A Conceptual Model of an Ideal EHR (Electronic Health Recorder) System in the Context of Bangladesh

BY

Md. Mhutashim Billa
ID: 213-17-498

This Report is Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science (MS) in Management Information System (MIS).

Supervised By

Dr. Md. Ismail Jabiullah
Professor
Department of CSE
Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY

DHAKA, BANGLADESH

JANUARY 2023

APPROVAL

This Thesis titled "**A Conceptual Model of an Ideal EHR (Electronic Health Recorder) System in the Context of Bangladesh**", submitted by **Md. Mhutashim Billa** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of MS in Management Information System and approved as to its style and contents. The presentation has been held on 24th January 2023.

BOARD OF EXAMINERS

Professor Dr. Touhid Bhuiyan — **Chairman**
Professor and Head
Department of CSE
Faculty of Science & Information Technology
Daffodil International University

Md. Sadekur Rahman — **Internal Examiner**
Assistant Professor
Department of CSE
Faculty of Science & Information Technology
Daffodil International University

Raja Tariqul Hasan Tusher — **Internal Examiner**
Assistant Professor
Department of CSE
Faculty of Science & Information Technology
Daffodil International University

Dr. Mohammad Shorif Uddin — **External Examiner**
Professor
Department of CSE
Jahangirnagar University

Declaration

We hereby declare that, this Thesis has been done by me under the supervision of **Dr. Md. Ismail Jabiullah, Professor, Department of CSE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

Supervised by:

Dr. Md. Ismail Jabiullah
Professor
Department of Computer Science and Engineering
Daffodil International University

Submitted by:

Md. Mhutashim Billa
ID: 213-17-498
Department of Computer Science and Engineering
Daffodil International University

Acknowledgements

First and foremost, I want to thank all mighty Allah for giving me the opportunity to complete my Master's thesis in time. I would like to thank by parent for giving me the support throughout my educational journey. Furthermore, I would like to thank my little brother who helped in my needs in the busy moments. Most importantly, I would like to thank my supervisor **Dr. Md. Ismail Jabiullah** (Professor, Department of CSE, Daffodils International University) for his time. He guided throughout my thesis journey like no other. I went to him many times for thesis discussion. Every time I have learnt something new from him. May God bless him. Furthermore, I would like to thank all the professors and faculty members, whom I had privilege to meet during my session in this university. Lastly, I would like to thank my fellow classmates. From whom I have learnt a lot during conversation, group assignment and presentation.

.

Abstract

In Bangladesh, a good amount of hospital settings still prescribe patient with pen and paper without the option for storing the information in a digitized format. Even though some private medical settings have taken the initiative to adopt e-health systems such as EMR (Electronic Medical Record), there still remains a gap in those solutions. Because in most cases the data is separated into different machines and it cannot be transferred outside of a particular hospital domain. Hence there is a need for adopting EHR (Electronic Health Record) system that can not only store medical information in a digital format but also be an interoperable system supporting various hospital settings. The main aim of the thesis is to articulate an EHR model in the context of Bangladesh. For implementing the proposed model guidance from various literature was gathered. And for further understanding, the working of some the existing systems has been taken into consideration. The model was created and showcased with appropriate diagrams. Appointment setting, Medical history, 24/7 prescription accessibility, and prescription sharing are few of the functionalities which will be supported by the model. The main drawback of this research is that my hypothetical model hasn't been used as an actual application. Therefore, it is not easy to forecast any uncomfortable circumstances that could occur during real-life implementation. The proposed HER system will be able to support configuration oversight of the existing system. This is clearly seen when doing a comparison examination between various systems. In addition, the software's future potential is quite promising given the emergence of more recent technologies like artificial intelligence (AI), Blockchain, and 5G connection.

Table of content

List of Figures

List of Tables

Chapter 1

Introduction

In most developed countries EHR (Electronic Health Recorder) is integrated into the medical sector. It stores user health information. Ranging from general information to medical and diagnostic information all in one place. Some of the countries have more than two decades of experience in using the solution. However, the application of this kind in a developing country like Bangladesh is very nascent.

Almost every hospital in Bangladesh is using computers for storing and processing data. However, in most cases, it can be seen that medical information is not one of them. It is still stored in a paper-based form factor. Thus, information remains very much vulnerable to fragmentation and it is easily prone to loss. On the bright sight, some well-known private hospitals are using health software, there is, however, still opportunity for development. The shortcomings of the current systems can be filled by implementing an EHR system.

1.1 Objectives

My main goal in this document is to render a clear perception of an ideal EHR system for Bangladesh. Furthermore, in contrast to the current status of EHR systems around the globe, I will be portraying steps to be taken for new and existing solutions in Bangladesh. Illuminating the popular recommendation and suggestions given by industry experts.

Illustrations of the objectives are given below,

- To give a clear understanding of an EHR system.
- To point out the benefit of using EHR from Bangladesh's perspective.
- To identify problems of the current eHealth systems and recommend countermeasures.
- To point out the current bottleneck for EHR implementation in Bangladesh and what measures should be taken accordingly.

