1 Informed Decision Making by Ministry of Health	8
1.6.2 Addressing Reporting Challenges for Alternative EMR Systems.....	8
1.6.3 Contributing to Health Informatics Knowledge and Practices	8
CHAPTER TWO.....	9
LITERATURE REVIEW	9
2.0 Introduction	9
2.1 Aggregate Reporting to the Ministry of Health	9
2.2 DHIS2 as Uganda’s national electronic healthcare data reporting system.....	11
2.3 The UgandaEMR in the context of EMR system diversity	12

2.4	Models and Frameworks used in healthcare data exchange.	13
2.4.1	The HL7 (Health Level 7).....	13
2.4.2	Fast Healthcare Interoperability Resources (FHIR)	14
2.4.3	InterOperability Service Layer (UgISL).....	14
2.5	The Conceptual Architectural Design.....	15
2.5.1	Standard Code Aggregator.....	16
2.5.2	EMR Systems Integration & Mapping Module	16
2.5.3	Efficient Data Exchange	16
2.5.4	The conceptual architectural design.....	17
2.6	The Chapter Summary	17
CHAPTER THREE		19
RESEARCH METHODOLOGY		19
3.0	Chapter Overview	19
3.1	Research design	19
3.2	Research Method	19
3.3	Study Setting.....	20
3.4	Sources of information.....	20
3.5	Sampling Technique	20
3.6	The Sample Size	21
3.7	Procedure for data collection	22
3.8	Data collection instruments.....	23
3.9	Quality/Error control.....	24
3.10	Data processing and analysis	26
3.10.1	Data Processing.....	26
3.10.2	Data Analysis	26
3.11	Ethical considerations	27
3.12	Methodological constraints.....	27
CHAPTER FOUR		28
PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS.....		28
4.0	Introduction	28
4.1	Demographics Information	28
4.2	The current process regarding generating aggregate data.....	32
4.2.1	Challenges faced while generating data.....	34

4.2.2	Data Quality	37
4.2.3	Data accuracy and completeness	38
4.3	The role of technology in enhancing aggregate data generation and exchange	39
4.4	The Implementation for proof of concept.....	45
4.4.1	The database design.....	46
4.4.2	The programming code editor.....	46
4.4.3	The Programming Language.....	46
4.5	Description of system operation	46
4.5.1	The Dashboard / Summary	47
4.5.2	The Standard Code Aggregator	47
4.5.3	The Synchronization Module.....	48
4.5.4	The HCP Management Module	49
4.5.5	The Patient Register.....	50
4.5.6	Visit Creation	51
4.5.7	The Mapping Module	52
4.5.8	Report Submission.....	53
CHAPTER FIVE	54
DISCUSSION OF FINDINGS, CONCLUSION AND RECOMMENDATIONS.....		54
5.0	Introduction	54
5.1	Challenges of data reporting in private healthcare providers using alternative EMR systems.....	54
5.2	Strategies that can be devised for the generation and exchange of aggregated healthcare data from the various EMR systems to DHIS2.....	55
5.3	The requirements for designing an application architecture for seamless data exchange and reporting between private healthcare providers and DHIS2.	56
5.4	The sequence of operation of the developed architecture.....	57
5.4.1	Sequence 1: Establishment of Standard Codes by MoH	57
5.4.2	Sequence 2: Registration of Healthcare Providers by MoH.....	58
5.4.3	Sequence 3: Implementation of Standard Code Mapping Module by Healthcare Providers.....	58
5.4.4	Sequence 4: Report Generation and Exchange by Healthcare Providers	58
5.4.5	Sequence 5: Acknowledgment of Receipt by MoH.....	58
5.5	Conclusion	58
5.6	Recommendation	59

5.7	Contribution of the Research study.....	60
	REFERENCE	61
	APPENDIX	66
	Survey Questionnaires.....	68

LIST OF TABLES

Table 1-1 Timeline of the study.....	7
Table 3-1 Cronbach Alpha.....	24
Table 3-2 Cronbach Alpha for the Likert scale items.....	25
Table 4-1 Respondent gender distribution.....	28
Table 4-2 Respondent age group	29
Table 4-3 Respondent role at the healthcare provider	29
Table 4-4 Respondent number of years engage in data related activities.....	30
Table 4-5 Respondent experience level rating in data management.....	30
Table 4-6 Respondents trained or not trained in data management.....	31
Table 4-7 Respondent highest level of education.....	32
Table 4-8 Healthcare provider average daily visit.....	32
Table 4-9 Hours spent consolidating aggregate report	33
Table 4-10 Tools used to access data for consolidation.	33
Table 4-11 Tools used for data consolidation.	34
Table 4-12 Limited access to reliable data sources	34
Table 4-13 Data Entry Errors.....	35
Table 4-14 Unavailability of data at service points e.g. Lab and Reception	35
Table 4-15 Lack of training on data consolidation techniques	36
Table 4-16 Technical challenges	36
Table 4-17 Time constraint.....	37
Table 4-18 Incomplete data	37
Table 4-19 Inaccurate data.....	38
Table 4-20 Duplicate entries.....	38
Table 4-21 Manual data validation	38
Table 4-22 Automated data validation.....	39
Table 4-23 Cross-referencing with other sources.	39
Table 4-24 Automating the process of report sharing will make our work significantly easier... 40	40
Table 4-25 Including MoH form formats within EMR system will simplify report generation. . 40	40
Table 4-26 Implementing data validation checks will enhance the accuracy of reports	41
Table 4-27 Providing training on EMR system usage will improve ability to generate and exchange reports effectively.	42
Table 4-28 Integrating data interoperability standards into EMR system will ensure seamless data exchange with the Ministry of Health.....	42
Table 4-29 Automating routine data consolidation tasks will free up time for data clerks to focus on analysis and decision support.....	43
Table 4-30 Improving the efficiency of EMRs in generating reports will significantly reduce delays in submission to the Ministry of Health.....	44
Table 4-31 Measure of central tendency on respondent opinion regarding the role of technology	44
Table 5-1 The Likert Scale	66
Table 5-2 Healthcare Facility Distribution Per Category	66

Table 5-3 Healthcare Facility Distribution Per Region 67

LIST OF FIGURES

Figure 2.1 An illustration of the conceptual architectural design.....	17
Figure 5.1 The developed architectural design.....	57
Figure 5.2 Create and manage healthcare provider by MoH.....	76
Figure 4 HeidiSQL user interface.....	76
Figure 5 SublimeText code editor.....	76
Figure 4 1 Moh Dashboard.....	47
Figure 4 2 MoH Code Aggregator.....	48
Figure 4 3 Healthcare synchronization List.....	48
Figure 4 4 Create New Healthcare Provider.....	49
Figure 4 5 EMR New Patient Register.....	50
Figure 4 6 EMR create new patient.....	51
Figure 4 7 EMR Record visit notes.....	51
Figure 4 8 Code Mapping.....	52
Figure 4 9 Report Generation, Submission and Update.....	53
Figure 9 1 Code Snippet to auto-check for new code from MoH.....	77

LIST OF ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immunodeficiency Disease Syndrome
API	Application Programming Interface
CSS	Cascading Style Sheets
CSV	Comma Separated Values
DHIS2	District Health Information System (Version 2)
DHO	District Health Office
EMR	Electronic Medical Record
EMRs	Electronic Medical Record System
EU	European Union
FHIR	Fast Healthcare Interoperability Resources
HISP	Health Information System Program
HIV	Human Immunodeficiency Virus
HL7	Health Level 7
ICD-10	International Classification of Diseases, 10th Revision
JSON	JavaScript Object Notation
KCCA	Kampala Capital City Authority
MoH	Ministry of Health (Uganda)

MySQL	My Structured Query Language
NGO	Non-Governmental Organization
PFP	Private-For-Profit
PHP	Hypertext Preprocessor
PNFP	Private and Not-For-Profit
RESTful	Representational State Transfer
SCA	Standard Code Aggregator
SMS	Short Message Service
SPSS	Statistical Package for the Social Sciences
UCU	Uganda Christian University
UgISL	Uganda Interoperability Service Layer
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter serves as the inaugural section of the research, outlining the contextual background, problem statement, objectives, research inquiries, scope, and significance of the study.

1.1 Background

The adoption and implementation of digital technologies in healthcare have been steadily rising across the globe. A few years ago, a World Health Organization (WHO) survey revealed that at least 40% of countries had adopted Electronic Medical Records (EMR) systems within their healthcare sectors. This trend is particularly pronounced in high-income countries, where significant investments in IT infrastructure and a broad base of digital expertise have enabled smoother integration of health technologies. The shift toward digital health systems is driven by the need for efficient access to patient histories, streamlined care coordination, and improved health outcomes.

Globally, the momentum continues to build. In 2024, over 68% of healthcare leaders reported increased reliance on digital tools, including EMRs, artificial intelligence, and telemedicine (Odoemene, 2024). These technologies are not only enhancing clinical decision-making but also enabling more responsive and data-driven public health strategies.

In Africa, the journey toward digital health transformation is gaining traction, albeit at a varied pace. While many countries still rely heavily on paper-based systems, there is growing recognition of the potential of EMRs and Electronic Health Records (EHRs) to revolutionize healthcare

delivery (Kavuma, 2019). Countries like Ethiopia, Kenya, and Rwanda have initiated national strategies to digitize health records and improve data interoperability (Berihun et al., 2020).

However, challenges such as limited infrastructure, inadequate funding, and shortages of skilled personnel continue to hinder widespread adoption. A 2024 comparative study found that only about 15% of low- and middle-income countries had achieved national-level EMR adoption, compared to much higher rates in high-income countries (Odoemene, 2024).

Despite these hurdles, the prospects are promising. There is increasing investment in digital health, and several pilot programs across the continent are demonstrating the feasibility and benefits of EMR systems. For instance, some countries are exploring open-source EMR platforms like OpenMRS, which are more adaptable to local contexts and resource constraints (Muinga et al., 2018).

In recent years, Uganda's healthcare sector did not make an exception. It has witnessed a remarkable transformation through the integration of modern technologies, particularly in the field of health information management (Namatovu et al., 2022; Nancy et al., 2022). A significant catalyst for this digital evolution is the adoption of Electronic Medical Records (EMR), a technology-driven approach that organizes and manages patient-centric health information (Kiwanuka et al., 2021).

According to Mamlin et al., (2021), EMR adoption presents a myriad of benefits, including streamlined data entry processes, enhanced accuracy, and swift access to patient information. Also, EMR facilitates comprehensive record-keeping and, ensures that healthcare professionals have a holistic view of patients' health (Kiwanuka et al., 2021). Improved care coordination through seamless sharing of information between departments, contributes to more effective and patient-

centric healthcare (Afaq et al., 2022) and provides decision support, offering real-time access to relevant data for evidence-based decision-making.

Over the years, Uganda has embarked on the implementation of more than 50 pilot EMR systems, especially in the government healthcare facilities with the support of various partners such as USAID, UNICEF, and WHO (Huang et al., 2017). According to Nagwovuma et al., (2021), one of the primary motivations behind the Ministry's pursuit of the EMR systems' adoption is to address the persistent challenge of delays in healthcare aggregated reporting by healthcare providers. EMR systems facilitate the swift generation and sharing of crucial reports, offering a solution to the issue of timely reporting.

Despite the benefits of EMR systems, their implementation and subsequent utilization in Uganda has faced a number of challenges. For example, there is low adoption of EMR from end users due to complex user interfaces, and unreliable computing infrastructure (Mugisha, 2024; Umezuruike et al., 2017a (MoH, 2021)). Also, Umezuruike et al., (2017a) noted that EMR usage in Uganda is challenged by existing knowledge gaps, lack of trained professionals, limited user engagement, resistance to change, and lack of a comprehensive evaluative examination of the infrastructure at all levels of healthcare delivery in Uganda. In addition, Bagyendera et al., (2023) noted that the limited use and utilization of health data in Uganda is hampered by the absence of standardized data formats, lack of data governance policies, unskilled data management human resources, limited data use culture, poor data quality, complacency, limited political will, and lack of interoperability. Timely and accurate healthcare reports from EMR systems support public health planning (Balaba Bogere et al., 2018).

Although, UgandaEMR emerged as a flagship solution, especially in the government/public healthcare space, the adoption of it among the private healthcare providers in Uganda is low. Thus

many healthcare service providers express a preference for alternative solutions that seamlessly blend both operational/administrative functions and clinical functions (Madore et al., 2015; Woldemariam & Jimma, 2023). For example, administrative functions include the human resources module and the financial module. Also, UgandaEMR is primarily designed for clinical details (Karunganwa et al., 2023), with no other administrative functions, for example, financial and human resources.

Several studies have probed into the challenges in EMR systems, shedding light on their multifaceted nature. Notably, the work by (Mukhiya & Lamo, 2021) delved into crucial aspects such as interoperability, user experience, and system integration. In addition, (Afaq et al., 2022; Luo et al., 2023) have tackled issues including data security.

Therefore, to address the difficulty in generating and exchanging aggregated healthcare data from the alternative EMR, we propose the development of an application architecture. At its core, the architecture introduces a Standard Code Aggregator (SCA), providing a centralized mechanism to define required data types and allowing for flexible expansion. EMR Systems are then required to develop a dedicated module that acts as a mapping interface, ensuring alignment with standardized codes mandated by the Ministry of Health, defined in the SCA. The whole synchronization is done over the internet. This solution aims to show how EMR systems, irrespective of their vendor, can generate and exchange healthcare data with the national electronic healthcare reporting system, DHIS2.

1.2 Statement of the problem

By the end of 2020, the DHIS2 online platform had more than 6232 healthcare providers registered, with 48% representing private entities who opted for alternative Electronic Medical

Record (EMR) systems over the Ministry of Health's UgandaEMR (Muhaise et al., 2019). Despite the superior functionalities of these alternative systems, a significant challenge arises from their lack of data exchange compatibility with the national healthcare reporting system, The District Health Information System Version 2 (DHIS2) (MoH, 2021). This persistent issue has led to delays in submitting crucial aggregated healthcare data to reporting centers.

The main challenge lies in the difficulties faced by healthcare providers, particularly those in private institutions when utilizing alternative EMR systems to generate necessary aggregated healthcare data. Subsequently, uploading this data onto the national DHIS2 platform becomes cumbersome (Stre@mlineEMR, 2020). While UgandaEMR proves efficient in government healthcare settings, the prevalent use of alternative EMR systems among private providers introduces complexities, resulting in delays in report submission. For example, (Zavuga et al., 2023) noted that private healthcare providers consistently failed to meet timely aggregated report submission targets. Despite the efficiency of UgandaEMR in government settings, the diverse use of alternative EMR systems in private healthcare institutions necessitates a standardized solution (MoH, 2021).

