ASHESI

ASHESI UNIVERSITY

ASSESSING HEALTHCARE INTEROPERABILITY TECHNOLOGIES FOR GHANAIAN HOSPITALS

CAPSTONE PROJECT

B.Sc. Management Information Systems

Najahat Antiku

2021

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Capstone Project submitted to the Department of Computer Science, Ashesi University in partial fulfilment of the requirements for the award of Bachelor of Science degree in Management Information Systems.

Najahat Antiku

2021

DECLARATION

I hereby declare that this capstone is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

Candidate's Name: Najahat Antiku

Date: 23/04/2021

I hereby declare that preparation and presentation of this capstone were supervised in accordance with the guidelines on supervision of capstone laid down by Ashesi University.

Supervisor's Signature:

Supervisor's Name: David Ebo Adjepon-Yamoah (Ph.D.)

Date: 14/05/2021

Acknowledgements

To my supervisor, Dr David Ebo Adjepon-Yamoah whose encouragement and academic advice helped me undertake this project, I say a very big thank you. From day one of this project, you have been my source of encouragement. The clear guidance and unrelented commitment you have shown has been massive. God continue to bless you abundantly.

Abstract

Healthcare Interoperability is essential to the effectiveness of healthcare delivery in the world. Over the years, hospitals have tried to digitize their services to make the delivery better. However, interoperability remains limited especially in African countries. Most hospitals have still not been able to properly make their systems interoperable to enable different departments as well as other health facilities access common health data even with the usage of different information systems.

This project seeks to investigate the technologies that can be used to implement healthcare interoperability in Ghanaian hospitals, and to assess the impact that would be created if these systems are being implemented.

Out of this research done, restful APIs were being used to allow users to access healthcare data without having real access or total control of the actual database.

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Chapter 1: Introduction

1.1 Background

This project is intended to investigate technologies that are suitable for interoperability in Ghana as well as to assess the potential impact it will have on Ghanaian healthcare. The goal of this project is to arrive at a recommended technology which will contribute to **SDG 3, Good Health and Wellbeing**. In 2018 an estimated 6.2 million children and adolescents under the age of 15 years died, mostly from preventable causes. Of these deaths, 5.3 million occurred in the first 5 years, with almost half of these in the first month of life [1]. This project is intended to contribute to realizing one of the targets of SDG 3. The intended target to be met is, By 2030, we should achieve universal health coverage including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all [1]. The idea is to make access to healthcare better coordinated and seamless. One should be able to reduce physical processes as much as possible. Especially in the era of a pandemic like COVID-19 where social distancing is encouraged, interoperability would enable people to access healthcare digitally and whenever there is the need for a physical visit, processes like starting a new health profile or going to look for health records manually will be minimized. The theory is that it will lead to a higher quality of care as well as better health outcomes for patients, by making sure a patient transitions appropriately through the healthcare system. This will strengthen the quality of healthcare delivery and the indicator for measuring the success of this goal is ***coverage of essential health services.***

According to the World Health Report in 2000 [2], the World Health Organization (WHO), mentioned that France provided the overall best healthcare worldwide. The WHO director-general stated that “the health and well-being of countries depend critically on the performance of their health systems.” The director of WHO’s Global Programme for Health Policy affirmed that virtually all countries under-utilized the resources available to them and this leads to large numbers of preventable deaths, unnecessary suffering, and denial of an individual’s basic right to health. As part of the indicators mentioned by WHO, it stated that the existence of a good health system contributes to good health and well-being [2]. Interoperability has been a major mention when it comes to ways of making the healthcare systems in the world effective. According to IEEE, “interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged” [3]. Interoperability in health has undergone several evolutions within the healthcare industry. In 2006, less than 10 percent of hospitals in the United states had a complete coordinated healthcare system [4]. Health Level Seven popularly known as HL7 has been working to promote interoperability within the healthcare industry since the late 1980s. During that time, they developed the HL7 V2 standard to share information across inter-departmental hospital systems. By 2000, the demand increased for data to support health related works outside hospital care. Therefore, HL7 V2 was becoming obsolete, and they had to introduce HL7 V3 which was based on XML coding. Several versions of HL7 has been released over the years until the recent HL7 FHIR was released in 2014 which used web standards to operate [5].