- To give recommendations to development teams on features and functionality along with legal and ethical concerns for EHR.
- To draw attention toward the functional and non-functional aspects of the EHR.
- To recommend international conventions for ensuring standard security is maintained for data integrity and accessibility.
- To recommend established legal & ethical standards for global use cases.
- To give recommendations to administrative personnel and policymakers about creating conducive environment for EHR.
- To give recommendations to Doctors and Practitioners on how to get maximum leverage from the solution.

1.2 Motivation

Bangladesh is more than prepared for a e-health system such as EHR where they can store and access their medical history for better care. The problem of paper-based system or parallel system is too big to ignore. Which is why, I am determined to articulate a model of the software. My motivation for doing a thesis on EHR can be attributed to the following points.

- I'm interested in working on medical information systems in the future.
- EHR solutions are becoming more popular in developing countries.
- The ROI (Return On Investment) of EHR is well-documented and internationally proven. So, it is the logical next step for medical care innovation in Bangladesh.
- It will create more job opportunities.
- Current problems such as medical mistreatment and the overall cost of medical care will be reduced.
- Secure accessibility to medical records and exponential storage capacity will be ensured.

1.3 Methodology of the Work

For any research it is a must to first gather and analyze data. Research may be divided into many categories depending on the goal and the type of data used. To illustrate an

EHR paradigm for Bangladesh, the research for this thesis will be exploratory and descriptive in nature. Both primary and secondary data will be collected and used here. Primary data will be collected via observation of existing systems in Bangladesh. However, because much of the research for this thesis is non-empirical in character, secondary data will predominate in this context. Reviews of various international publications and sources (Journals, Research Articles, Conference papers, Books etc.) from reputable research websites (IEEE explore, Springerlink, ResearchGate, PubMed etc) will be included as secondary data. Points and suggestions from global literature will be used as a guide for both implementation and regular use cases. On the other hand, local literature will help identify the problem related to EHR implementation in Bangladesh, the barriers that are hindering the implementation, and the area of improvement for the currently serving health systems.

Below, given the development methodology which will be followed when the proposed EHR model will be developed in actuality. If others are interested, this methodology can be used as a guidance for other future developers as well.

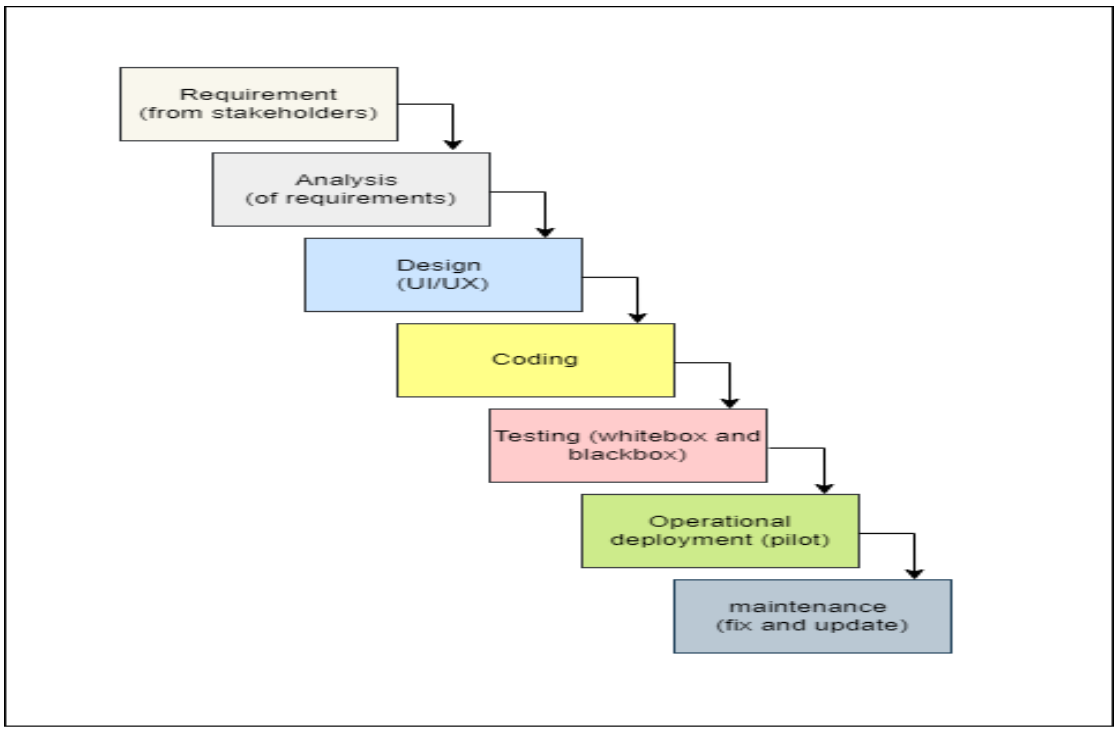

Figure 1.1 Software Development Methodology.

1.4 Expected Outcome

The expected outcome of this thesis is to articulate a model of an EHR system that is simple enough to develop in the near future for Bangladesh. The model will satisfy all if not most of the recommendations found in the works of literature. It will incorporate essential features that are either present or lacking in the existing systems. To verify the claim an output analysis of the proposed system will be conducted to demonstrate the results that the software would provide for the users, and subsequently, a comparison study with other current systems will be conducted.