Addressing this challenge is crucial as it impedes the timely submission of essential healthcare data. The delays hinder informed decision-making, disease surveillance, and strategic public health planning, particularly for Uganda (Nsaghurwe et al., 2021).

In response to this challenge, this study proposes the design of application architecture. At its core is a Standard Code Aggregator (SCA), serving as a centralized mechanism to define required data types and allowing for flexible expansion. EMR Systems are then mandated to develop and integrate a dedicated module, functioning as a mapping interface, ensuring alignment with the Ministry of Health, as defined in the Standard Code Aggregator. The entire synchronization

process occurs over the internet. This architectural design benefits both healthcare providers and the Ministry of Health Uganda by enabling seamless, aggregated healthcare data exchange. It supports informed decision-making, strengthens disease surveillance, and serves as a cornerstone for strategic public health planning, with the added advantage of timely data availability.

1.3 Objectives

1.3.1 General Objective

To develop an application architecture to enhance Uganda's healthcare data reporting by seamlessly integrating alternative EMR systems with DHIS2.

1.3.2 Specific Objective

1. To investigate the challenges of aggregated data reporting from different EMR systems to DHIS2 to determine requirements for the design of the architecture.
2. To design a data exchange application architecture between the alternative EMR systems within Uganda's healthcare landscape and DHIS2.
3. To implement the resulting architectural design for proof-of-concept.

1.4 Research Question

1. What are the workflows and challenges of data reporting in private healthcare providers using alternative EMR systems?
2. What strategy can be devised for the generation and exchange of aggregated healthcare data from the alternative EMR systems to DHIS2?
3. What are the requirements for designing an application architecture for seamless data exchange and reporting between private healthcare providers and DHIS2?

1.5 Scope

1.5.1 Geographical Scope

The geographic scope of this study was confined to the Kampala metropolitan area, chosen due to the concentration of numerous private healthcare facilities that have made substantial investments in advanced EMR systems (Namatovu et al., 2022). Additionally, Kampala experiences high patient traffic (Alunyu et al., 2021), leading to a substantial volume of data generated, making it a suitable location for this research.

1.5.2 Content Scope

This entailed reviewing existing literature, gathering requirements, and designing an exchange architecture. In addition, there was an implementation of a prototype application architecture purposely for proof of concept.

1.5.3 Timeline

Table 1-1 Timeline of the study

SN	SPECIFIC OBJECTIVE	PERIOD
1	To investigate the challenges of aggregated data reporting from different EMR systems to DHIS2 to determine requirements for the design of the architecture.	Feb 2024 (Week 1 & 2)
2	To design a data exchange application architecture between the alternative EMR systems within Uganda's healthcare landscape and DHIS2.	Mar 2024 (Week 3)
3	To implement the resulting architectural design for proof-of-concept.	April 2024 (Week 4)

1.6 Significance / Justification of the study

1.6.1 Informed Decision Making by Ministry of Health

The proposed solution will minimize delays and ensure that the Ministry is equipped with comprehensive healthcare data when required. According to (Katwesige et al., 2020), doing so will empower the MoH to make informed decisions, allocate resources effectively, and formulate evidence-based policies for public health strategies.

1.6.2 Addressing Reporting Challenges for Alternative EMR Systems

The research actively tackles reporting complexities encountered by private healthcare providers utilizing alternative EMR systems. This saves time and effort of both healthcare practitioners and data clerks at these healthcare service providers. Hence, allow them to focus more on giving quality care and services to their clients (Balaba Bogere et al., 2018).

1.6.3 Contributing to Health Informatics Knowledge and Practices

Beyond its immediate applications, this study seeks to contribute to the evolving field of health informatics, particularly in the realm of health information exchange (Borna et al., 2023; Nsaghurwe et al., 2021). Through the exploration of insights, methodologies, and models, the study endeavors to offer valuable contributions to the broader body of knowledge. These contributions are envisioned to serve as a foundation for future research and studies in similar contexts.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a comprehensive review of related literature, encompassing both theoretical and empirical perspectives. It begins by defining key study variables, followed by an exploration of the conceptual architectural design.

2.1 Aggregate Reporting to the Ministry of Health

In Uganda, the healthcare sector is practiced by both public and private players, comprising over 6,676 health facilities across the country (MoH, 2021). These facilities are categorized into three main types, i.e. Government-owned, Private and Not-For-Profit (PNFP), and Private-For-Profit (PFP), with a small percentage representing community-owned facilities. Each of these categories plays a significant role in ensuring public health.

As of the latest data, Government-owned healthcare facilities account for the majority, constituting 45.16% of the total, which translates to 3,441 facilities. These facilities are an integral part of the public healthcare system, serving diverse communities with a focus on providing accessible and subsidized healthcare services.

Private For Profit (PFP) health facilities make up a substantial portion, accounting for 40.29% of the total facilities in Uganda. With 2,260 facilities falling under this category, these private enterprises play a vital role in offering a wide range of healthcare services, often with a focus on efficiency and innovation.

Irrespective of ownership, all these health facilities play a crucial role in the healthcare ecosystem of Uganda. It is noteworthy that each facility, regardless of ownership type, participates in the healthcare reporting process by providing monthly aggregated reports to the Ministry of Health (Huang et al., 2017).

The process of reporting health data in Uganda is a structured journey that commences at the grassroots level and culminates at the Ministry of Health. They meticulously complete hard copy forms (HMIS form 105 and 108 for outpatient and Inpatient respectively), capturing a diverse array of critical information related to diagnoses, presenting complains and other fundamental aspects of health service delivery (White et al., 2022).

These completed forms serve as the foundation of health data reporting and are then submitted to the reporting centers, e.g. Kampala Capital City Authority (KCCA), the District Health Office, (DHO), among others (Balaba Bogere et al., 2018; DHIS2, 2022; Kiwanuka et al., 2021). These centers assume the responsibility of collating and organizing these reports before forwarding them to the next level, i.e. district level. In this phase, data clerks play a vital role, facing the demanding task of converting information from hard copies into a digital format. This shift to digital is essential for subsequent analysis and incorporation into the national electronic health reporting system, DHIS2, the national electronic health data reporting system (DHIS2, 2022). However, healthcare providers at Level 3, take a more direct route, submitting their reports directly through the DHIS2 portal (MoH-Uganda, 2020). This streamlined approach not only minimizes handling points but also opens avenues for quicker and more precise reporting.

Despite the well-defined hierarchy in place, the reliance on hard copy forms as the primary aggregation source introduces challenges associated with manual handling and the potential for delays and inaccuracies at various stages.

2.2 DHIS2 as Uganda's national electronic healthcare data reporting system

The District Health Information System version 2 (DHIS2) stands as a beacon of innovation, offering a free and open-source platform that has garnered global recognition (Mwakabira et al., 2023). This comprehensive system is harnessed by various organizations, including the European Union (EU), and is in use by governments in over 50 countries, with several of them currently in the pilot stage or early phases of national deployment (DHIS2, 2022).

The journey of DHIS2 began in 2006, and since its inception, it has become a cornerstone for NGOs and national governments in over 60 countries. Its applications span a wide spectrum, from patient health monitoring to enhancing disease surveillance, pinpointing outbreaks, and facilitating swift access to healthcare-related data for further analysis and research.

Developed by the Health Information Systems Program (HISP) and backed by the University of Oslo's Department of Informatics, DHIS2 emerged as the successor to DHIS, initially conceived for grassroots health committees and Community Information Systems in South African health districts (Twabi et al., 2022). Its rapid adoption, including national implementation by South Africa and other African nations, marked a turning point, leading to the development of the web-based DHIS2 in 2005-2006. Therefore, in Uganda, DHIS2 stands at the central repository of all the healthcare aggregate data from all healthcare providers within the country.

On a more positive note, the integration of the UgandaEMR with DHIS2 signifies a positive step towards a more efficient and automated data exchange (Nancy et al., 2022). Facilities using this EMR can directly exchange data with DHIS2, contributing to the Ministry of Health's overarching goal of leveraging technology for streamlined, accurate, and timely health data reporting.

2.3 The UgandaEMR in the context of EMR system diversity

An Electronic Medical Record (EMR) system is a digital keeper of health information, offering a sophisticated and efficient way to manage and organize patient data (Mamlin et al., 2021). Unlike traditional paper records, EMRs provide a centralized and accessible electronic repository for a person's health history. Imagine it as a dynamic and comprehensive digital file capturing essential details about an individual's healthcare journey.

Within an EMR, crucial information includes patient demographics, medical history, clinical notes from healthcare visits, and results from diagnostic tests like laboratory reports and imaging studies (Adegboire & Omowumi, 2021; Mohamed, 2022; Spatar et al., 2019). This digital platform not only reduces paperwork but also ensures that healthcare providers have immediate access to accurate and up-to-date information when making crucial decisions about a patient's care.

The UgandaEMR is an example of this technology in action. Developed as an open-source EMR, it signifies a collaborative approach to healthcare information management. Open-source platforms like the UgandaEMR are designed to be flexible and adaptable to the unique needs of healthcare systems. By June 2022, it was operational in over 1000 healthcare facilities, showcasing its acceptance and effectiveness in various healthcare settings (UgandaEMR, 2023).

In the dynamic landscape of healthcare technology adoption, it's noteworthy that many private healthcare providers in Uganda exhibit a distinct preference for EMR systems that seamlessly integrate both administrative and clinical record functions (Umezuruike et al., 2017b). This inclination stems from a desire for comprehensive solutions that not only manage patient health information efficiently but also address broader operational needs such as customer experience

management, appointment scheduling, inventory management, and most importantly financial tracking (Dayananda, 2020; Spatar et al., 2019).

This preference has led to a diverse adoption of EMR systems across private healthcare facilities, with each institution seeking a solution that aligns closely with its specific requirements. The healthcare sector, characterized by its diversity in practice and service offerings, witnesses a range of EMR systems chosen by private providers to best suit their individual operational and patient care needs.

2.4 Models and Frameworks used in healthcare data exchange.

2.4.1 The HL7 (Health Level 7)

Health Level Seven (HL7) stands as a cornerstone in the realm of healthcare informatics, offering a suite of international standards designed to harmonize the exchange and integration of electronic health information (Mukhiya & Lamo, 2021). These standards provide a structured framework, fostering interoperability among various health information systems. This interoperability is vital for the seamless communication of health data across various platforms, including EMR systems, laboratory systems, and medical imaging systems.

According to Hidayat, HL7 standards serve as a baseline for healthcare technologies, ensuring a common language and format for the exchange of health-related data (Hidayat & Hermanto, 2020). Notably, HL7 standards come in different versions, with HL7 version 2.x and HL7 version 3 being prominent in the field. Version 2.x utilizes a text-based, pipe-and-hat delimiter format, while version 3 employs an XML-based approach, catering to more complex and structured data exchanges.

2.4.2 Fast Healthcare Interoperability Resources (FHIR)

Fast Healthcare Interoperability Resources (FHIR) stands also out as a modern and flexible standard within the realm of health data exchange. Developed by Health Level Seven International (HL7), FHIR is designed to address the evolving needs of healthcare information interoperability by leveraging contemporary web standards (Mukhiya & Lamo, 2021).

FHIR employs a resource-based model, allowing for the representation of healthcare data in a structured and easily accessible manner. It utilizes widely adopted technologies such as RESTful APIs (Application Programming Interfaces) and JSON (JavaScript Object Notation) for data representation, making it more developer-friendly and adaptable to the current technology landscape.

One of FHIR's key advantages is its scalability and modular approach, enabling healthcare systems to implement specific resources and functionalities as needed. This makes FHIR well-suited for the integration of the various EMR systems in the healthcare space, from mobile applications to large-scale healthcare information systems.

2.4.3 InterOperability Service Layer (UgISL)

At the heart of the intricate data exchange ecosystem between UgandaEMR and DHIS2 lies the Interoperability Service Layer, known as UgISL. UgandaEMR adopts an innovative approach that doesn't hinge on a distinct module or user interface for data exchange (Nancy et al., 2022). What sets it apart is the absence of a separate option for mapping reports with datasets. UgandaEMR streamlines the process by directly integrating pre-built CODE values into the reporting module.

Category Option CODEs are specific codes assigned to individual options within a category. Each option within a category, such as "Disease Type," is allocated a unique code for identification.

This coding system ensures a standardized and efficient representation of various options within a category. For instance, in reporting diseases, the "Disease Type" category might include options like "Malaria," "HIV/AIDS," and "Tuberculosis," each assigned a Category Option CODE like "MAL," "HIV," and so forth for precise identification.

UgISL plays a crucial mediating role in transmitting data to DHIS2. Notably, UgISL excels in converting CODE values to unique IDs before the data payload reaches DHIS2. This transformation ensures a smooth and standardized exchange, contributing to the overall efficiency of data interchange.

The communication channel between UgandaEMR and DHIS2 follows a standardized format termed UgEMR-eDX JSON. This format acts as the conduit for data exchange, maintaining a structured and consistent approach.

It's crucial to highlight that both DHIS2 and UgandaEMR are open source, emphasizing that the model's compatibility is specific to UgandaEMR. The reliance on specific CODE values and the UgEMR-eDX JSON format renders this model less universally applicable, particularly for alternative EMR systems employed by healthcare providers. Each EMR system structure necessitates tailored solutions for compatibility.

2.5 The Conceptual Architectural Design

The conceptual design, depicted in Figure 2.1, comprises multiple components, each described below. Certain components share similarities with those employed in UgandaEMR, stemming from the intention to directly exchange data with DHIS2. Notably, both DHIS2 and UgandaEMR are built on the same open-source platform and overseen by MoH Uganda affiliates. Consequently,

much of the mapping and standardization are pre-built or predefined, minimizing the need for additional input to ensure uniformity, as they adhere to MoH's stipulated requirements.

2.5.1 Standard Code Aggregator

The proposed architecture introduces a Standard Code Aggregator, aligning with the data requirements specified by DHIS2, (Central Public Health Laboratories, 2020). This aggregator serves as a centralized mechanism defining the types of data needed. Notably, it allows for seamless expansion by facilitating the easy addition of new items to accommodate evolving healthcare reporting needs.

2.5.2 EMR Systems Integration & Mapping Module

To ensure compatibility with the standardized codes established by the aggregator, EMR Systems will be mandated to develop a dedicated integration module. This new module acts as a mapping interface, enabling EMR Systems to align their internal data items with the standardized elements mandated by MoH. This mapping process ensures uniformity and consistency in data representation.

A comparable module is utilized by UgandaEMR (UgandaEMR, 2023); however, it lacks a user interface, as the items for mapping are predefined within the system itself, leveraging the same open-source architecture managed by MoH. Alternative EMRs must devise strategies to align with the codes mandated by the MoH.

2.5.3 Efficient Data Exchange

Once the mapping is successfully executed, the proposed model facilitates efficient data sharing between EMR Systems and DHIS2. This streamlined exchange mechanism ensures that healthcare data from diverse EMR Systems are made available for use by MoH.