This research involved the review of related literature works to gain insights into what interoperability in healthcare really is, and the various places it was being implemented. Research was further done to delve deeper into the various technologies already in place and an analysis was done on these technologies. After seeking validation from the

Institutional Review Board (IRB), a questionnaire was sent out to health workers and experts of interoperability to help assess the technologies in place and to give their general thoughts on the possibility of implementing interoperability in our Ghanaian hospitals. After all these processes, and a lot more, a technology called FHIR (Fast Healthcare Interoperability Resources) was recommended.

1.2 Purpose of Research

The purpose of this research is to assess the following:

1. The readiness of Ghana to adopt interoperable healthcare technologies,

2. The interoperable technologies already in place (if any),

3. The potential impact of interoperability on Ghanaian healthcare as opposed to the traditional methods (paper-based approach).

1.3 Research Questions

RQ1: What technologies can be used to build interoperable systems in Ghanaian hospitals?

RQ2: What will be the impact of this system on healthcare interoperability in Ghana?

1.4 Hypothesis

H1 : HL7 standard can be used to build interoperable systems in Ghanaian hospitals.

H2: The impact of a system built on HL7 will be that health data and messages will be shared quickly among different health information systems to promote quality delivery of healthcare.

Chapter 2: Literature Review

(Comparative Analysis of Healthcare Interoperability Technologies)

The Alberta Electronic Health Record Information System (EHRIS) dates to 1997. Its main domains consist of access tools, repositories, registries, and infrastructure. The access tools allow users to view health data across repositories, but it holds no actual patient data. The repositories capture, store, and maintain patient data. The registries capture, store, and provide data on places, identities, and events used by repositories and access tools for identification purposes. Infrastructure enables connection and transmission of health data. **Connect care** was introduced in November 2019, to implement a one-patient-one-record vision. It is the central access point to health information and has replaced 1300 stand-alone health systems across the province. Connect Care is based on a highly customized version of EpiCare to meet the needs of Alberta. Emergencies can be managed through the central system; critical information can be shared in real time with the entire healthcare system [6].

Also, since hospitals would not want to give up their current standalone systems, due to fear of loosing control over their data, the idea of a **virtual electronic patient record (VEPR)** has been proposed for South African hospitals. This is supported in pre-existing information systems and could facilitate the communication among these systems without jeopardizing the existing data. The general architecture of the VEPR allow the collection, integration, and availability of records and provide an up-to-date overview of a patient medical history at all points of care. Two major systems were designed: The **Multi-Agent System for Integration of Data (MAID),** and **the visualization module (VIZ).** They provide for automatic document retrieval and show patient data upon request respectively. MAID collects health reports from the different departments in the hospital and stores the information in a central repository which holds the reports in a database and a file system where reports are stored. When a user searches the database, VEPR users can access the integrated data of a particular patient through a web-based interface. To select a particular report, the content is downloaded from the central repository file system to the browser. The VEPR system server runs on a Pentium 4 (1.8 GHz), with 768 Mb RAM and a Linux RedHat Fedora Core 1.0 operating system. The central repository file system, which contains the clinical reports files, is located on a HP StorageWorks SAN, which is mounted in the VEPR server using the NFS protocol. The database, which contains the patient's identification and references to the clinical records, is stored on two HP Server RP5740 RISC computer cluster running an Oracle database management system. MAID **is built on JADE (Java Agent Development Framework)** as a multi-agent FIPA compliant development platform, for agents' management and deployment. The design of MAID takes some characteristics of the multi-agent systems paradigm namely their independence, autonomy, scalability, and reliability. The retrieval of documents automatically is because of two independent actions performed by a set of agents. List agents are responsible for the retrieval of report references, balancer and file agents are for retrieval of report files, express agents are responsible for immediate retrieval of a clinical report that is not yet available centrally but has been requested by a user. A set of plug-ins are there for the purpose of network communication such as HTTPS, database communication such as Oracle, logging, and digital signing. Equipment, power redundancy, backups, and monitoring of the system were put in place to ensure that the system is always available [7].

The Canadian Health Infoway has also worked on a system called **PrescribeIT.** It makes healthcare interoperability possible by connecting community-based prescribers such as physicians and nurse practitioners to retail pharmacies and making the transmission of prescriptions possible digitally. PrescribeIT uses **FHIR** messaging standards. It uses a FHIR-based API service and a blockchain-enabled consent service.

The features of the service are secure clinical messaging, prescription status notification, integration with public drug formularies, standardized terminology through the Canadian Drug Data set, enhanced user identity proofing with multi-factor authentication [8].