1.5 Report Layout

This document has seven chapters in total. Starting from Chapter 1 introduction, which has the objectives, motivation, methodology of work and expected outcome portrayed. Here, each part contributes to the overall rationale of the thesis.

Chapter 2 is the background, which gives a full idea about different eHealth systems along with future prospects. This chapter also incorporates the literature review, showing the related research that has been done on this topic.

Chapter 3, showcases three existing systems which are currently used in Bangladeshi medical sector. Here, both their strengths and weaknesses are highlighted.

Chapter 4, illustrates the proposed model. Here the model is described by using text, conceptual design (flow diagram, flow chart) and algorithm.

Chapter 5, addresses the output of the proposed system. The services the system will give to the society and the limitation of the system are discussed here.

Chapter 6, showcases the comparative analysis among the existing systems with the proposed system. From here the real value of the proposed software can easily be highlighted.

Chapter 7, portrays the overall summary of the thesis with information regarding future scope.

Chapter 2

Background

2.1 Introduction

This chapter will be illustrating the concept of EHR system along with its history, architecture, users and future market implication. A proper distinction between the EHR and EMR will be given here as well. Furthermore, related works can also be found towards the end of the chapter. Which will portray what professionals and scholars wrote about in their literature on the subject of EHR in both global and local contexts. This will be done in order to visualize a recommended approach.

2.2 E-Health

Generally, E-Health refers to the application of various electronic systems that assist in giving advance healthcare and wellness. The solution that are under the e-health category are namely EHR (Electronic Health Record), EMR (Electronic Medical Record), health information system, telemedicine and mobile health (m-health) apps to name a few. Enhancing the effectiveness, quality, and accessibility of healthcare services is the aim of e-health.

2.2.1 Evolution of E-Health

Without a doubt medical records are the essential gems for any e-health system. Looking back from a previous decade it has transform exponentially. Procedures of collecting, processing and recording health information has changed. All thanks to newer Health Information Technologies.

In the early 1900s, American health institutions stored medical reports in paper-based format. In the medical record room, information on patient visits, histories, diagnoses, test results, medications, and any other details were manually kept on paper.

Key clinical details regarding the patient and his care were documented in the medical record. Using medical records as a tool, the Joint Commission on Accreditation of Hospitals began regularly inspecting hospitals and other care facilities to assess the

quality of the medical treatment provided[1]. With these initiatives, the hospital experienced the most progress in terms of standardizing the medical record section with established regulations. Soon after, the usage of standards for hospitals in the United States and Canada was started by the American College of Surgeons (ACS) in order to improve the clinical care environment[2]. Currently, the organization of professionals is known as the American Health Information Management Association (AHIMA).

One such product was created by Lockheed in the middle of the 1960s and has since been transferred to the vendor Technicon, TDS Healthcare, and Eclipsys, which is now a part of Allscripts[3].

In 1968, POMR was introduced to the medical world. It was one of the earliest health system. That was the most strategic way for capturing a patient care record in those times[4]. By using the solution patient will first describe their symptoms and other problems to the doctor or nurse. The nurse or helper will next enter the data into an I.B.M. Ramac 305[5].

A method for entering patient data into POMR was called SOAP (Subjective, Objective, Assessment, and Plan). The use of SOAP enhances patient care and aids medical personnel in delivering organized care and treatment. It basically showed the overall patient's medical information in a very organized way[6].

After that the adoption of legacy EMR (Electronic Medical Record) systems were started. Some of the system allowed transmission of information among different health provider under the same organization. This made patient information readily available for use by medical professionals[7].