2.5.4 The conceptual architectural design.

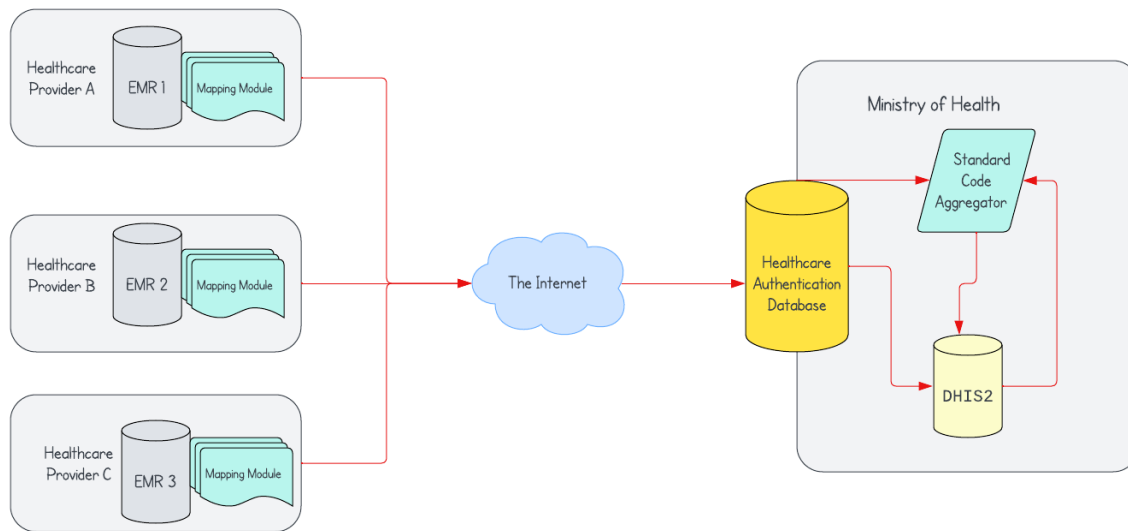


Figure 2.1 An illustration of the conceptual architectural design

2.6 The Chapter Summary

In summary, the current process of submitting health data relies heavily on paper-based forms. This method is not only time-consuming but also prone to errors, which often results in delays when submitting aggregate data. These delays make it difficult for the Ministry of Health (MoH) to access timely information needed for effective decision-making.

Although UgandaEMR is the system recommended by the MoH, it does not fully support the operational needs of many for-profit healthcare providers. Important features such as advanced financial management and customer retention tools are missing. Because of this, many private providers prefer to use alternative EMR systems that better suit their requirements.

The purpose of this study is to design an architectural framework that can be adopted by vendors of these alternative EMR systems. This framework will enable the systems to share aggregate

healthcare data with DHIS2, the platform used by the MoH. As a result, data will be submitted more promptly, allowing the ministry to make better-informed decisions. Additionally, healthcare practitioners will benefit from a simplified aggregation process, as the need for manual data compilation will be eliminated.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Chapter Overview

In the methodology section, the research approach, research design, research strategy, research method, and data collection tools & analysis are discussed in detail to illustrate how the objectives set forth were achieved.

3.1 Research design

A cross-sectional design was adopted. In addition, an inductive approach was employed. This approach is rooted in the recognition that the EMR system utilization in Uganda's healthcare landscape is diverse and dynamic, with unique challenges and contextual nuances. In addition, inductive reasoning, as emphasized by scholars (Mark N.K. et al., 2019) allowed for a bottom-up exploration of the complexities involved, starting with detailed observations, and moving on to identifying patterns in the existing healthcare data reporting systems. By embracing an inductive lens, this study sought to understand the specific needs and constraints faced by healthcare providers using alternative EMR systems regarding aggregated reporting. This ensured that the resulting application architecture is not only technically developed but also tailored to the distinctive requirements as defined by the Ministry of Health.

3.2 Research Method

The research employed the survey research method (Melnikovas, 2018), involving the distribution of structured questionnaires to a representative sample within the target population. This method, previously described by (Stuart & Nicola, 2011) offers a structured and systematic approach to

collecting quantitative data, facilitating a thorough examination of the existing reporting landscape.

3.3 Study Setting

The study was conducted within the Kampala metropolitan area due to several compelling reasons. Firstly, the region boasts a dense concentration of private healthcare providers who have made substantial investments in information communication technology, particularly in the adoption of EMR systems. Secondly, Kampala experiences high patient traffic, resulting in a substantial volume of data being collected. Consequently, the generation of reports requires significant effort due to the sheer volume of data. These factors collectively make the Kampala metropolitan area an ideal location for conducting this study.

3.4 Sources of information

Both primary and secondary data sources were utilized in this study. Primary data were collected through an online survey administered via Google Forms, reaching the target audience through WhatsApp, text messages, and email. The survey comprised 23 questions, including single selection, multiple selection, and Likert scale rating formats. On the other hand, secondary data were primarily sourced from literature obtained from various reputable organizations and publications. Databases such as the African Journal, Open Research Library (ORL), and Springer Link were accessed. Additionally, the Ministry of Health online library provided valuable literature relevant to this study.

3.5 Sampling Technique

Despite limited literature on the prevalence of EMR system utilization among healthcare providers in Uganda, studies such as (Balaba Bogere et al., 2018; Muhaise et al., 2019) suggest a growing

trend, particularly within the private health sector. For this reason, the study purposively sampled 20 healthcare providers. A total of 30 respondents/individuals participated in the survey, with some healthcare providers having two respondents. The survey specifically targeted data clerks and those individuals responsible for compiling reports sent to MoH reporting centers. This sampling approach, also employed by (Huang et al., 2017), ensured that the chosen providers met predefined criteria essential for their meaningful participation in the study. The key criteria included a significant investment in EMR systems, geographically located within Kampala and being fully or partially under private ownership.

3.6 The Sample Size

Determining an appropriate sample size is essential to ensure the study's findings are both reliable and representative of the target population. This research employs a purposive sampling technique, focusing exclusively on facilities within Kampala Metropolitan Area that have made substantial investments in EMR systems. The total population of such facilities was identified as 35.

To establish a statistically sound sample size, the Krejcie and Morgan (1970) formula for finite populations was applied. This formula is particularly suitable for small, well-defined populations and adjusts sample size calculations to avoid overestimation.

Table 5.3 shows the distribution of healthcare facilities in Kampala. According to the set criteria in the sample technique, about 35 healthcare facilities were eligible for this study. Therefore, to determine the actual sample size, the formula below was used.

$$S = \frac{X^2 \cdot N \cdot P \cdot (1 - P)}{d^2 \cdot (N - 1) + X^2 \cdot P \cdot (1 - P)}$$

Where:

- S = required sample size
- N = population size
- P = population proportion (assumed to be 0.5 for maximum sample size)
- d = margin of error (typically 0.05)
- X^2 = Chi-square value for 1 degree of freedom at the desired confidence level (3.841 for 95% confidence)

- $N = 35$
- $P = 0.5$
- $d = 0.05$
- $X^2 = 3.841$

$$S = \frac{3.841 \cdot 35 \cdot 0.5 \cdot (1 - 0.5)}{0.05^2 \cdot (35 - 1) + 3.841 \cdot 0.5 \cdot (1 - 0.5)}$$

$$S = \frac{3.841 \cdot 35 \cdot 0.25}{0.0025 \cdot 34 + 3.841 \cdot 0.25}$$

$$S = \frac{33.10875}{0.085 + 0.96025}$$

$$S = \frac{33.10875}{1.04525} \approx 31.7$$

$$S \approx 32$$

Although the sample size used in this study (30 participants) is slightly smaller than the recommended 32 based on Krejcie and Morgan's formula, representing a 6.25% reduction, this was due to a lower than expected response rate. However, this does not affect reliability and is unlikely to affect the overall results.

3.7 Procedure for data collection

Prior to questionnaire administration, questions were developed and reviewed by a supervisor for possible improvements, with adjustments made accordingly. These questions were then formatted using Google Forms, allowing for various question types, and a test link was shared with

colleagues to assess usability, with feedback incorporated, such as making questions mandatory for better response rates. Subsequently, the final link was generated for distribution to target respondents. During administration, facilities were physically visited, and requests to meet data collection personnel were made, rescheduling when necessary. For facilities where respondents were available, a brief introduction emphasized the survey's brevity and purpose, which positively influenced respondent participation. Links were shared via preferred communication methods, and respondents confirmed completion. Following administration, a thank-you message was sent to respondents, and data was imported into CSV format and uploaded to SPSS software for analysis.

3.8 Data collection instruments

This study primarily relied on questionnaires for data collection. The design process started by identifying key variables. These variables were then grouped into three categories: respondent profile, challenges faced by private healthcare providers using alternative EMR systems for reporting to the MoH, and the role of technology in improving the aggregate reporting process. Each category had a specific set of questions tailored to gather relevant information aligned with the study's objectives. The final questionnaire was formatted and administered through Google Forms, an online platform.

The choice of Google Forms was based on its user-friendly interface, versatility in accommodating different question formats (including single and multiple selection, as well as open-ended questions), making it particularly suitable for quantitative studies. Additionally, the platform is cost-free, allowing the form to be built without financial investment. It also offers unlimited submissions and is easily accessible on smartphone devices, enhancing convenience and accessibility for respondents.

3.9 Quality/Error control

(Segal & Coolidge, 2018) defines reliability as the consistency and stability in the results of a test or scale. In other words, if the same test is administered overtime, the results should be consistent or rather very similar.

The questionnaire underwent validity testing in two ways. First, a supervisor review was conducted, with necessary corrections implemented. Additionally, a subset of colleagues received the questionnaire to assess validity, yielding impressive results. The validity was measured using the Content Validity Index (CVI), calculated as the proportion of valid/relevant items to the total number of items, resulting in a CVI of 0.9, signifying high validity (Roebianto et al., 2023).

Furthermore, the questionnaire exhibited Cronbach's Alpha reliability of .610, indicating consistency among the items in measuring the intended construct—the role of technology in enhancing aggregated data generation and exchange. An index of above 0.6 is considered moderate and those above 0.7 is considered very reliable (Segal & Coolidge, 2018).

Table 3-1 Cronbach Alpha

Cronbach's Alpha	N of Items
.624	6

Table 3-2 shows how the different items are represented on the Likert scale, according to Cronbach alpha.

Table 3-2 Cronbach Alpha for the Likert scale items

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Automating the process of report sharing will make our work significantly easier.	22.40	6.938	-.004	.688
Including Ministry of Health (MOH) form formats within your EMR system will simplify the process of generating reports.	22.60	4.593	.500	.513
Providing comprehensive training on EMR usage will improve our ability to generate and exchange reports effectively.	22.40	5.421	.457	.546
Integrating data interoperability standards into our EMR system will ensure seamless data exchange with the Ministry of Health.	22.60	4.593	.463	.532
Automating routine data consolidation tasks will free up time for data clerks to focus on analysis and decision support.	22.53	6.189	.194	.635
Improving the efficiency of EMRs in generating reports will significantly reduce delays in submission to the Ministry of Health.	22.47	5.016	.538	.509

Automating the process of report sharing will make our work significantly easier.	22.40	6.938	-.004	.688
---	-------	-------	-------	------

3.10 Data processing and analysis

3.10.1 Data Processing

The responses were downloaded from the online form in a comma-separated values format, commonly referred to as CSV format. Subsequently, the data underwent cleaning procedures, which involved removing the timestamp and standardizing fields that respondents were required to fill out to ensure uniformity. For instance, fields such as the name of the EMR system used and the name of the facility to which respondents belonged were standardized.

Variables were created for the data, specifying attributes such as name, type, length, label, and others. This process essentially defines the data formats within the SPSS software.

Each response was then entered onto the system using the coded values. For instance, gender was coded in binary, either 1 or 0 representing Male or Female, respectively. The same idea was applied to all the responses. However, for other responses, such as the Likert scale, values ranged up to 5, with 0 representing "strongly disagree" and 5 representing "strongly agree". Despite variations in the number of options available, the underlying principle remained consistent.

3.10.2 Data Analysis

During the analysis phase, descriptive techniques in the SPSS software were employed. This included the use of frequency distributions along with measures of central tendency, such as mean and standard deviation.

The frequencies indicate the extent to which each variable has received responses, serving as the starting point for descriptive statistics. This analysis was applied to all questions in the dataset.

The measure of central tendency was primarily utilized to analyze the Likert scale responses, providing insight into sentiments regarding the role of technology. This analysis was crucial as it offered an average stance per variable. Subsequently, this value was compared against a Likert table to precisely ascertain the average respondent's perspective on a particular variable.

In addition, reliability test was carried out using Cronbach Alphas' method and results presented as generated.

3.11 Ethical considerations

Ethical considerations were paramount throughout the research. Privacy and confidentiality of healthcare data was rigorously upheld, adhering to ethical standards and legal regulations within the legal framework of the Republic of Uganda (Republic of Uganda, 2019). Informed consent was sought from healthcare providers participating in the research. Transparent communication and collaboration with stakeholders was maintained to foster trust and ethical practice.

3.12 Methodological constraints

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS

4.0 Introduction

This chapter presents the study's findings. It explores the response rates, demographics of the participants, and key results aligned with the research objectives. Data analysis was conducted using SPSS software, employing descriptive statistics such as frequency tables and measures of central tendency to summarize the collected information. In addition, it also showcases the implementation for proof of concept.

4.1 Demographics Information

In the survey question about gender, there were almost equal numbers of male and female respondents. Specifically, there were 16 males representing 53.3%, and 14 females representing 46.7%.

Table 4-1 Respondent gender distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Male	16	53.3	53.3	53.3
Female	14	46.7	46.7	100.0
Total	30	100.0	100.0	

While the survey included respondents from various age groups, the 25 to 34 age group was heavily represented, constituting roughly 73.3% while 35 to 44 had 26.7 % of all participants. This indicates a predominance of young adults in the survey population. It's important to note, however, that there was a complete lack of respondents from several age groups, including those under 18, 18 to 24, 45 to 54, 55 to 64, and 65 or older.

Table 4-2 Respondent age group

	Frequency	Percent	Valid Percent	Cumulative Percent
25-34	22	73.3	73.3	73.3
Valid 35-44	8	26.7	26.7	100.0
Total	30	100.0	100.0	

Approximately 53.3% of the participants in the study are actively engaged in healthcare roles or practices. This suggests that their primary responsibilities may not involve data management activities within healthcare providers but rather serve as supplementary duties. Conversely, around 34% of the participants hold positions directly associated with data management, such as Data Clerks and Data Analysts.