The Hong Kong's Electronic Health Record Sharing System provides a platform electronically to the citizens of Hong-Kong. The system is built on **hl7 v2** and enables a two-way communication among public and private healthcare providers. It takes record of personal identification and demographic data, allergies, appointments, clinical notes, laboratory records, health referrals, and other information relevant to a patient's health history. It gives access to data based on the role of the user in order to ensure privacy of data [9].

Argentina's National Interoperability Network uses standards to enable communication between participating health information systems, providing a bridge for identity management across systems, sharing documents and patient summaries, managing ePrescriptions and supporting national registries. It used **HL7 CDA** and **FHIR** as its interoperable technologies [10].

The Milk Bank Management System in Canada uses **HL7 v2** to manage and distribute mother donor's milk. The system collects human donor's milk to support mothers who are unable to produce enough breast milk for their babies [11].

Salud.uy is an initiative in Uruguay to make national electronic medical history possible and secure. It used **HL7 V2** and **CDA** standards. This makes it possible for the health team to get access to the information they need from each patient in real time, from anywhere in the country [12].

From reviewing the different systems and technologies used globally, it was realized that HL7 was a common standard used irrespective of the version. In the next chapter, research would be done to answer RQ1 and RQ2 and to validate H1 and H2. Below is an analysis of the various technologies identified through literature review.

Table 1: Comparison of different healthcare interoperable systems and the standards/technologies used.

Name of system	Location	Standard Used	How it works
Connect Care	Alberta, Canada	HL7 FHIR	Gives healthcare providers access to central information.
Virtual Electronic Patient Record (VEPR)	South Africa	The Multi-Agent System for Integration of Data (MAID)	This is supported in pre-existing information systems and could facilitate the communication among these systems without jeopardizing the existing data. - Web based interface
Hong Kong's Electronic Health	Hong Kong, China	Hl7 v2	managing patient data on care episodes, lab

Record Sharing System			results, radiology studies and drug items
Canada's Health Infoway	Canada	FHIR-based API service and a blockchain-enabled consent service	PrescribeIT, electronically shares prescription information from clinicians with pharmacies for dispensing
Argentina's National Interoperability Network	Argentina	CDA and FHIR	uses standards to enable communication between participating health information systems, providing a bridge for identity management across systems, sharing documents and patient summaries, managing ePrescriptions and

			supporting national registries.
The Milk Bank Management System	Canada	HL7 v2	Created to manage and distribute mother donor's milk.
Salud.uy	Uruguay	HL7 V2, CDA	Make national electronic medical history (HCEN) possible and secure.

Chapter 3: Methodology

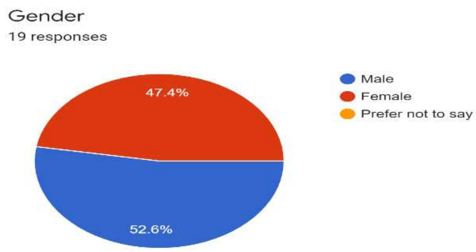
In answering RQ1, a qualitative approach was employed by using **case studies as a tool** gotten from the literature review. A total of 7 publications on related works in Africa and outside Africa were reviewed. Also, a mixed-method approach was employed still in the process of answering RQ1. This is where a **questionnaire was used as a tool** to send out both close-ended and open-ended questions to the sample population. A **sample size of 32** persons where targeted across the 16 regions in Ghana. This was with the intention that each region would have at least two respondents who fell under the category of health workers or someone who had knowledge on interoperable technologies or both. The **sampling strategy used was purposive sampling** because we had to be intentional about the type of respondents. The questions were related to health and the usage of interoperable technologies in healthcare facilities in Ghana. The questionnaire was distributed using a google form which was **shared through social media handles**. For the **analysis of the data, google analytics** was used by google forms.

In answering RQ2, which is assessing the potential impact on interoperability in Ghanaian healthcare, a part of the questionnaire asked questions concerning the impact it would have. However, another **qualitative research with interviews as a tool** was conducted after the proof of concept was built. A **sample size of at 3 persons** were used to test the impact of the technology. This sample population consisted of health workers who will directly use such systems if implemented. The sampling strategy was **purposive** because it is related to health and data collected should not be on random basis.