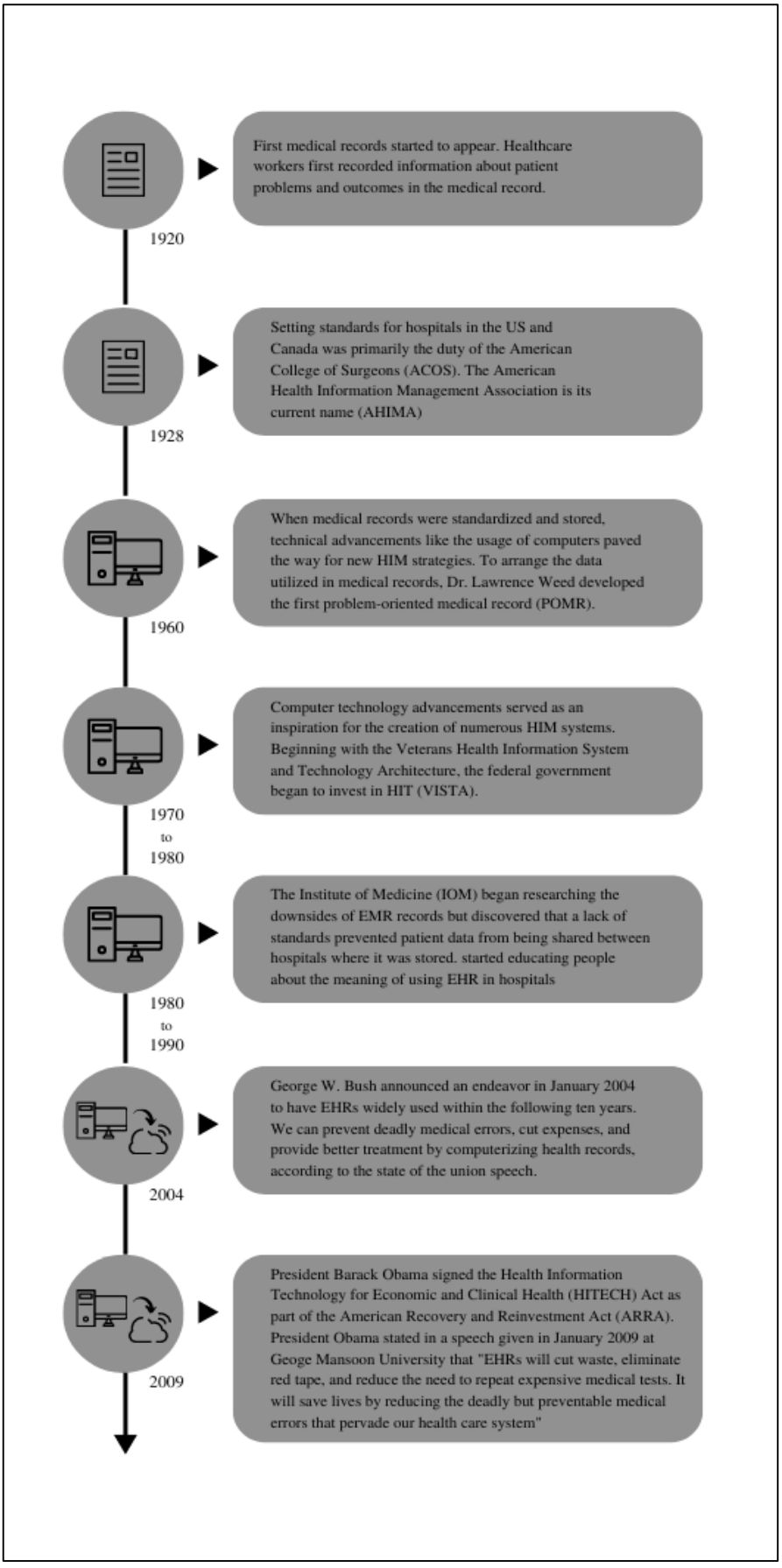

Figure 2.1 EHR History Timeline

Greater attempts have been made to promote the use of EHR since the 1980s. The Institute of Medicine (IoM) acknowledged the necessity of a thorough examination of paper medical records. They also released a report that was the first to make the case for EHR use, include it as one of the top seven suggestions for bettering patient records, and suggest a method for converting paper records to electronic ones. It also identified obstacles to EHR adoption (lack of standards, security concerns, expense), and it made funding recommendations for both commercial and governmental development. When the commercial sector learned about the IoM's conclusions, advocates established the Computer-Based Patient Record Institute (CPRI), which assisted in removing obstacles to the growth of EMRs[8]. The Health Information and Management Systems Society, or HIMSS, later amalgamated with it.

To Err is Human, a study on medical errors published by the IOM in 2000, came to the conclusion that the implementation of methods like computerized physician order input will make healthcare safer[9].

From EMR to EHR happened when US president Barak Obama signed Health Information Technology for Economy and Clinical Health (HITECH) act[10].

In order for patients to receive better care, the primary goal of the HITECH Act is to encourage the use of electronic health records and other supporting health IT in the United States[11].

2.2.2 About EMR

EMR (Electronic Medical Record) system is a solution that works in an individual health institution. It is a stand-alone program that offers comprehensive documentation of patients' medical histories for a limited time period and under the sole control of one specific healthcare institution[12]. It stores information regarding medication, prescriptions, test reports, billing, and some time even inventory management. EMR benefits might include reduced paper work for health organization, patient tracking, as well as pre-propagated paperwork to make hospital discharge and follow-up with outpatients easier[13]. Because EMRs are not intended to be shared outside of a specific practice, it is challenging to transfer information between medical facilities including labs, pharmacies, and specialists[14].

2.2.3 About EHR

EHR (Electronic Health Recorder) is a software that keeps track of data on a person's health and wellness as it is produced by different stakeholders (doctor, clinician, nurse) in the health and care systems. Here, health is an umbrella term. It refers to many aspects and dimensions. For example, it can be a record of medical history, allergies, demographic information, test reports, radiology images, diagnosis reports, prescriptions, or treatment plans to name a few [12].

EHR solution stores these types of isolated yet in most cases essentially linked information in a relational and orderly way. Thus, enabling users to have medical data readily available. EHRs are most frequently used by clinicians to make diagnoses and write prescriptions because they enable data to be promptly and securely accessible to authorized users [15].

In contrast to Electronic Medical Records (EMR), an EHR is typically an inter-organizational tool that can be shared by numerous healthcare organizations and professionals and contains longitudinal records with information on all significant health events that have occurred during the individual's life since birth[12].

Benefits of EHR are written below,

- It helps to showcase detailed and life-long medical history of a person in a single solution.
- Quick access to patient health information is guaranteed by it.
- It helps reducing the use of paper and physical storage space. Thus, reducing cost.
- It organizes the information in such a way that important information can be found easily.
- Using the application user can easily share their medical history in different medical institutions.
- It enhances the workflow of a practitioner without sacrificing accuracy.
- It plays a major role in reducing the medical cost of a patient. As it protects patients from duplication of testing.