Table 4-3 Respondent role at the healthcare provider

	Frequency	Percent	Valid Percent	Cumulative Percent
Data clerk	7	23.3	23.3	23.3
Data analyst	3	10.0	10.0	33.3
Valid Health worker/Practitioner	16	53.3	53.3	86.7
Manager/Supervisor	3	10.0	10.0	96.7
Other	1	3.3	3.3	100.0
Total	30	100.0	100.0	

In terms of experience with data-related activities, the survey revealed a spread across several categories. Nearly half (43.3%) of respondents reported involvement for 1-3 years, while 16.7%

indicated less than a year of experience. A significant portion, 30%, have 4-6 years of experience, and around 10% have been involved for more than 6 years. This suggests that a considerable portion of the respondents have some experience handling data, but a sizeable group is also relatively new to the field.

Table 4-4 Respondent number of years engage in data related activities

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Less than 1 year	5	16.7	16.7	16.7
1-3 years	13	43.3	43.3	60.0
4-6 years	9	30.0	30.0	90.0
More than 6 years	3	10.0	10.0	100.0
Total	30	100.0	100.0	

However, when asked do a self-rating regarding their level of experience in data management and analysis, respondents indicated a range of expertise. More than half (53.3%) considered themselves Intermediate, while 20% identified as Beginners and 26.7% reported being Advanced. This distribution suggests a mix of experience levels within the respondent pool.

Table 4-5 Respondent experience level rating in data management

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Beginner	6	20.0	20.0	20.0
Intermediate	16	53.3	53.3	73.3
Advanced	8	26.7	26.7	100.0
Total	30	100.0	100.0	

In terms of formal training, a significant majority (66.7%) of respondents indicated having received training related to data management or health information systems. Only 33.3% reported no formal training in these areas. This suggests that a strong emphasis may be placed on equipping staff with the necessary knowledge to handle data within this organization.

Table 4-6 Respondents trained or not trained in data management

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	20	66.7	66.7	66.7
No	10	33.3	33.3	100.0
Total	30	100.0	100.0	

When respondents were asked about their highest level of education, the distribution of responses revealed interesting patterns. Notably, the vast majority of participants, accounting for 80% of the total, reported holding a Bachelor's degree, indicating a well-educated respondents. Additionally, a significant proportion, representing 16.7% of respondents, reported having obtained a Diploma, further underscoring the educational attainment within the surveyed group. A smaller fraction, constituting 3.3% of participants, reported holding a Certificate as their highest qualification. Interestingly, no respondents indicated having completed only primary or secondary education, while none reported possessing a Master's degree or higher qualification. This breakdown highlights the predominance of Bachelor's degree holders among the respondents, reflecting a relatively high level of academic achievement within the surveyed cohort

Table 4-7 Respondent highest level of education

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Certificate	1	3.3	3.3	3.3
Diploma	5	16.7	16.7	20.0
Bachelor's degree	24	80.0	80.0	100.0
Total	30	100.0	100.0	

The survey on daily patient load at the facility revealed a diverse landscape. While 6.4% reported a low volume of 0-10 visits daily, a substantial 60% (33.3% for 100-200 visits and another 26.7% for 50-100 visits) manage moderate to high patient volumes.

Table 4-8 Healthcare provider average daily visit

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0 – 10	2	6.7	6.7	6.7
10 – 50	10	33.3	33.3	40.0
50 – 100	8	26.7	26.7	66.7
100 – 200	10	33.3	33.3	100.0
Total	30	100.0	100.0	

4.2 The current process regarding generating aggregate data.

Consolidating data for the Ministry of Health reports proves to be a time-consuming task across facilities, with no respondents indicating it takes less than an hour. A significant portion, nearly three-quarters 70% -(combining the 26.7% who spend 1-2 hours and the 43.3% who spend 3-4 hours), dedicate a moderate amount of time on this process. However, a noteworthy 30% invested

over five hours, highlighting the potential need for streamlining the data aggregation and reporting procedures.

Table 4-9 Hours spent consolidating aggregate report

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1 - 2 hours	8	26.7	26.7	26.7
3 - 4 hours	13	43.3	43.3	70.0
More than 5 hours	9	30.0	30.0	100.0
Total	30	100.0	100.0	

When gathering health information for reporting purposes, facilities overwhelmingly rely on electronic data management. While a significant majority (76.7%) utilize a combination of EMR system and paper records, no facilities reported using paper records alone. This mixed approach suggests that a complete transition to EMR system may be underway but hasn't been fully implemented everywhere.

Table 4-10 Tools used to access data for consolidation.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Electronic Medical Records	7	23.3	23.3	23.3
Both paper and EMRs.	23	76.7	76.7	100.0
Total	30	100.0	100.0	

The landscape of data consolidation and analysis tools in these facilities leans heavily towards the EMR systems represented at 81.5%. This suggests a potential preference for integrated solutions that manage both patient data and reporting functionalities. However, a significant minority (18.5%) still relies on Microsoft Excel, highlighting a possible need for either additional training

on EMR system functionalities or for more user-friendly reporting features within those systems. This distribution indicates a potential gap between the capabilities of existing EMR systems and the comfort level of some users with those tools.

Table 4-11 Tools used for data consolidation.

	Frequency	Percent	Valid Percent	Cumulative Percent
Microsoft Excel	6	20.0	20.0	20.0
Valid EMR System	24	80.0	80.0	100.0
Total	30	100.0	100.0	

4.2.1 Challenges faced while generating data.

The survey revealed that 43.3% of respondents reported having limited access to reliable data sources, while 56.7% stated otherwise. This indicates a significant portion of healthcare facilities may encounter hurdles in accessing dependable data, potentially hindering the accuracy and completeness of their reporting to health authorities. The implication of this challenge suggests a need for interventions aimed at improving data infrastructure and accessibility to enhance the quality and reliability of health data.

Table 4-12 Limited access to reliable data sources

	Frequency	Percent	Valid Percent	Cumulative Percent
No	17	56.7	56.7	56.7
Valid Yes	13	43.3	43.3	100.0
Total	30	100.0	100.0	

An overwhelming 80% of respondents acknowledged experiencing data entry errors, while only 20% reported otherwise. This high prevalence of errors in data entry poses a critical challenge to the integrity and reliability of EMR systems. The potential implication of this issue underscores the importance of implementing robust data validation processes, training programs, and technological solutions to mitigate errors and enhance data accuracy.

Table 4-13 Data Entry Errors

	Frequency	Percent	Valid Percent	Cumulative Percent
No	6	20.0	20.0	20.0
Valid Yes	24	80.0	80.0	100.0
Total	30	100.0	100.0	

According to the survey findings, 26.7% of respondents faced challenges due to the unavailability of data at service points such as labs and reception areas, while 73.3% did not encounter this issue.

Table 4-14 Unavailability of data at service points e.g. Lab and Reception

	Frequency	Percent	Valid Percent	Cumulative Percent
No	22	73.3	73.3	73.3
Valid Yes	8	26.7	26.7	100.0
Total	30	100.0	100.0	

The vast majority (76.7%) of respondents had training on data consolidation techniques. Offering supplementary training could encourage wider adoption and potentially improve data analysis efficiency.

Table 4-15 Lack of training on data consolidation techniques

	Frequency	Percent	Valid Percent	Cumulative Percent
No	23	76.7	76.7	76.7
Valid Yes	7	23.3	23.3	100.0
Total	30	100.0	100.0	

Technical issues like internet connectivity or power outages pose challenges for over 46% of facilities, potentially causing significant disruptions to the data consolidation process.

Table 4-16 Technical challenges

	Frequency	Percent	Valid Percent	Cumulative Percent
No	16	53.3	53.3	53.3
Valid Yes	14	46.7	46.7	100.0
Total	30	100.0	100.0	

A significant portion (63.3%) of facilities struggle with time constraints during data consolidation. As discussed earlier, a large portion spends a considerable amount of time on this process, suggesting potential inefficiencies that could be addressed through exploring ways to streamline the consolidation process, such as improving data quality or automating repetitive tasks, to free up valuable time for facility staff.

Table 4-17 Time constraint

	Frequency	Percent	Valid Percent	Cumulative Percent
No	11	36.7	36.7	36.7
Valid Yes	19	63.3	63.3	100.0
Total	30	100.0	100.0	

4.2.2 Data Quality

A significant majority (73.3%) struggles with incomplete data, hindering the consolidation process. Missing information can create gaps in the final reports, affecting their accuracy and usefulness.

Table 4-18 Incomplete data

	Frequency	Percent	Valid Percent	Cumulative Percent
No	8	26.7	26.7	26.7
Valid Yes	22	73.3	73.3	100.0
Total	30	100.0	100.0	

While less prevalent than incomplete data, a substantial portion (33.3%) still encounters inaccurate data. This can lead to misleading reports and hinder effective decision-making by the Ministry of Health. Implementing stricter data entry protocols and validation procedures can help ensure data accuracy.

Table 4-19 Inaccurate data

	Frequency	Percent	Valid Percent	Cumulative Percent
No	20	66.7	66.7	66.7
Valid Yes	10	33.3	33.3	100.0
Total	30	100.0	100.0	

A staggering majority (90%) faces challenges with duplicate entries. This can significantly inflate reported figures and skew data analysis. Streamlining data collection processes and implementing deduplication techniques within EMR systems can help minimize duplicate entries.

Table 4-20 Duplicate entries

	Frequency	Percent	Valid Percent	Cumulative Percent
No	3	10.0	10.0	10.0
Valid Yes	27	90.0	90.0	100.0
Total	30	100.0	100.0	

4.2.3 Data accuracy and completeness

A significant majority (70%) relies on manual data validation checks, suggesting a labor-intensive process potentially susceptible to human error.

Table 4-21 Manual data validation

	Frequency	Percent	Valid Percent	Cumulative Percent
No	9	30.0	30.0	30.0
Valid Yes	21	70.0	70.0	100.0
Total	30	100.0	100.0	

The minority (16.7%) do not utilize automated data validation checks while 83.3% have EMR systems that perform automatic data validation. This highlights a potential opportunity to streamline the process and potentially improve accuracy.

Table 4-22 Automated data validation

	Frequency	Percent	Valid Percent	Cumulative Percent
No	25	83.3	83.3	83.3
Valid Yes	5	16.7	16.7	100.0
Total	30	100.0	100.0	

90% of respondents reported cross-referencing their data with other sources to ensure accuracy and completeness. While cross-referencing is a common practice to validate data, it can be time-consuming. This approach involves comparing data entries against external sources or databases to validate their accuracy and detect any discrepancies.

Table 4-23 Cross-referencing with other sources.

	Frequency	Percent	Valid Percent	Cumulative Percent
No	3	10.0	10.0	10.0
Valid Yes	27	90.0	90.0	100.0
Total	30	100.0	100.0	

4.3 The role of technology in enhancing aggregate data generation and exchange

The survey on automating report sharing revealed a positive sentiment towards the idea. While there were no dissenting voices (0% for Strongly Disagree and Disagree), a small portion (6.7%) remained undecided. The vast majority, however, expressed agreement (26.7% Agree and a

resounding 66.7% Strongly Agree). This suggests that automation is seen as a welcome solution to streamlining the report sharing process.

Table 4-24 Automating the process of report sharing will make our work significantly easier

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Undecided	2	6.7	6.7	6.7
Valid Agree	8	26.7	26.7	33.3
Valid Strongly Agree	20	66.7	66.7	100.0
Valid Total	30	100.0	100.0	

The survey results overwhelmingly favor incorporating MoH form formats directly into electronic medical record (EMR) systems. A very strong majority, nearly two-thirds (56.7%), of respondents indicated Strong Agreement with this proposition. An additional 33.3% expressed agreement, bringing the total positive response to 90%. However, 3.3% strongly disagreed with the notion and only a minimal portion (6.7%) remained undecided.

This strong consensus highlights the potential benefits seen in streamlining report generation by embedding MoH standard formats within EMR systems.

Table 4-25 Including MoH form formats within EMR system will simplify report generation.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Strongly Disagree	1	3.3	3.3	3.3
Valid Undecided	2	6.7	6.7	10.0
Valid Agree	10	33.3	33.3	43.3
Valid Strongly Agree	17	56.7	56.7	100.0
Valid Total	30	100.0	100.0	

The survey regarding real-time data validation checks within EMR systems yielded a resounding endorsement for this approach. There was a complete absence of disagreement (0% for Strongly Disagree and Disagree), with a small portion (10%) unsure. However, the sentiment overwhelmingly leaned towards positive implementation. Averagely a third (33.3%) of respondents expressed agreement, and a very strong majority (56.7%) indicated Strong Agreement. This unified perspective underscores the potential of real-time data validation to significantly enhance the accuracy of reported data. By catching errors as they occur, this approach can ensure the integrity of information submitted to relevant authorities.

Table 4-26 Implementing data validation checks will enhance the accuracy of reports

	Frequency	Percent	Valid Percent	Cumulative Percent
Undecided	3	10.0	10.0	10.0
Valid Agree	10	33.3	33.3	43.3
Valid Strongly Agree	17	56.7	56.7	100.0
Total	30	100.0	100.0	

The survey results on the impact of EMR training for report generation and exchange are overwhelmingly positive. There was near-unanimous agreement on the value of training, with 3.3% of respondents indicating a disagreement. Majority (66.7%) expressed strong agreement. An additional third (30.3%) simply agreed.

Table 4-27 Providing training on EMR system usage will improve ability to generate and exchange reports effectively.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Disagree	1	3.3	3.3	3.3
Valid Agree	9	30.0	30.0	33.3
Valid Strongly Agree	20	66.7	66.7	100.0
Valid Total	30	100.0	100.0	

The survey results regarding integrating data interoperability standards into EMR systems to ensure seamless data exchange with MoH reveal a positive sentiment. There's a clear majority (56.7% Strongly Agree and 36.7% Agree) who believe this integration would be beneficial. This translates to nearly two-thirds of respondents (93.4%) favoring standardized data exchange.

While a small percentage (3.3% each) expressed disagreement or strong disagreement, there were no undecided responses. This suggests a clear consensus on the potential advantages of standardized data exchange. Implementing these standards could streamline reporting processes, improve data quality and accuracy for the MoH, and potentially save time and resources for healthcare facilities.

Table 4-28 Integrating data interoperability standards into EMR system will ensure seamless data exchange with the Ministry of Health.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Strongly Disagree	1	3.3	3.3	3.3
Valid Disagree	1	3.3	3.3	6.7
Valid Agree	11	36.7	36.7	43.3
Valid Strongly Agree	17	56.7	56.7	100.0
Valid Total	30	100.0	100.0	

The survey findings highlight a strong consensus among respondents regarding the potential benefits of automating routine data consolidation tasks to enable data clerks to prioritize analysis and decision support. A significant majority, comprising 56.7% of respondents, strongly agree with this proposition, indicating a high level of confidence in the positive impact of automation on task efficiency and resource allocation. Additionally, 33.3% of respondents agree with this notion, further supporting the idea that automating routine tasks can create opportunities for data clerks to engage in higher-value activities such as analysis and decision support. This overwhelming support suggests a widespread recognition of the importance of leveraging automation technologies to streamline workflow processes and optimize resource utilization within healthcare settings. However, a small minority of respondents, representing 11.1%, remain undecided about the efficacy of this approach.