Results from Survey (Questionnaire)

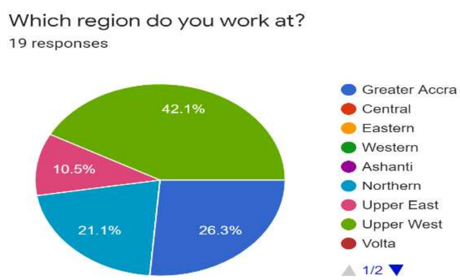
Here are some of the most useful snapshots of the research carried out to answer RQ1 and RQ2.

Figure 1: Percentage of gender groups who filled the questionnaire.



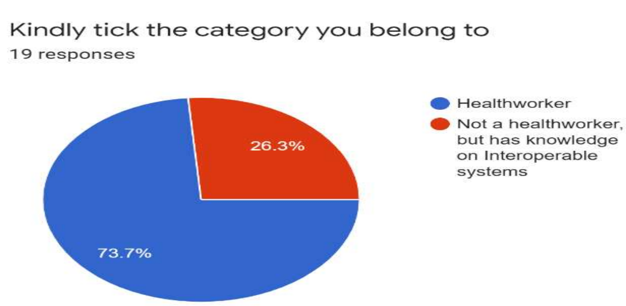
A total of 47.4% of females and 52.6% took part in the questionnaire .

Figure 2: Percentage of regions represented.



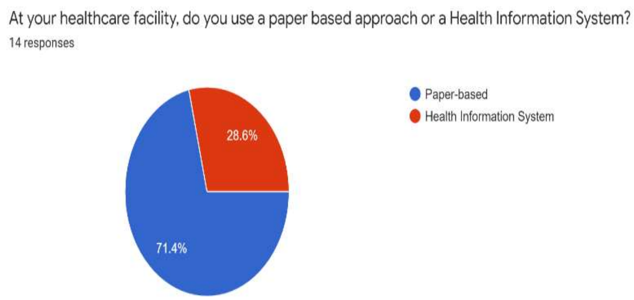
4 regions out of the 16 regions had respondents. Upper West (42.1%), Greater Accra (26.3%), Northern Region (21.1%), and Upper East (10.5%)

Figure 3: Percentage distribution of respondents according to profession



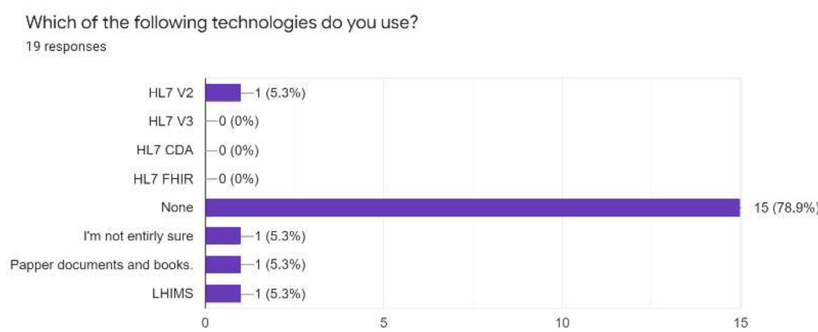
73.7% of the respondents were medical practitioners (medical doctors, health assistants, medical laboratory technicians, pharmacists, etc) while 26.3% of the remaining respondents were not health workers but had knowledge on interoperable systems.

Figure 4: Percentage of Ghanaian healthcare facilities that use paper-based approach or health information systems



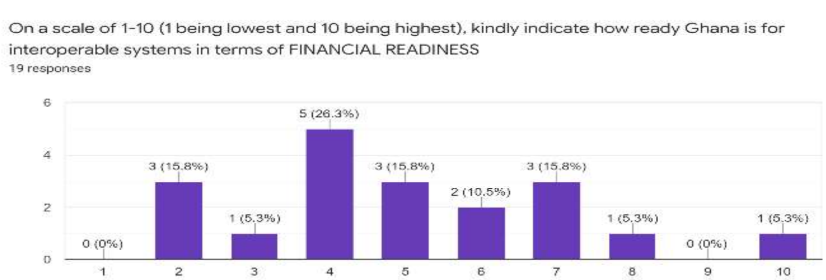
Only about 28.6% of the respondents' health facilities use health information systems. 71.4% of them still rely on paperwork.