- It helps patient by giving a platform to express their feeling in the dairy section. This helps as a therapy.
- It ensures standard formatting, complete documentation and readability. Thus, reducing avoidable prescription error which is very common in the manual paper-based process.
- Interaction and communication is also improved by EHR. Because, it facilitates access to up-to-date medical information, coordination of care, and reduction of errors.
- EHR improves a practitioner's efficiency by delivering safer treatment, reducing medical mistake, and making accurate diagnoses.

2.2.4 EMR vs EHR

Table 1. EHR vs EMR

EHR	EMR
This is an interoperable software.	This is standalone software.
Enables patient's medical information to move outside of practice. So, streamlined exchange of real-time data with other providers, laboratories, etc.	It does not allow patient's information to be shared outside of the providers domain.
Access to decision making tools are available here.	It is only used for treatment and diagnosis purpose. So, no external DSS (Decision Support System) functionality.
Electronic medium of patients Health information.	Electronic version of patient health chart.
Regardless of location, EHR enables doctors to readily exchange records with other healthcare professionals[16].	Digital patient charts are provided by an EMR for a particular practice.

2.2.5 Workflow of EHR

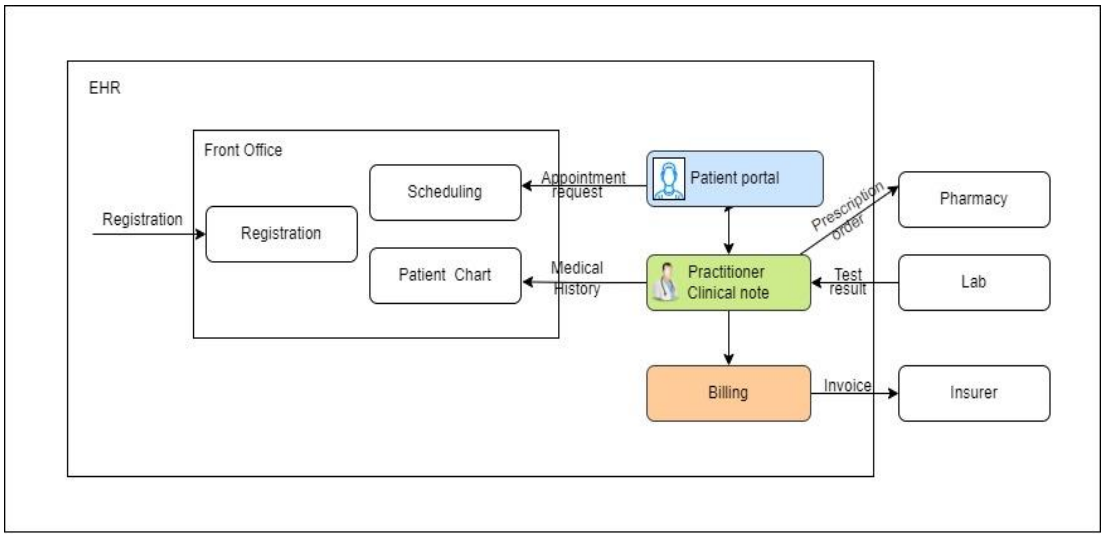

Figure 3 EHR Workflow

In an EHR system, the medical procedure often begins with a patient making an appointment through a specific gateway (Patient portal). After the patient gets an appointment and reaches the medical facility his information is registered into the system. The appointed practitioner will be able to access medical chart of the patient in an orderly format. After observing the patient and learning about medical history, practitioner can order test from the hospital lab and medicine from the hospital pharmacy. And finally at the end through the system all the medical billing will be invoiced to insurer if the patient has insurance, which is very common in developed countries. If the patient does not have any insurance, then the billing will be submitted to patient via email or printed document.