Table 4-29 Automating routine data consolidation tasks will free up time for data clerks to focus on analysis and decision support

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Undecided	3	10.0	10.0	10.0
Valid Agree	10	33.3	33.3	43.3
Valid Strongly Agree	17	56.7	56.7	100.0
Valid Total	30	100.0	100.0	

The survey on improving EMR efficiency for report generation yielded a strong endorsement of this approach. The vast majority of respondents (63.3%) indicated Strong Agreement. An additional 30% expressed agreement, bringing the total positive response to 93.3%. This overwhelming consensus highlights the significant potential of improved EMR efficiency to

expedite report submissions to the Ministry of Health. Streamlining report generation through EMR enhancements can lead to faster turnaround times, ensuring timely data reaches the Ministry for informed decision-making. This can ultimately benefit public health efforts and improve patient care.

Table 4-30 Improving the efficiency of EMRs in generating reports will significantly reduce delays in submission to the Ministry of Health.

	Frequency	Percent	Valid Percent	Cumulative Percent
Disagree	1	3.3	3.3	3.3
Undecided	1	3.3	3.3	6.7
Valid Agree	9	30.0	30.0	36.7
Strongly Agree	19	63.3	63.3	100.0
Total	30	100.0	100.0	

Based on the above opinions collected regarding the role of technology in enhancing the reporting process within healthcare facilities, it's evident that there is a widespread consensus towards embracing technological solutions to streamline reporting procedures. An average mean of 4.40 was observed. Refer to Table 5-1 for Likert scale ranges and definition.

Table 4-31 Measure of central tendency on respondent opinion regarding the role of technology

	N	Min.	Max	Mean	Std. Dev.
Automating the process of report sharing will make our work significantly easier.	30	3	5	4.60	.621

Including Ministry of Health (MOH) form formats within your EMR system will simplify the process of generating reports.	30	1	5	4.40	.894
Implementing real-time data validation checks within our EMR system will enhance the accuracy of our reports.	30	3	5	4.47	.681
Providing comprehensive training on EMR usage will improve our ability to generate and exchange reports effectively.	30	2	5	4.60	.675
Integrating data interoperability standards into our EMR system will ensure seamless data exchange with the Ministry of Health.	30	1	5	4.40	.932
Automating routine data consolidation tasks will free up time for data clerks to focus on analysis and decision support.	30	3	5	4.47	.681
Improving the efficiency of EMRs in generating reports will significantly reduce delays in submission to the Ministry of Health.	30	2	5	4.53	.730
Valid N (listwise)	30				

4.4 The Implementation for proof of concept

The implementation of the developed architecture utilized established technologies. This process involved creating two databases and two straightforward web applications to mimic the

functionalities of DHIS2 and private healthcare EMR systems. Due to the complexity of accessing the live DHIS2 deployment, a decision was made to simulate its operations on another platform. However, the focus remained on showcasing the architectural operations rather than replicating the entire DHIS2 functionality. Similarly, the EMR system showcased a select few functionalities, with particular emphasis placed on mapping and synchronization, as depicted in Figure 2.1 of the conceptual architectural design.

4.4.1 The database design.

The database was designed using MySQL 5.5. HeidiSQL, a familiar software, was employed to create the table structures (refer to Figure 4). This choice was based on its capabilities and user-friendly nature, making configuration and interface navigation straightforward.

4.4.2 The programming code editor

Sublime Text, a free and user-friendly code editor, was utilized to write both front and back-end logic. This choice was made due to its accessibility and ease of use. See Figure 5.

4.4.3 The Programming Language

For backend logic and database access, PHP was employed, while HTML and CSS (considered markup and styling tools, respectively) were utilized for front-end development and formatting. JavaScript played a crucial role in enhancing user experience, particularly in navigation, page-refresh, and loading. To streamline development, many functionalities were integrated using class names within the Bootstrap 4.x framework.

4.5 Description of system operation

The system description will be presented in two parts: first, an overview of the simulated DHIS2, followed by a description of the EMR system's operations. We'll start with the simulated DHIS2.

4.5.1 The Dashboard / Summary

This section provides a summary of various key metrics within the simulated DHIS2, including total daily visits, malaria positive cases, and the total number of healthcare providers who have successfully submitted data, among other pertinent statistics.

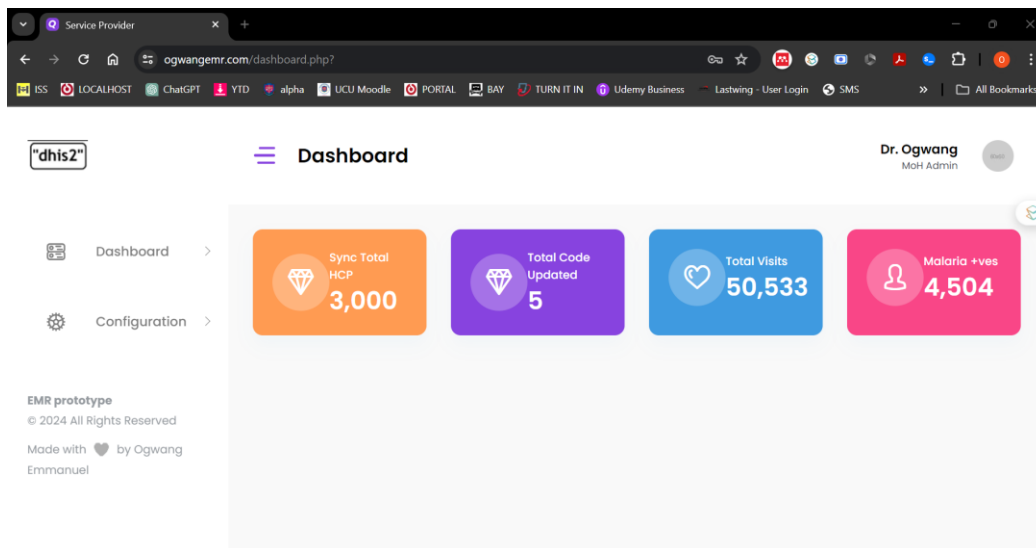


Figure 4 1 Moh Dashboard

4.5.2 The Standard Code Aggregator

This segment serves as the interface where MoH defines the diseases slated for surveillance. It encompasses the ICD-10 codes, disease descriptions/names, and the respective dates of addition. Healthcare providers pick these codes for mapping into their respective EMR systems using the code mapping module. Refer to Figure 5.1.

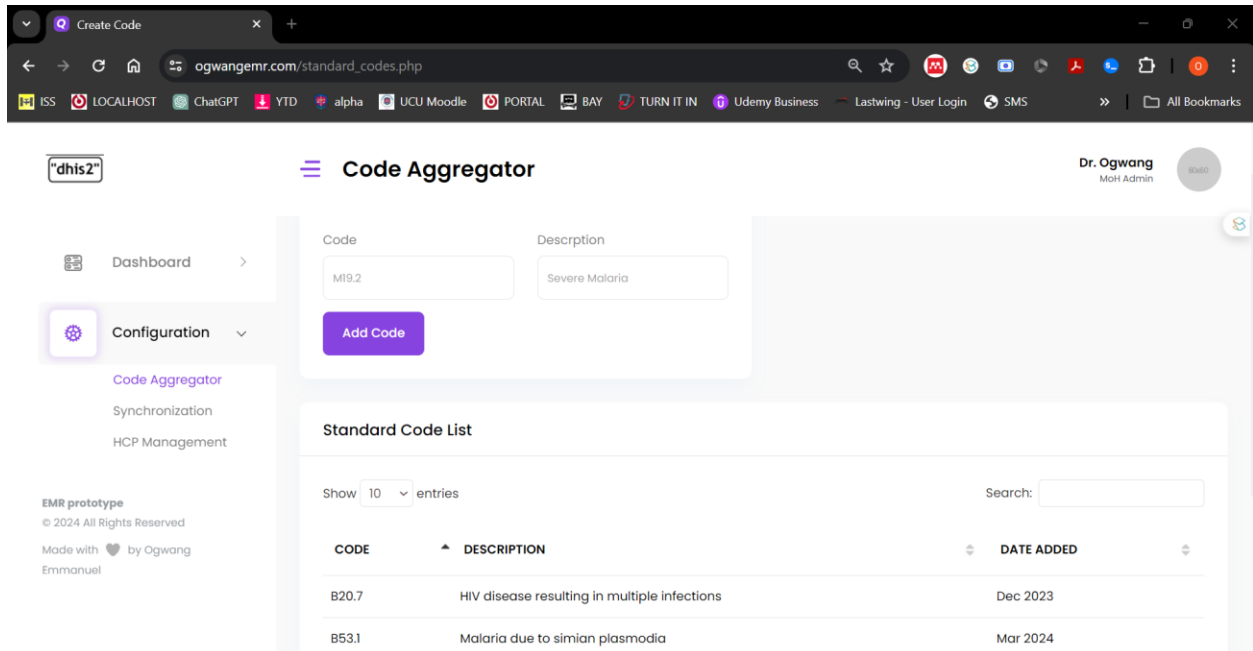


Figure 4 2 MoH Code Aggregator

4.5.3 The Synchronization Module

Here, service MoH can view the healthcare providers who have already sent data, including the last data of synchronization.

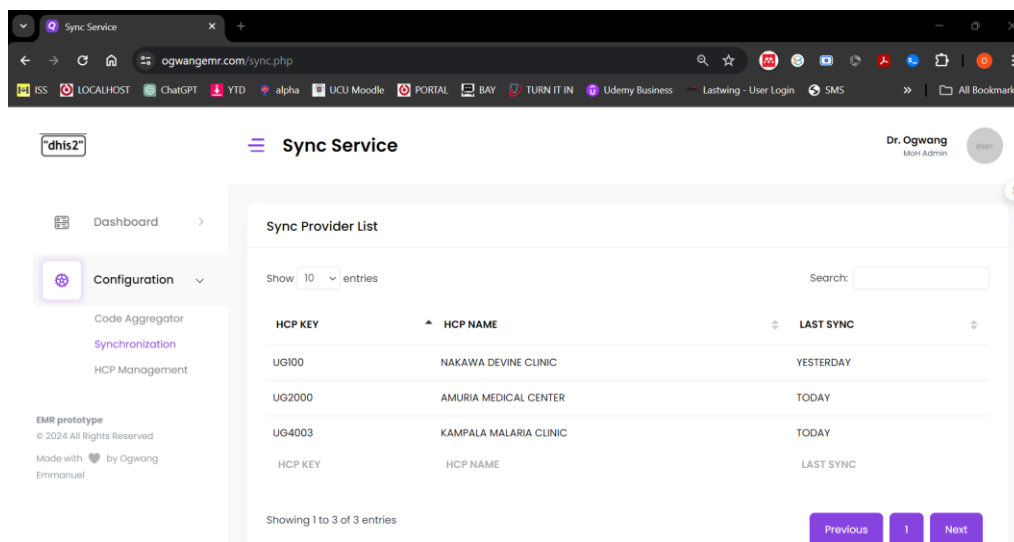


Figure 4 3 Healthcare synchronization List

4.5.4 The HCP Management Module

This module facilitates the registration process for healthcare providers by MoH. It generates a unique identifier for each provider and creates corresponding usernames and passwords. These credentials are utilized by healthcare providers within the integration module to exchange data with MoH.

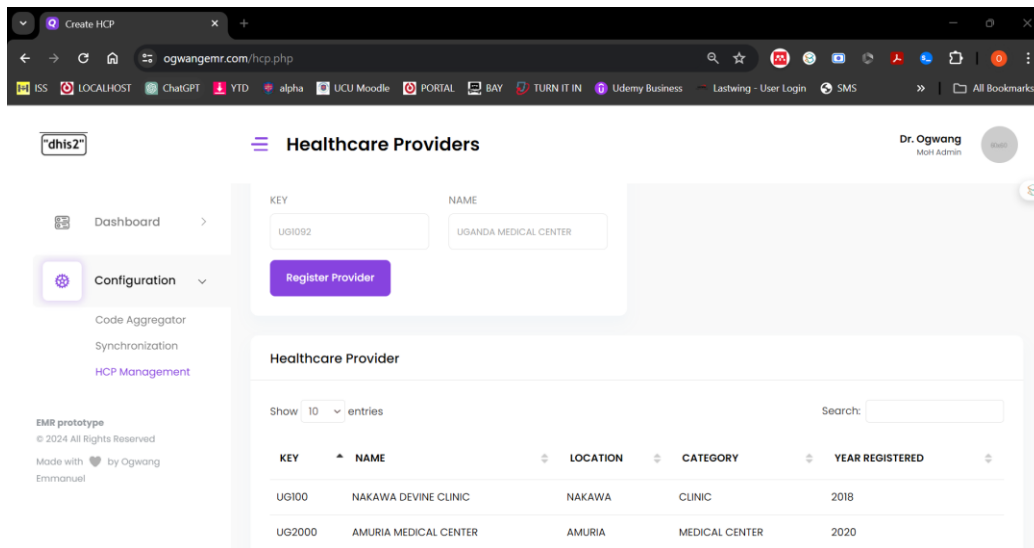


Figure 4 4 Create New Healthcare Provider

Now, let's explore how the EMR systems connect with the MoH. The following screenshots will illustrate the functionalities within the EMR systems.

4.5.5 The Patient Register.

Healthcare providers gather patient information before administering services, which is retained for future reference. Each patient is assigned a unique identifier, known as a registration number.