Figure 5: Percentage of interoperble technologies used in Ghanaian hospitals



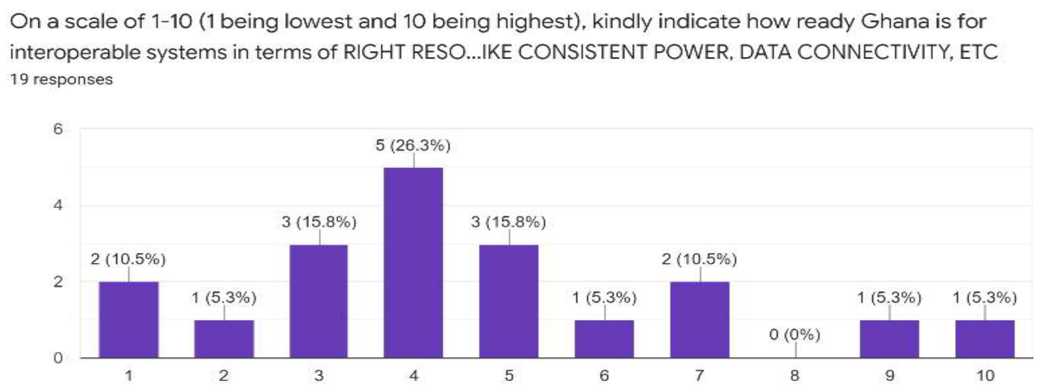
A greater percentage (78.9%) use no interoperable technologies. 5.3% use hl7 v2

Figure 6: Financial readiness of Ghana for interoperable systems



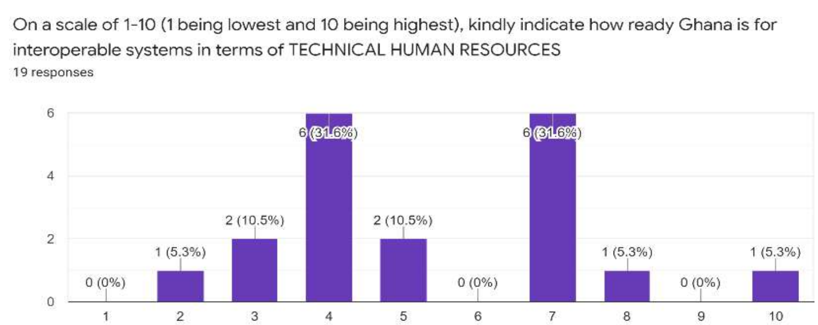
26.3% of the respondents believe that Ghana is 40 percent financially ready for such systems.

Figure 7: Readiness of Ghana for healthcare interoperability in terms of resources



26.3% of the respondents believe that Ghana is 40 percent ready in terms of resource availability for such systems.

Figure 8: Readiness of Ghana in terms of technical human resources to adopt healthcare interoperability



31.6% believe that Ghana is 40% ready while another 31.6% conversely believe that Ghana is 70% ready with regards to technical human resources that are needed to build and manage interoperable systems.

Figure 9: Responses to the potential impact of interoperable healthcare in Ghana.

What impact could these systems have on Ghanaian Healthcare

19 responses

It will help health workers to provide quality health care to client and make the work flow easy and fast

very good improvement in healthcare

better healthcare delivery

Improvement of data storage

Easy correlation of data from different health centers and combating of diseases based on data correlation

Healthcare delivery would be improved

Efficient Healthcare delivery

Table 2: Analysis of Most Mentioned Technologies

Name of standard/technology	**HL7 V2**	**HL7 V3**	**HL7 CDA**	**HL7 FHIR**
Format	Built with pipe and hat characters	XML	XML	XML,/JSON,APIs
Grasping the concept	Weeks	Months	Months	Weeks
Interoperability Method	Syntactic	Syntactic and Semantic	Syntactic and Semantic	
Require special tool	Parser	Model compiler	Model compiler	Only console + browser

Recommended Solution

Fast Healthcare Interoperability Resources (FHIR)

This standard defines how healthcare data can be exchanged between different computer systems regardless of how the data is stored in those systems. The development of FHIR started in 2012 to respond to the changing needs of users. People needed faster and easier ways to exchange growing health data. It has so many advantages. Some of which are:

1. Fast and easy implementation
2. Many implementation libraries
3. The other versions of HL7 and co-exist with FHIR.
4. It is concise and easily understood.
5. It has a human-readable serialization format for the easy use of developers [13].