2.2.6 Features of EHR

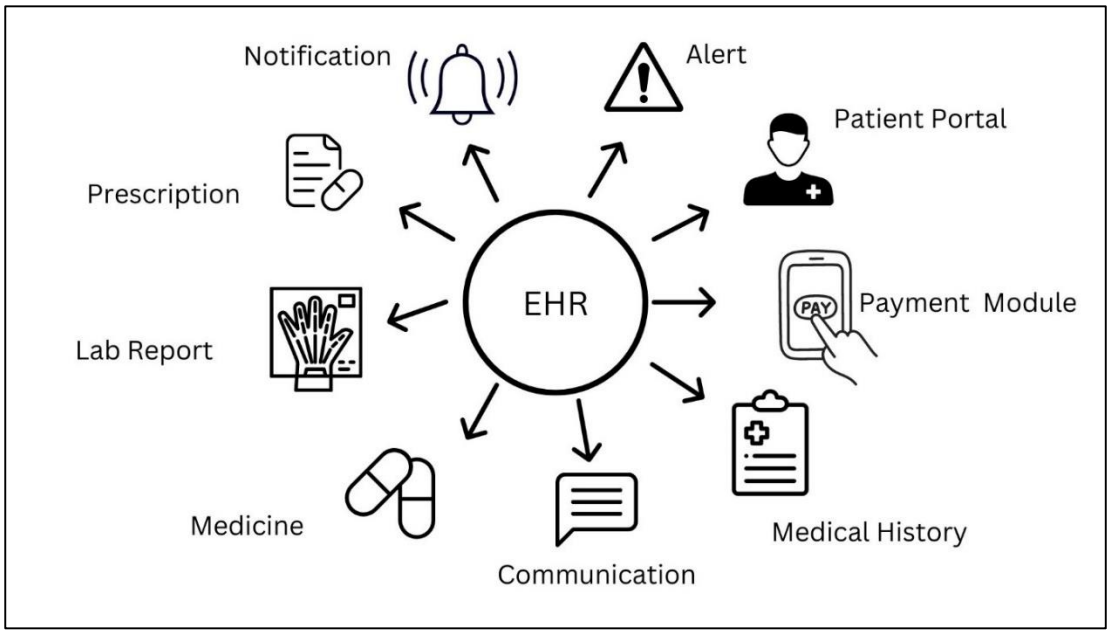

Figure 4. Features of EHR

Typically, the EHR solution embodies various features. Depending on the size of the system, the list of features can vary. However generally the functionality that can be see are listed below.

- Electronic Prescription: to have the soft copy (document) of the prescription.
- Patient Portal: for patient to access their medical information.
- Medical history details: to showcase all medical information about a patient.
- Report storing and documentation: for storing various medical archive in an organized way.
- Notification system: to notify patient or practitioner about important event.
- Medicine: to store information related to pharmacy medicine and order medicine directly from the system.
- Payment: to store billing and services information.
- Communication module: to share information between patient, practitioner and medical institutions.

2.2.7 Type of Users of EHR

There are different types of users for EHR. Each type of user will use the software in a different manner. The type of users who will be using the application are namely, patients, medical professionals (general practitioner, in hospital physician, specialist, rescue service), pharmacies, researchers, public authority, health insurance company[17].

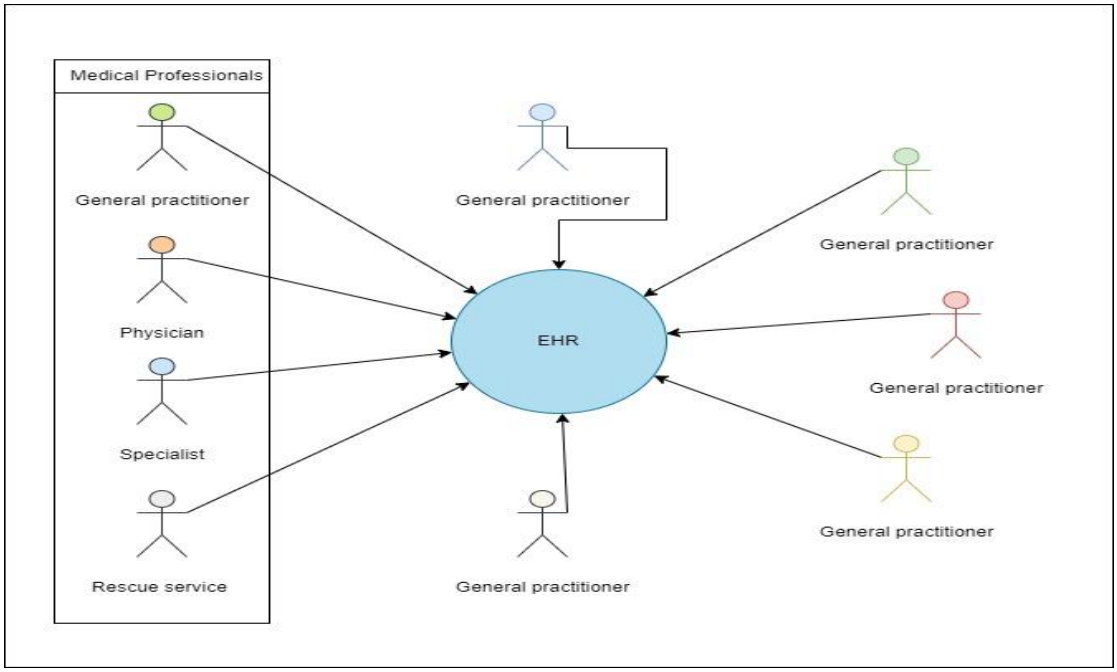

Figure 5. Type of Users of EHR.

2.2.8 Statistical Analysis of EHR

From the primitive time of the eHealth system the adoption of new technology in health industry has been a growing factor. From WHO (2016) survey report, we learn that in the first fifteen years of the 21st century the adoption rate compounded.