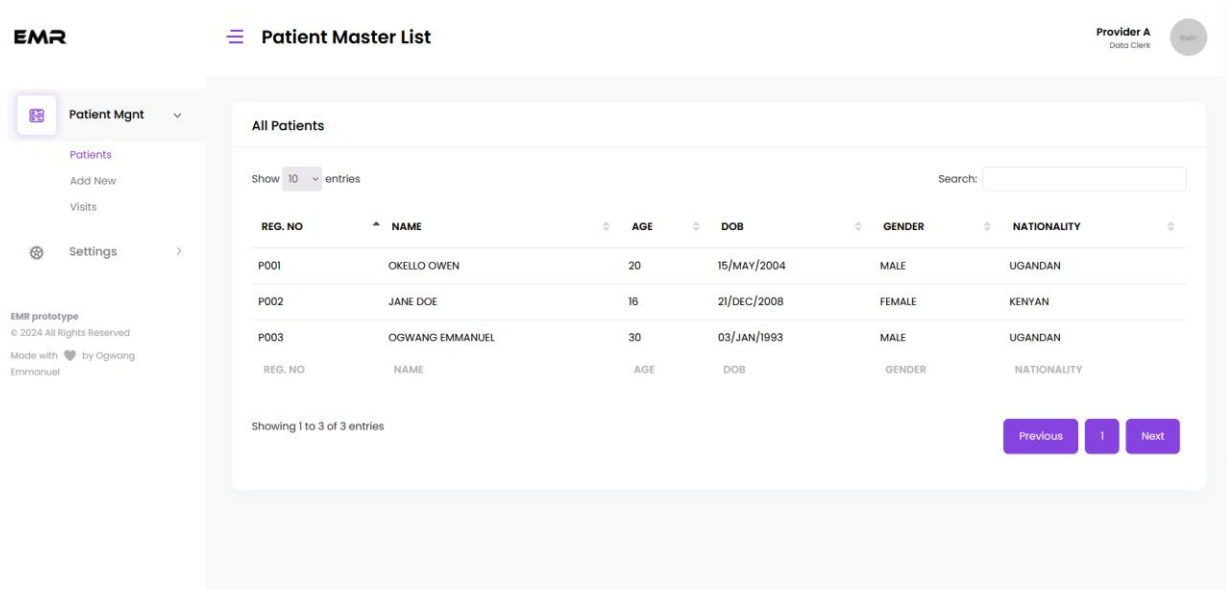


Figure 4 5 EMR New Patient Register

For patients who are not yet in the system, there is an interface available for registration. Please refer to the figure below for details.

Figure 4 6 EMR create new patient

4.5.6 Visit Creation

The medical practitioner records clinical notes, which encompass the chief complaint, examination findings, and laboratory investigation results. For this demonstration, we'll simplify the results to denote only negative or positive outcomes.

Figure 4 7 EMR Record visit notes

4.5.7 The Mapping Module

Healthcare providers have the option to select the ICD revision they wish to preload into their EMR systems. MoH utilizes the 10th Revision of ICD. To ensure compatibility between healthcare providers' codes and those of the MoH, a mapping process is necessary. This module continually monitors for any new codes added by the MoH for surveillance and maps them to corresponding codes within the EMR system.

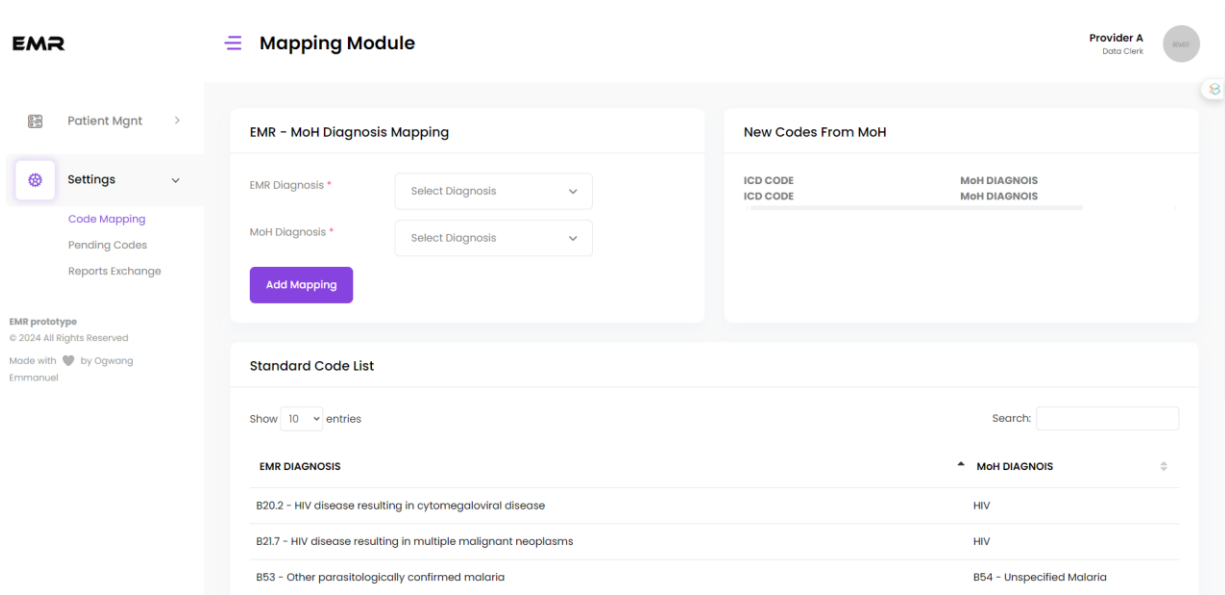


Figure 4 8 Code Mapping

4.5.8 Report Submission

Once all visits are concluded, healthcare providers can generate reports and submit them to MoH using this module. A timestamp is logged on both the healthcare provider's EMR system and DHIS2. This ensures that updates can be made within the same day without overwriting earlier submissions. Essentially, subsequent submissions made within the same day will be incremental to the initial submission.

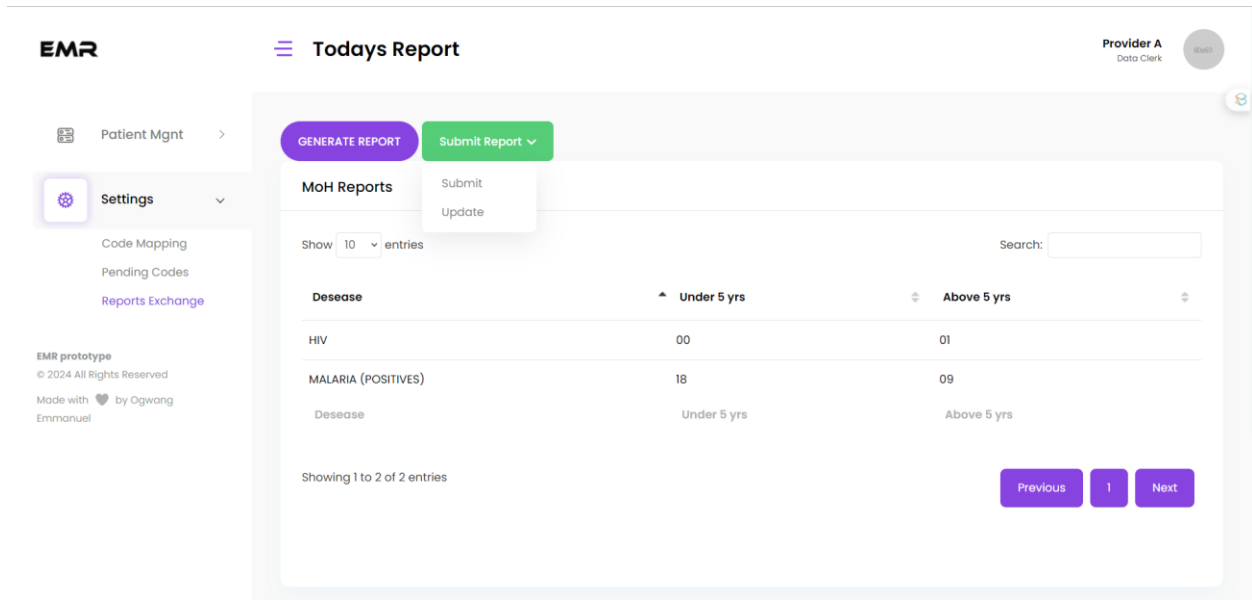


Figure 4 9 Report Generation, Submission and Update

CHAPTER FIVE

DISCUSSION OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter marks the conclusion of the study. It will delve into the results, guided by the research questions and objectives outlined for this research. Additionally, it will showcase how these findings align with the literature previously reviewed.

5.1 Challenges of data reporting in private healthcare providers using alternative EMR systems.

This study is grounded in the understanding of the challenges healthcare providers face in routine reporting. Subsequent paragraphs will delve into how this study has further solidified our understanding of these challenges.

The findings of this study revealed that more than half of the service providers spend over 3 hours consolidating aggregate data to be sent to MoH. Moreover, approximately 80% still rely on both paper-based and EMR systems to access the data pieces for consolidation. Clearly, a significant time investment is required by most healthcare providers to prepare these reports. This observation resonates with the research conducted by (Zavuga et al., 2023) which highlighted a notable delay in routine reporting submission to MoH. Their analysis indicated a consistent failure among private healthcare providers to submit reports punctually. Specifically, in 2020, only 65% managed to submit the monthly report on time, with even poorer performance for the weekly report.

Furthermore, 80% of providers encounter issues related to data entry errors, while almost 50% have expressed concerns about technical challenges such as power outages and internet unavailability, impeding timely access to necessary data for aggregation. These findings echo

those presented by (Aggrey et al., 2022) which revealed that technical factors significantly influence the utilization of routine health information for decision-making.

In terms of data quality, over 70% of providers face challenges related to incomplete data, while a staggering 92.6% encounter duplicate entries during the consolidation process. Additionally, 70.4% must perform manual data validation checks, and 88.9% resort to cross-referencing with other sources to validate data accuracy and validity. It is surprising that only 7.4% of healthcare providers have implemented automated data validation checks to ensure data quality. These reliability issues are consistent with the findings of (Abias Katesigwa, 2016) in her study on the "Determinants of Effective Utilization of Routine Health Information in Private Health Facilities in Kampala, Uganda."

Therefore, it is evident that healthcare providers invest significant time in preparing required reports for submission to MoH, as reflected by 60% of providers expressing concerns about time constraints.

5.2 Strategies that can be devised for the generation and exchange of aggregated healthcare data from the alternative EMR systems to DHIS2.

92.6% of respondents firmly believe that automating the report sharing process would significantly streamline their workload. This resounding sentiment underscores the potential effectiveness of implementing an automated report service. Additionally, 89% of providers advocate for the integration of MoH aggregate report format into alternative EMR systems, emphasizing the importance of standardization. This integration is expected to simplify report generation and enhance reliability, aligning with the findings of (Stre@mlineEMR, 2020) regarding report generation.

In response to combating invalid data entries, 59% strongly agree and 29.6% agree on the necessity of implementing real-time data validation checks within alternative EMR systems to ensure report accuracy.

Furthermore, over 55% express strong support for the idea of integrating data interoperability standards into these systems to facilitate seamless data exchange of aggregated reports with the Ministry of Health. This aligns with the recommendations of several studies, including (Bagyendera et al., 2023; Josephine et al., 2021; Kiwanuka et al., 2021), all of which emphasize the importance of building systems capable of validation and interoperability with other systems. These findings provide strong support for the recommendations outlined in 5.3, which outlines the architectural requirements suggested by this study.

5.3 The requirements for designing an application architecture for seamless data exchange and reporting between private healthcare providers and DHIS2.

This study finds four (04) key components in line with the requirements that is needed for designing an application architecture. These are already included on Figure 5.1. These are purely based on the survey done backed by the several literatures done prior to the survey. The components are as listed below: -

1. An auto synchronization service can be implemented to ensure that these reports are sent automatically at specified time.
2. A standard code manager/aggregator can be implemented to ensure that the alternative EMR systems have got the latest items/codes required by the ministry of health on specific reports.

3. Inclusion of ministry of health report format in the system is ideal for efficient reporting.
4. The internet, required for connectivity from the healthcare provider, to MoH.
5. And finally, integrating data interoperability standards to ensure a seamless data exchange to MoH

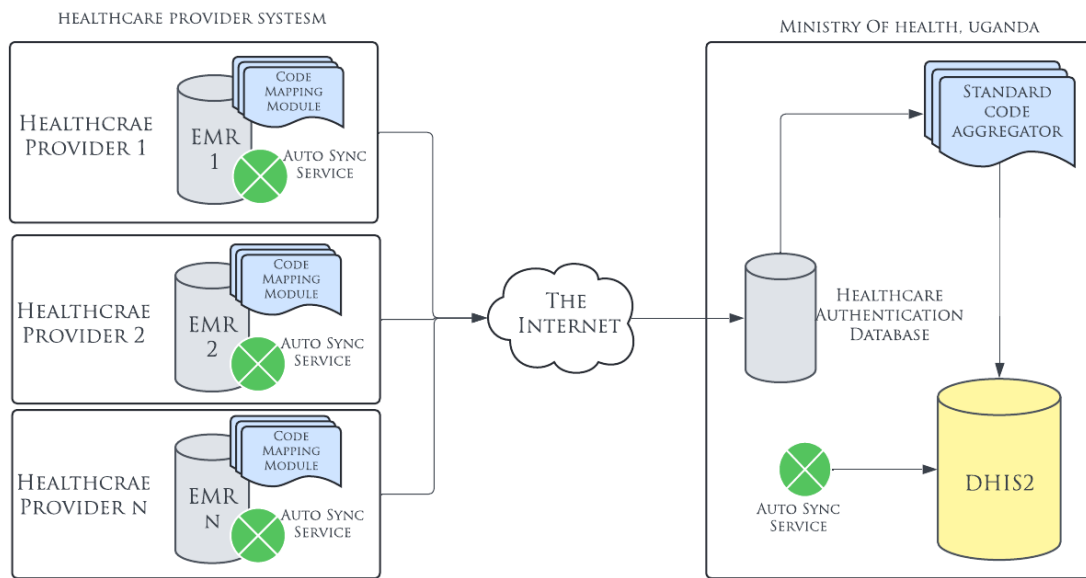


Figure 5.1 The developed architectural design.

5.4 The sequence of operation of the developed architecture

5.4.1 Sequence 1: Establishment of Standard Codes by MoH

MoH establishes a database defining standardized codes, such as Diagnosis/Disease codes, for surveillance purposes, see Figure 4 2. These codes, as per MoH guidelines, are derived from the ICD10 framework (MoH, 2016).

5.4.2 Sequence 2: Registration of Healthcare Providers by MoH

Healthcare providers undergo registration within the MoH database, where they are assigned a unique identifier and provided with a username and password for integration configuration, see Figure 4 4. Failure to register in the database results in denied data exchange privileges.

5.4.3 Sequence 3: Implementation of Standard Code Mapping Module by Healthcare Providers

Given the diverse versions of the ICD utilized in alternative EMR systems, healthcare providers must employ a Code Mapping Module to map their codes with those defined by MoH for surveillance purposes, see Figure 4 8. This standardization is clearly discussed by (Josephine et al., 2021) in their work regarding requirements for digital health standards.

5.4.4 Sequence 4: Report Generation and Exchange by Healthcare Providers

Healthcare providers have the capability to generate and review aggregated reports before electronically submitting them to MoH for further processing.

5.4.5 Sequence 5: Acknowledgment of Receipt by MoH

MoH acknowledges the receipt of submitted aggregates, updating them on the dashboard, and adding the respective healthcare providers to the list of submissions received.