Development Process of FHIR

HL7 V2 standard took an ad hoc development procedure and HL7 v3 also followed a rigid top-down approach. However, FHIR was built with an iterative and incremental approach. This means that it was implemented bit by bit and tested after every design process. This was done repeatedly [14].

Criticism of FHIR

Even though FHIR has enormous advantages over the older versions of HL7, it has very little guidance concerning how the base resources are built. "There is no support for workflow and dynamic behavior beyond base CRUD operations" [14].

Proof of Concept/Implementation

The implementation involves the usage of a REST API for data exchange in hospitals in Ghana. Our recommended solution, FHIR is described as 'RESTful'. This means that transactions are performed directly on the server using HTTP request and response [15]. The restful APIs enables web applications that are built with different programming languages to communicate with each other via JavaScript Object Notation (JSON). It also allows web applications to reside on different operating systems such as Windows or Linux. REST means Representational State Transfer. In the context of health interoperability, on the server, we can expose an endpoint or a URL to the user to allow them create, update, read, and delete hospital data. This means that the users will not have direct access to our database for security reasons, but they will have access to an URL that will allow them access and manage patients and doctors' resources.

FastAPI was used to generate the API in our implementation. FastAPI comes with an inbuilt database (SQL). It has very high performance and is one of the fastest python frameworks [16].

Python was used as the backend language because it makes the application run faster and offer other benefits such as scalability and high performance.

Postman was used as the API client for the testing. It allows the user to add patient and doctor information, edit, delete, and read their data as well.

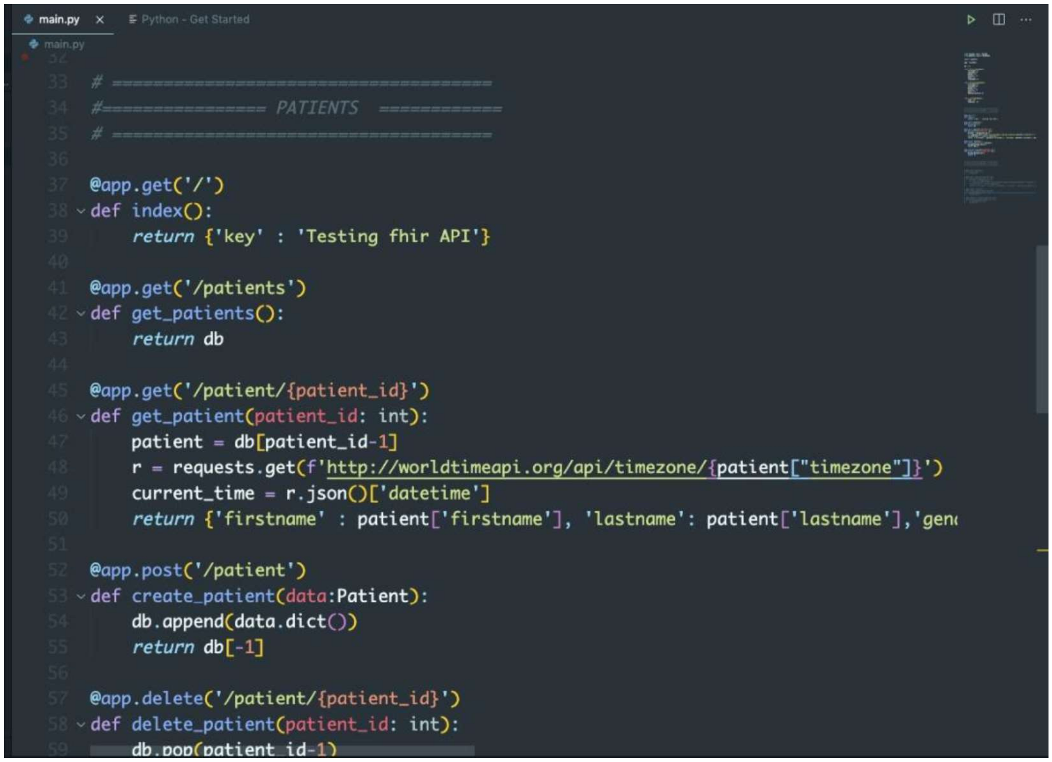
Chapter 4: Results

In the process of implementing the proposed technology, series of code and tests were done. Below are snapshots of some relevant parts.

Figure 10 : The model in which patient and doctor's data was stored.