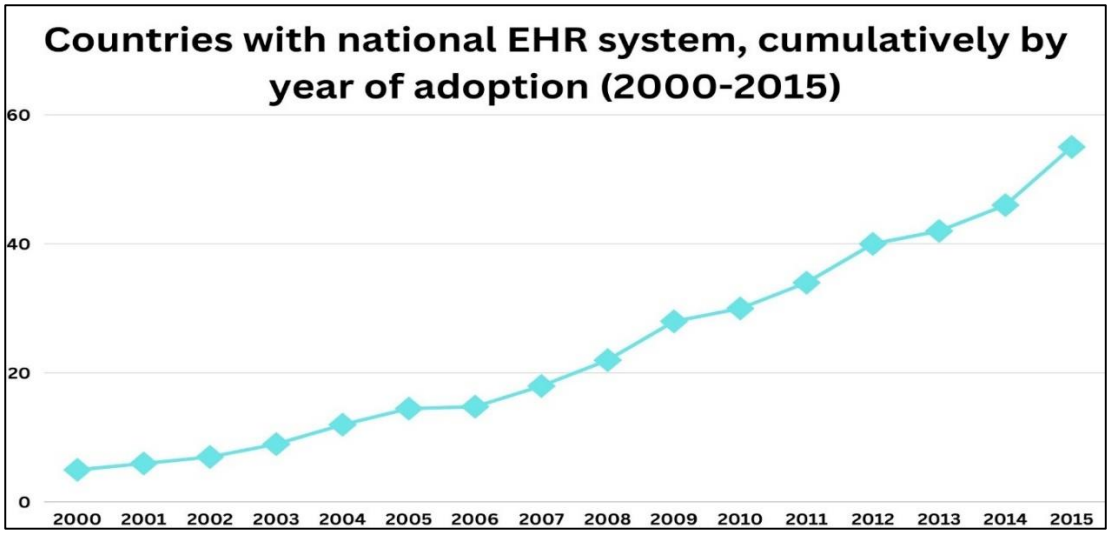

Figure 6. Cumulative Adoption of EHR in different countries

From 2000 to 2015 the adoption of country wide eHealth and EHR system have risen tenfold[18]. Only between the year (2010-2015) year of adoption risen 46%. However, not all the countries have reported that the adoption completed fully.

EHR usage in different countries according to their income status is different. A report of Third Global Survey (2016) on e-Health, showed that, about a third (35%) of middle income countries, half (52%) of high income country and nearly two third (66%) of the wealthier countries have adopted nationwide EHR system[18]. Whereas, only 15% of low income countries adopted national EHR system.

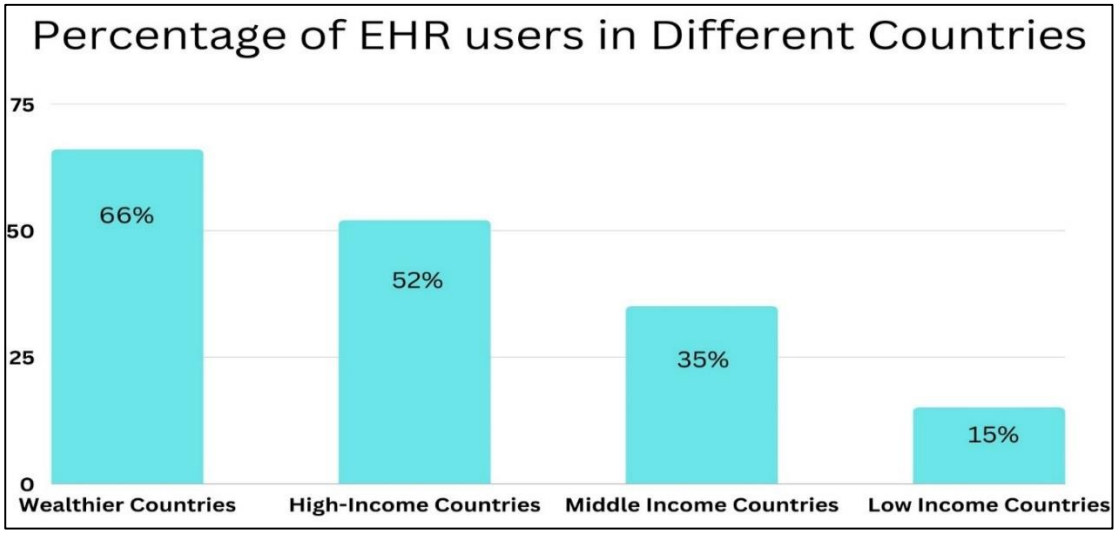

Figure 7. Income-wise EHR users in Different Countries

So, adoption of a national EHR system is lowest in low income countries and highest in high income countries. The more income a country has, the more possibility there is for national EHR system to be adopted. logical deduction suggests that the surplus income is typically invested on R&D. Thus, high income countries adopt and advance more on e-health sector.

In the marketplace currently, there are two types of EHR systems. web-server-based EHR system and client-server-based system.