5.5 Conclusion

As a reminder, the study sought to investigate the challenges of aggregated data reporting from alternative EMR systems to DHIS2 and to determine requirements for the design of the architecture. Several challenges emerged with a high degree of emphasis. These challenges include incomplete data, duplicate data, manual data validation and technical challenges, among others.

All these challenges increase on the turnaround time that is required for these healthcare providers to consolidate and submit the required aggregate reports to ministry of health. This delay aligns with the observations made by (Zavuga et al., 2023), in their study on the Timeliness and Completeness of monthly disease surveillance data reporting in Uganda.

There is clearly less emphasis put forth by healthcare providers using alternative EMR systems in regard to aggregated reporting to ministry of health, while choosing a system. It appears that priority is put on other functionalities that could dwell much on patient management and administrative roles rather than reporting to ministry of health.

However, there is a strong agreement in line with the possible improvement that can be made on these EMR systems to enhance performance regarding reporting. An average of 4.65 out of 5 is demonstrated while analyzing the perception of the role of technology in enhancing the performance of EMR systems.

5.6 Recommendation

The research primarily focused on the challenges faced by healthcare providers using the alternative EMR systems regarding reporting to MoH. Therefore, to better understand a whole rounded challenge faced by these healthcare providers in line with EMR usage, research should carry our future studies in those areas.

Furthermore, healthcare providers should prioritize reports required by MoH before implementing an EMR system. This will eliminate the delays caused by challenges discussed in the previous sections.

In addition, system developers should consider working with MoH to have their EMR solutions accredited by the ministry. Emphasis should be put on ability to generate and exchange aggregated healthcare data directly with ministry of health.

Last but not least, healthcare providers should consider enriching the knowledge of their employees in regard to data management. From the study, more than 60% of the respondents were not employed in data related roles like data clerk or data analyst, but rather are active health practitioners. In my opinion, having people who know how to manipulate data ensures data reliability and readiness when required,

5.7 Contribution of the Research study

The study aimed to solve delays in submitting healthcare data to the ministry, especially by private healthcare providers using alternative EMR systems that can't exchange aggregate data with DHIS2. It led to the development of an architectural design that can be adopted by EMR system developers to enable seamless data exchange with MoH. This is the study's significant contribution.

In addition, the study noted challenges faced while using these alternative EMR systems and made recommendations for future studies, hence adding to the body of knowledge especially in the field of health informatics.

Last but not least, it's crucial to recognize that this architectural design isn't limited to DHIS2 integration alone; rather, it's adaptable to any future system the MoH might adopt as the national electronic healthcare reporting system.

REFERENCE

- Abias Katesigwa, A. (2016). *DETERMINANTS OF EFFECTIVE UTILIZATION OF ROUTINE HEALTH INFORMATION WITHIN PRIVATE HEALTH FACILITIES IN KAMPALA - UGANDA*.
- Adebore, A. M., & Omowumi, A. T. (2021). Factors Influencing Electronic Medical Record Systems Success in Selected Tertiary Healthcare Facilities in South-West, Nigeria. *Information Impact: Journal of Information and Knowledge Management*, 12(1), 14–32. <https://doi.org/10.4314/ijikm.v12i1.2>
- Afaq, K. M., Prayitno, Tsai, Y.-Y., Chen, Y.-C., & Shae, Z.-Y. (2022). Mobile-based Patient-centric EMR Sharing System Using Blockchain. *2022 IEEE 4th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS)*, 217–220. <https://doi.org/10.1109/ECBIOS54627.2022.9945017>
- Aggrey, A. P. C., Odongo, A. O., & Kerochi, A. (2022). *Factors Influencing Utilization of Routine Health Information For Decision Making Among Health Workers: A Case Study of Health Facilities in Moyo District, Uganda*. <https://doi.org/10.22541/au.167061325.50298848/v1>
- Alunyu, A., Wamema, J., Kiwanuka, A., Moses, B., Amiyo, M., Kambu, A., & Nabukenya, J. (2021). Investigating the Impediments to Accessing Reliable, Timely and Integrated Electronic Patient Data in Healthcare Sites in Uganda. *Proceedings of the 14th International Joint Conference on Biomedical Engineering Systems and Technologies*, 522–532. <https://doi.org/10.5220/0010266705220532>
- Bagyendera, M., Nabende, P., & Nabukenya, J. (2023). Critical factors influencing data use and utilization in health systems: a focus on data and interoperability standards for health information exchange (HIE) in Uganda’s health care system. *Oxford Open Digital Health*, 1. <https://doi.org/10.1093/oodh/oqad015>
- Balaba Bogere, J., Mulira, H., & Munyambabazi, E. (2018, February 9). *Health Management Information System (HMIS) in Uganda*. <https://Mets.or.Ug/Health-Management-Information-System-Hmis-in-Uganda/>.
- Berihun, B., Atnafu, D. D., & Sitotaw, G. (2020). Willingness to Use Electronic Medical Record (EMR) System in Healthcare Facilities of Bahir Dar City, Northwest Ethiopia. *BioMed Research International*, 2020. <https://doi.org/10.1155/2020/3827328>
- Borna, S., Maniaci, M. J., Haider, C. R., Maita, K. C., Torres-Guzman, R. A., Avila, F. R., Lunde, J. J., Coffey, J. D., Demaerschalk, B. M., & Forte, A. J. (2023). Artificial Intelligence Models in Health Information Exchange: A Systematic Review of Clinical Implications. *Healthcare*, 11(18), 2584. <https://doi.org/10.3390/healthcare11182584>
- Central Public Health Laboratories. (2020). *DHIS2 User Manual Uganda V2.3*. Central Public Health Laboratories/NHLDS.

- Dayananda, M. (2020). Factors influencing Adoption of Electronic Medical Records in Government Hospitals of Sri Lanka. *International Journal of Scientific Research in Computer Science Engineering and Information Technology*, 6, 190–199. <https://doi.org/10.32628/CSEIT206624>
- DHIS2. (2022). *Leveraging DHIS2 to plan, monitor and evaluate national development programs in Uganda*. <https://Dhis2.Org/Uganda-e-Governance-Platform/#:~:Text=Due%20to%20its%20extensive%20and,Decision%2Dmaking%20and%20further%20planning>.
- Hidayat, I. F., & Hermanto, B. R. (2020). A Preliminary Implementation of HL7 FHIR to Achieve Interoperability in Indonesia's Local EHR. *2020 27th International Conference on Telecommunications (ICT)*, 1–5. <https://doi.org/10.1109/ICT49546.2020.9239534>
- Huang, F., Blaschke, S., & Lucas, H. (2017). Beyond pilotitis: taking digital health interventions to the national level in China and Uganda. *Globalization and Health*, 13(1), 49. <https://doi.org/10.1186/s12992-017-0275-z>
- Josephine, N., Andrew, K., Mercy Rabekah, A., Andrew, A. E., Moses, B., Achilles, K., & Joseph, W. (2021). *Strengthening Uganda's Health System Through Standardizing Digital Health: Requirements for Digital Health Standards and Enterprise Architecture Framework*.
- Karunganwa, N., Namale, A., Mulira, H., Kanssiime, E., & Ssendiwala, J. (2023). *Functionalization of HIV Testing Services (HTS) Module in UgandaEMR*.
- Katwesige, J. F., Nabende, P., Kasasa, S., Ssenyonga, R., Nakafeero, M., & Kissa, J. (2020). Integration of DHIS2 and Climatic Data for Disease Prediction: A Case of Malaria occurrence in Gulu District, Uganda. *2020 IST-Africa Conference (IST-Africa)*, 1–8.
- Kavuma, M. (2019). The usability of electronic medical record systems implemented in Sub-Saharan Africa: A literature review of the evidence. In *JMIR Human Factors* (Vol. 6, Issue 1). <https://doi.org/10.2196/humanfactors.9317>
- Kiwanuka, A., Bagyendera, M., Wamema, J., Alunyu, A., Amiyo, M., Kambugu, A., & Nabukenya, J. (2021). Establishing the State of Practice about Data Standards in Monitoring Healthcare Interventions for HIV in Uganda's EMR-based Health Information Systems. *Proceedings of the 14th International Joint Conference on Biomedical Engineering Systems and Technologies*, 200–211. <https://doi.org/10.5220/0010264302000211>
- Luo, H., Mei, N., Du, C., & Yu, C. (2023). A Distributed EMR Data Storage Scheme Based on LWE. *2023 Fifth International Conference on Blockchain Computing and Applications (BCCA)*, 174–179. <https://doi.org/10.1109/BCCA58897.2023.10338928>
- Madore, A., Rosenberg, J., Muyindike, W. R., Bangsberg, D. R., Bwana, M. B., Martin, J. N., Kanyesigye, M., & Weintraub, R. (2015). Implementation of electronic medical records requires more than new software: Lessons on integrating and managing health technologies from Mbarara, Uganda. *Healthcare*, 3(4), 264–269. <https://doi.org/10.1016/j.hjdsi.2015.08.006>

- Mamlin, B. W., Shivers, J. E., Glober, N. K., & Dick, J. J. (2021). OpenMRS as an emergency EMR—How we used a global good to create an emergency EMR in a week. *International Journal of Medical Informatics*, 149, 104433. <https://doi.org/https://doi.org/10.1016/j.ijmedinf.2021.104433>
- Mark N.K., S., Philip, L., & Adrian, T. (2019). *Research Methods for Business Students* (8th ed.).
- Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Futures Studies*, 23(2), 29–44. [https://doi.org/10.6531/JFS.201812_23\(2\).0003](https://doi.org/10.6531/JFS.201812_23(2).0003)
- MoH. (2016). *The Uganda Clinical Guidelines (UCG)*.
- MoH. (2021). *The Uganda Health Information and Digital Health Strategic Plan 2020/21 - 2024/25*.
- Mohamed, H. (2022). Conceptualization of a modern digital-driven health-care management information system (HMIS). In *Knowledge Engineering for Modern Information Systems* (pp. 187–200). De Gruyter. <https://doi.org/10.1515/9783110713633-011>
- MoH-Uganda. (2020). *Annual Health Sector Performance Report*.
- Muhaise, H., Kareyo, M., Wycliffe, J., & Muwanga-Zake, F. (2019). Factors Influencing the Adoption of Electronic Health Record Systems in Developing Countries: A Case of Uganda. *Technology, and Sciences (ASRJETS) American Scientific Research Journal for Engineering*, 61(1), 160–166. <http://asrjetsjournal.org/>
- Muinga, N., Magare, S., Monda, J., Kamau, O., Houston, S., Fraser, H., Powell, J., English, M., & Paton, C. (2018). Implementing an Open Source Electronic Health Record System in Kenyan Health Care Facilities: Case Study. *JMIR Medical Informatics*, 6(2), e22. <https://doi.org/10.2196/medinform.8403>
- Mukhiya, S. K., & Lamo, Y. (2021). An HL7 FHIR and GraphQL approach for interoperability between heterogeneous Electronic Health Record systems. *Health Informatics Journal*, 27(3), 14604582211043920. <https://doi.org/10.1177/14604582211043920>
- Mwakabira, I. S., Byson, L. F., Manda, T. D., Phiri, Y. D., & Simwela, A. (2023). Design Gaps in Configurable Systems: Adaptability of DHIS2 to other Domains. *2023 IST-Africa Conference (IST-Africa)*, 1–8. <https://doi.org/10.23919/IST-Africa60249.2023.10187872>
- Nagwovuma, M., Ndagire, L., & Eilu, E. (2021). Performance Evaluation for Electronic Health Information Systems in Uganda. *2021 IST-Africa Conference (IST-Africa)*, 1–8.
- Namatovu, H. K., Semwanga, A. R., Kiberu, V. M., Ndigezza, L., Magumba, M. A., & Kyanda, S. K. (2022). *Barriers and Facilitators of eHealth Adoption Among Healthcare Providers in Uganda – A Quantitative Study* (pp. 234–251). https://doi.org/10.1007/978-3-031-06374-9_15

- Nancy, K., Stephen, M. S., & Jonathan, M. (2022). *Fostering interoperability for Data Exchange across Health Information Systems in Uganda*.
- Nsaghurwe, A., Dwivedi, V., Ndesanjo, W., Bamsi, H., Busiga, M., Nyella, E., Massawe, J. V., Smith, D., Onyejekwe, K., Metzger, J., & Taylor, P. (2021). One country's journey to interoperability: Tanzania's experience developing and implementing a national health information exchange. *BMC Medical Informatics and Decision Making*, 21(1), 139. <https://doi.org/10.1186/s12911-021-01499-6>
- Odoemene, M. I. (2024). Developing Strategies For Adopting And Implementing Electronic Medical Records/Electronic Health Records: A Comparative Analysis Between Low-Middle-Income And High-Income Countries. *IOSR Journal of Nursing and Health Science (IOSR-JNHS)*, 13(2), 14–41. <https://doi.org/10.9790/1959-1302011441>
- Roebianto, A., Savitri, I., Sriyanto, A., Syaiful, I., & Mubarokah, L. (2023). Content validity: Definition and procedure of content validation in psychological research. *TPM - Testing*, 30, 5–18. <https://doi.org/10.4473/TPM30.1.1>
- Segal, D., & Coolidge, F. (2018). *Reliability* (pp. 1835–1836). <https://doi.org/10.4135/9781506307633.n683>
- Spatar, D., Kok, O., Basoglu, N., & Daim, T. (2019). Adoption factors of electronic health record systems. *Technology in Society*, 58, 101144. <https://doi.org/10.1016/j.techsoc.2019.101144>
- Stre@mlineEMR. (2020, August 20). *HMIS REPORTING MADE EASY WITH STRE@MLINE EMR*. <https://Streamlinehealth.Org/Hmis-Reporting-Made-Easy-with-Stremline-Emr/>.
- Stuart, M., & Nicola, H. (2011). *Research Methods Handbook - Introductory guide to research methods for social research*. Centre for Local Economic Strategies.
- Twabi, A., Mwakabira, I., Byson, L., Phiri, Y., Twalibu, H., & Chamdimba, T. (2022). On the enhancement of collaboration & group support in DHIS2 program rule management. *2022 International Conference on Electrical, Computer and Energy Technologies (ICECET)*, 1–5. <https://doi.org/10.1109/ICECET55527.2022.9872957>
- UgandaEMR. (2023, February). *UgandaEMR User Manual - Send Aggregate Reports*. https://Mets-Programme.Gitbook.Io/Ugandaemr-Documentation/Data-Exchange/Sending_aggregate_reports_to_dhis2.
- Umezuruike, C., Nwankwo, W., Mcpn, & Kareyo, M. (2017a). Implementation Challenges Of Health Management Information Systems In Uganda: A Review. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 4, 2458–9403.
- Umezuruike, C., Nwankwo, W., Mcpn, & Kareyo, M. (2017b). Implementation Challenges Of Health Management Information Systems In Uganda: A Review. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 4, 2458–9403.
- White, E. B., Hernández-Ramírez, R. U., Majwala, R. K., Nalugwa, T., Reza, T., Cattamanchi, A., Katamba, A., & Davis, J. L. (2022). Is aggregated surveillance data a reliable method for

constructing tuberculosis care cascades? A secondary data analysis from Uganda. *PLOS Global Public Health*, 2(11), e0000716. <https://doi.org/10.1371/journal.pgph.0000716>

Woldemariam, M. T., & Jimma, W. (2023). Adoption of electronic health record systems to enhance the quality of healthcare in low-income countries: a systematic review. *BMJ Health & Care Informatics Online*, 30(1), e100704. <https://doi.org/10.1136/bmjhci-2022-100704>

Zavuga, R., Mugisha, R., Gonahasa, D., Kadobera, D., Kwesiga, B., Okello, E. P., Bulage, L., Aceng, L. F., Kayiwa, J., Makumbi, I., & Ario, R. A. (2023). Timeliness And Completeness Of Monthly Disease Surveillance Data Reporting in Uganda, 2020 -2021. *Uganda National Institute of Public Health (UNIPH)*.