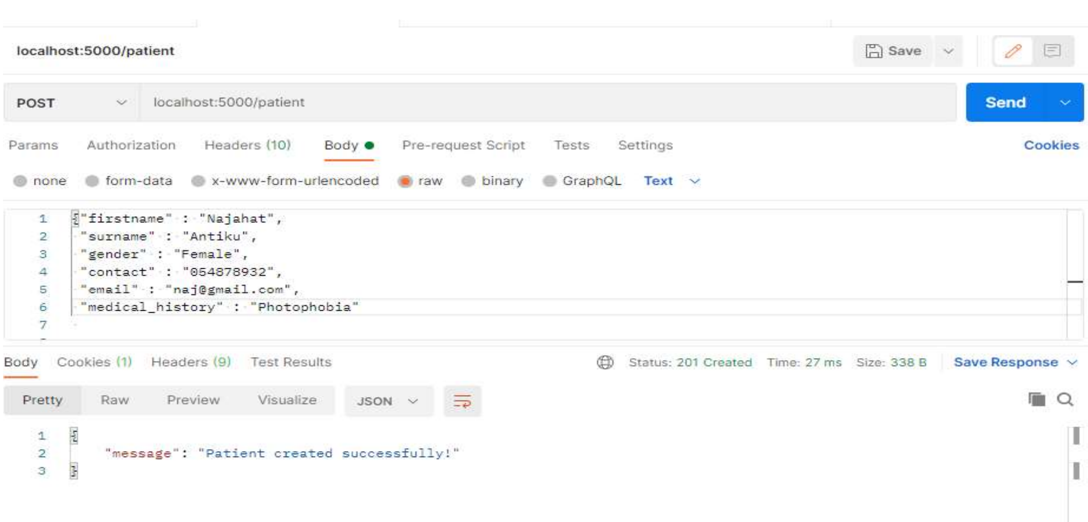
This diagram shows the datatypes that were used in storing the data of doctors and patients. It allows the user to enter certain details of doctors and patients so that upon request, those data can be retrieved.

Figure 11: Code for posting and getting patient's data



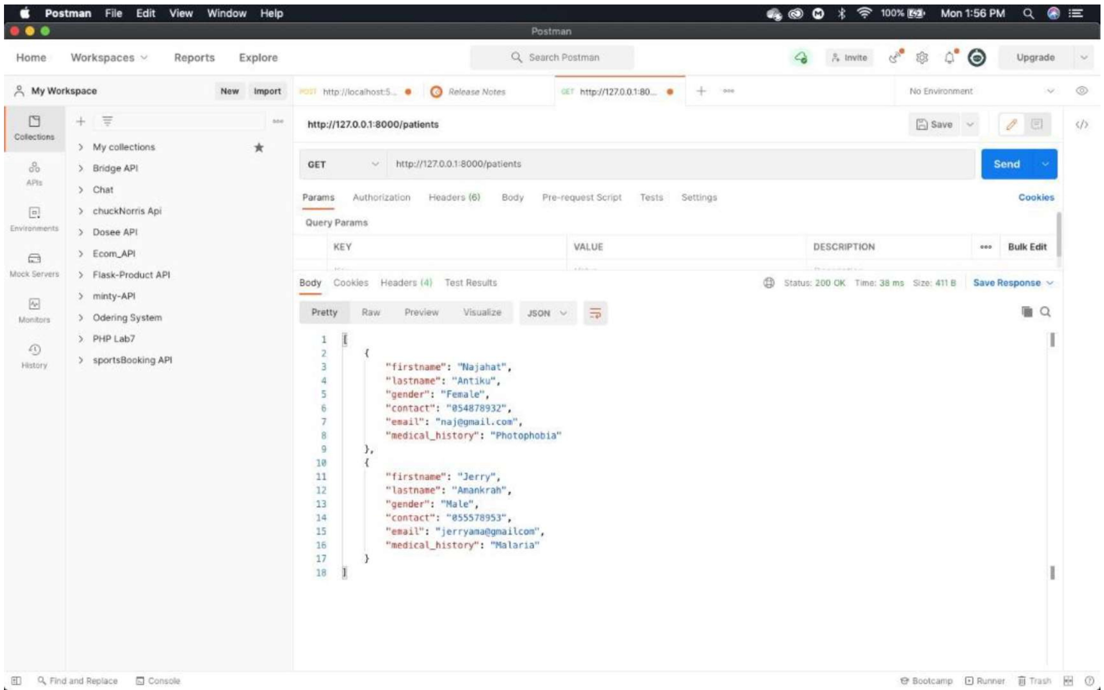
This code allow users to perform CRUD operations on the data. This means that it allows a user to create, read/view, update/edit, and delete/remove data.