APPENDIX

Table 5-1 The Likert Scale

SCALE	VALUE	INTERVAL	LOWER LIMIT	UPPER LIMIT	RANGE
Strongly Disagree	1	0.80	1.00	1.80	1.00 - 1.80
Disagree	2	0.80	1.80	2.60	1.80 - 2.60
Undecided	3	0.80	2.60	3.40	2.60 - 3.40
Agree	4	0.80	3.40	4.20	3.40 - 4.20
Strongly Agree	5	0.80	4.20	5.00	4.20 - 5.00

Table 5-2 Healthcare Facility Distribution Per Category

Facility Level	Government	Private For Profit	Private Not For Profit
General Hospital	54	65	75
Health Center II	1,704	1,459	453
Health Center III	1,450	249	358
Health Center IV	200	28	37
NRH (National Referral Hospital)	8	-	-
RBB (Regional Blood Bank)	4	-	-
RRH (Regional Referral Hospital)	17	-	-
Specialized Hospital	1	-	-

Table 5-3 Healthcare Facility Distribution Per Region

Region	Clinic	Health Center II	Health Cente III	Health Cente IV	General Hospital	Regional Referral Hospital	National Referral Hospital	Total
South Central	61	515	291	32	18	3	0	920
Kampala	15	797	42	16	37	0	8	915
North Central	75	356	213	34	19	2	0	699
Busoga	44	334	150	21	11	1	0	561
Ankole	66	239	178	25	16	1	0	525
Tooro	5	218	179	21	16	1	0	440
West Nile	23	151	173	15	13	2	0	377
Kigezi	8	216	93	21	8	1	0	347
Acholi	24	183	97	10	8	1	0	323
Bunyoro	16	109	132	18	8	1	0	284
Bugisu	11	112	126	14	7	1	0	271
Bukedi	56	87	107	9	11	0	0	270
Teso	5	119	100	14	11	1	0	250
Lango	13	93	124	11	6	1	0	248
Karamoja	3	87	52	4	5	1	0	152

Survey Questionnaires.

A Questionnaire Survey on the Development of An Architectural Design for Aggregated Healthcare Reporting from alternative Electronic Medical Record Systems to Ministry of Health's, DHIS2

Dear Participant,

I'm Emmanuel Ogwang, a master's student in Information Technology at Uganda Christian University, focusing on health informatics.

This study aims to identify current practices and challenges in healthcare aggregated data reporting to Ministry of Health, Uganda. Your feedback will guide the development of a new architectural design to streamline this process.

The survey is confidential, voluntary, and will take about 10 minutes, consisting of 23 multiple-choice questions across three sections.

Your participation is greatly appreciated and will significantly contribute to enhancing healthcare reporting in Uganda.

Thank you.

Emmanuel Ogwang

(BsCS, UCU)

SECTION A: DEMOGRAPHIC INFORMATION

1. What is your gender?
 - Male
 - Female
2. What is your age bracket?
 - Under 18
 - 18-24
 - 25-34
 - 35-44
 - 45-54
 - 55-64
 - 65 or older
3. What is your highest level of education?
 - Primary school
 - Secondary school
 - Certificate
 - Diploma
 - Bachelor's degree
 - Master's degree or higher
4. What is your primary role in the organization?
 - Data clerk
 - Data analyst
 - Health worker/Practitioner

- Manager/Supervisor
 - Other:.....
5. How long have you been involved in data related activities?
- Less than 1 year
 - 1-3 years
 - 4-6 years
 - More than 6 years
6. How would you describe your level of experience in data management and analysis?
- Beginner
 - Intermediate
 - Advanced
 - No Experience at all
7. Have you received any formal training related to data management or health information systems?
- Yes
 - No
8. Which facility do you belong?
- C-CARE IHK
 - Case Hospital
 - Lifelink Medical Center
 - Nakasero
 - Bethany Women's and Family Hospital
 - Ntinda Hospital Limited

- Mengo Hospital
- Other:.....

9. What is the name of the EMR system you are using?

- Navision Microsoft Dynamics
- Med360
- Clinic Master
- Smarthealth+
- Streamline
- Medic Plus
- Other.....

10. On average, how many patients visit is recorded daily at the facility?

- 0 – 10
- 10 – 50
- 50 – 100
- 100 – 200
- Over 200

SECTION B: THE CURRENT PROCESS REGARDING GENERATING AGGREGATE DATA

11. On average, how many hours do you spend consolidating aggregate data for submission to the Ministry of Health?
- Less than 1 hours
 - 1 - 2hours
 - 3-4 hours
 - More than 5 hours
12. When you need to gather and combine health information for reporting, how do you usually access this information?
- Paper-based records
 - Electronic Medical Records
 - Both paper and electronic records.
13. What tools or software do you use for data consolidation and analysis?
- Microsoft Excel
 - Electronic Medical Record System (EMR System)
14. What are the main challenges you encounter when consolidating aggregate data for submission to the Ministry of Health? (Select all that apply)
- Limited access to reliable data sources
 - Data entry errors
 - Unavailability of data at service points eg Lab and Reception
 - Lack of training on data consolidation techniques
 - Technical issues (e.g., internet connectivity, power outages)

- Time constraints

15. Are there any specific data quality issues you encounter during the consolidation process?

(Select all that apply)

- Incomplete data
- Inaccurate data
- Duplicate entries

16. How do you ensure data accuracy and completeness before submitting it to the Ministry of Health?

- Manual data validation checks
- Automated data validation checks
- Cross-referencing with other sources

SECTION C: ROLE OF TECHNOLOGY IN ENHANCING AGGREGATE DATA GENERATION AND EXCHANGE

On a scale of 1 – 5, 1 being Strongly Disagree and 5 being Strongly Agree, rate your level of agreement with the following statements.

17. Automating the process of report sharing will make our work significantly easier.

Strongly Disagree 1 2 3 4 5 Strongly Agree

18. Including Ministry of Health (MOH) form formats within your EMR system will simplify the process of generating reports.

Strongly Disagree 1 2 3 4 5 Strongly Agree

19. Implementing real-time data validation checks within our EMR system will enhance the accuracy of our reports.

Strongly Disagree 1 2 3 4 5 Strongly Agree

20. Providing comprehensive training on EMR usage will improve our ability to generate and exchange reports effectively.

Strongly Disagree 1 2 3 4 5 Strongly Agree

21. Integrating data interoperability standards into our EMR system will ensure seamless data exchange with the Ministry of Health.

Strongly Disagree 1 2 3 4 5 Strongly Agree

22. Automating routine data consolidation tasks will free up time for data clerks to focus on analysis and decision support.

Strongly Disagree 1 2 3 4 5 Strongly Agree

23. Improving the efficiency of EMRs in generating reports will significantly reduce delays in submission to the Ministry of Health.

Strongly Disagree 1 2 3 4 5 Strongly Agree

Once again, thank you for agreeing to participate in this study. Your willingness to share your experiences and insights is greatly appreciated and will play a vital role in advancing our understanding and improvement of healthcare data reporting to the Ministry of Health. We really value your time and contribution immensely.

Figure 5.2 Create and manage healthcare provider by MoH

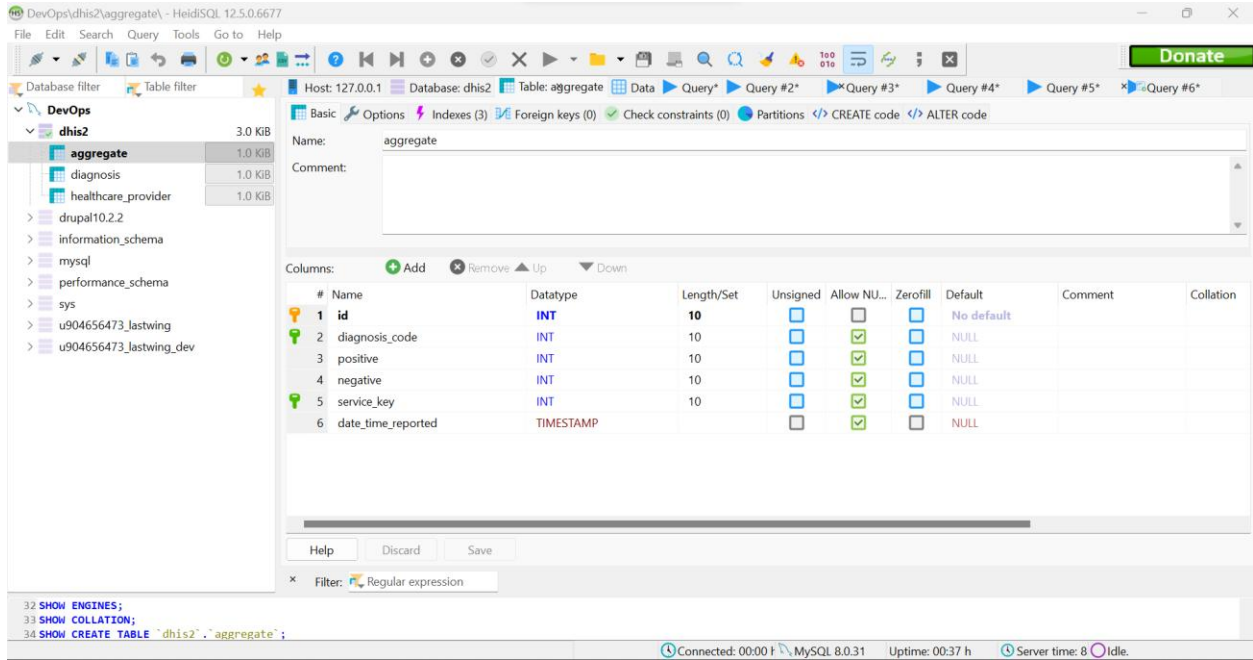


Figure 4 HeidiSQL user interface.

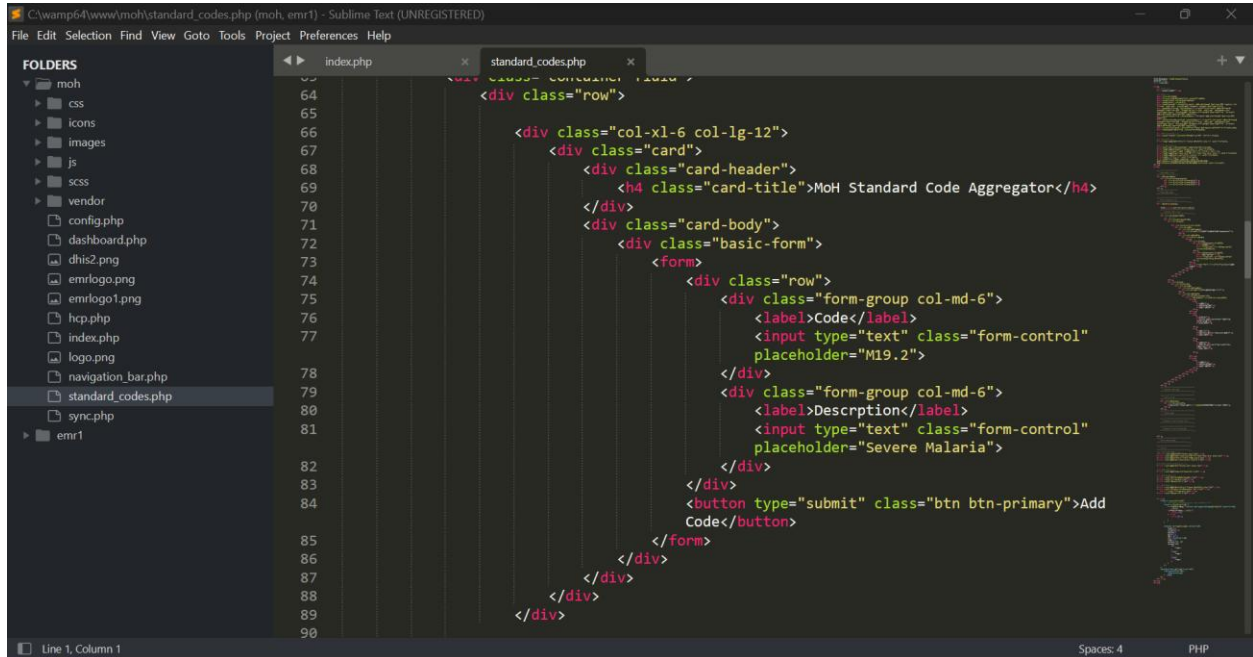


Figure 5 SublimeText code editor

```
File Edit Selection Find View Goto Tools Project Preferences Help
navigation_bar.php mapping.php ui-Authtn.html exchange.php check_codes.html visit.php
FOLDERS
  moh
  emr1
  css
  icons
  images
  js
  scss
  vendor
  xdi_patient.php
  check_codes.html
  config.php
  dhid2.png
  emrlogo.png
  emrlogo1.png
  exchange.php
  hcp.php
  index.php
  mapping.php
  navigation_bar.php
  patients.php
  visit.php
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
$(document).ready(function(){
  function checkForUpdates(){
    $.ajax({
      url: 'ogwangemr.com',
      type: 'GET',
      dataType: 'json',
      success: function(response){
        if(response.length > 0){
          // Clear existing table rows
          $('#updateTable tbody').empty();

          // Populate table with new data
          $.each(response, function(index, item){
            $('#updateTable tbody').append('<tr><td>' + item.code + '</td><td>' + item.
              description + '</td></tr>');
          });
        }
      },
      error: function(xhr, status, error){
        console.error('Error:', error);
      }
    });
  }

  // Check for updates initially when the page loads
  checkForUpdates();

  // Check for updates every 5 seconds (adjust as needed)
  setInterval(checkForUpdates, 5000);
});
</script>
```

Figure 9 1 Code Snippet to auto-check for new code from MoH