Figure 10 : Creating a patient in postman.



This demonstrates a user POSTING or CREATING a new patient and afterwards, a success message is displayed.

Figure 11. Displaying a patient's data using postman



After creating a patient, it is also possible to display the information using a GET command as seen above. Once the user requests for the information stored, it is displayed as it was stored.

Chapter 5: Conclusion

This project has helped to explore various standards and technologies used in the health industries around the world, both in developed and developing countries. It has educated us on the differences of the various technologies, and which one is the best for the context of Ghanaian healthcare. In a general context, our targeted goal which is achieving universal health and well-being will be met with the recommended technology.

In the beginning of this research, the indicator measure was **coverage of essential health services** and in using **Fast Health Interoperability Resources**, hospitals in Ghana and beyond would be able to achieve this. In the long run, good health and well-being will be achieved.

This study was limited in terms of face to face conducting of research because it was carried out in the era of a pandemic, COVID-19. Participants had to interact with the researcher virtually and sometimes through online forms. Ideally, one on one round table discussions would have added great content to the paper. Also, articles related to the topic in developing countries especially in Ghana were difficult to find.

In the future, people researching in a similar space can explore the factors that will make or break interoperability in developing countries.

References

[1]"Goal 3: Good health and well-being," Goal 3: Good health and well-being | Joint SDG Fund. https://www.jointsdgfund.org/sustainable-development-goals/goal-3-good-health-and-well-being (accessed Apr. 22, 2021).

[2]"World Health Organization Assesses the World's Health Systems." https://www.who.int/news/item/07-02-2000-world-health-organization-assesses-the-world's-health-systems (accessed Apr. 21, 2021).

[3] IEEE (2013). Standards glossary. In IEEE Retrieved from http://www.ieee.org/education_careers/education/standards/standards_glossary.html

[4] D. Smaltz and E.S Berner, E. S. The executive's guide to electronic health records. Health Administration Press. 2017.

[5]"Data exchange architectures and standards: the evolution of Interoperability in Healthcare," Enovacom, Apr. 15, 2019. https://www.enovacom.com/interoperability/the-critical-need-for-interoperability-rises/ (accessed Apr. 22, 2021).

[6] S. Mathews and P. Pronovost, "The need for systems integration in health care.," vol. 305, no. 9, pp. 934–935, 2011.

[7] D. Baumgart, "Digital advantage in the COVID-19 response: perspective from Canada's largest integrated digitalized healthcare system. NPJ Digital Medicine," vol. 3, no. 1, pp. 1–4, 2020.

[8]A. Coleman, "An integrated model to share patient health records in public and private hospitals in South Africa. Studies on Ethno-Medicine," vol. 7, no. 2, pp. 87–93, 2013.

[9]M. Rahman, "PrescribeIT: Canada's Electronic Prescription Service | Canada Health Infoway." https://www.infoway-inforoute.ca/en/solutions/safer-medication-practices/prescribeit (accessed Mar. 30, 2021).

[10] R. Ong and S. Sabapathy, "Enhancing patient privacy protection under Hong Kong's Electronic Health Record Sharing System.," vol. 49, no. 1, pp. 4–30, 2020.

[11] J. Kuo and A. Kuo, Integration of Health Information Systems Using HL7: A Case Study. 2017.

[12] "Qué es Salud.uy | Agencia de Gobierno Electrónico y Sociedad de la Información y del Conocimiento." https://www.gub.uy/agencia-gobierno-electronico-sociedad-informacion-conocimiento/politicas-y-gestion/programas/es-saluduy (accessed Apr. 22, 2021).

[13] "What Is FHIR®?," [Online]. Available: http://www.hl7.org/fhir/.(accessed Apr. 22, 2021).

[14] D. Bender and K. Sartipi, "HL7 FHIR: An Agile and RESTful approach to healthcare information exchange," in Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems, Jun. 2013, pp. 326–331, doi: 10.1109/CBMS.2013.6627810.

[15] "What is a REST API?" https://www.redhat.com/en/topics/api/what-is-a-rest-api (accessed Apr. 22, 2021).

[16]"FastAPI." https://fastapi.tiangolo.com/ (accessed Apr. 26, 2021).