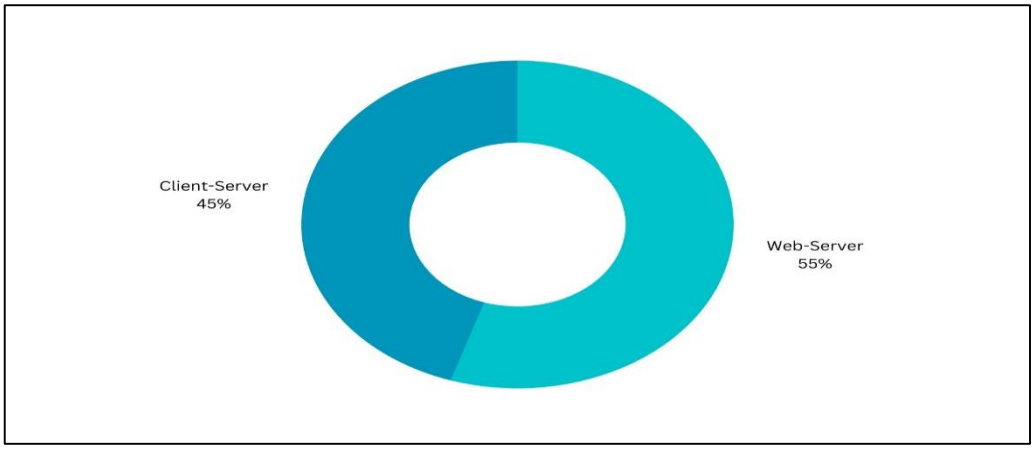

Figure 8. EHR Product-wise Market Share

web-server-based EHR system accounts for 55% of the solution and client-server-based system which accounts for the remaining 45% of the solution present currently in the market. This is due to the fact that web-based system is more accessible and platform independent.

From the inception of EHR in 2009 the adoption of the system is still an ongoing process and it is expected to grow with time.

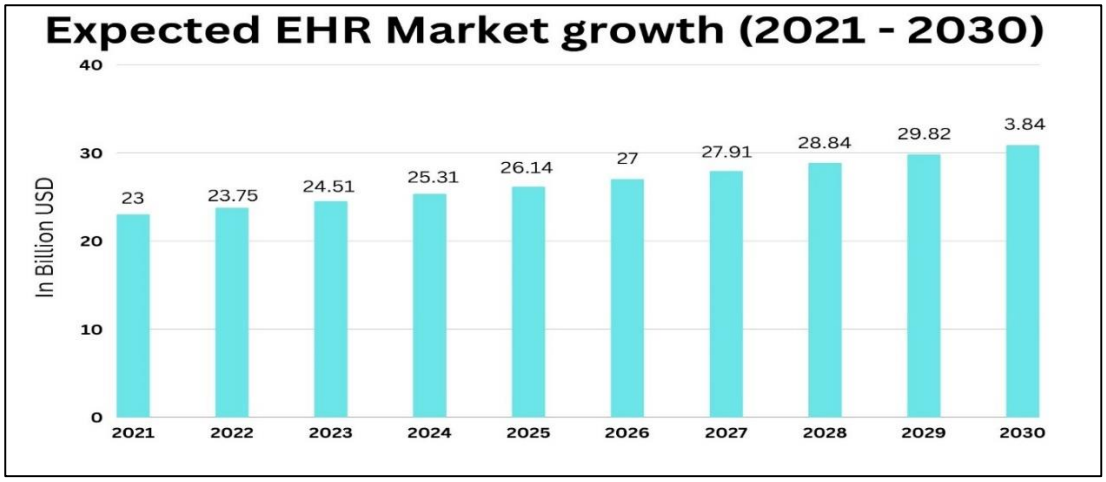

Figure 9. Expected Market Growth of EHR (2021 to 2030)

According to Precedence Research publication, in 2021 the global EHR market share was estimated $23 billion. It is expected to have a compound annual growth rate (CAGR) of 3.3% during the forecast period 2022 to 2030[19].

Furthermore, EHR market share by region portrays that USA has the biggest market share. This is due to the fact that they have very high adoption rate of innovative digital technology in the health sector which fueled the market growth tremendously.

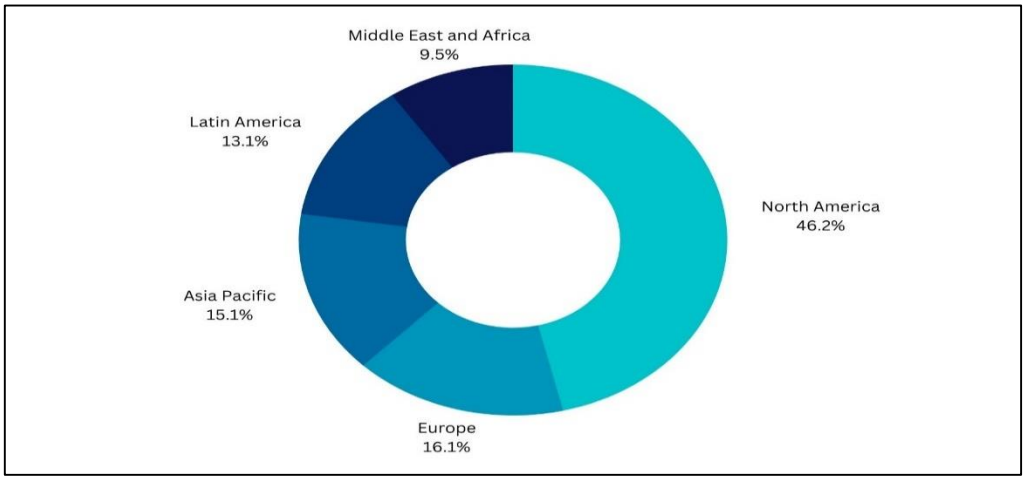

Figure 10. EHR Market by Region

However, the market of eHealth systems in general have been saturated in most of the developed countries. That is why the growth rate is higher in developing countries. According to the same research the fastest growing market region is Asia Pacific by their estimates. So, in the near future, high growth rate of eHealth solution such as EHR can be predicted in developing countries like Bangladesh as well.

2.3 Related Works

We learned earlier that the inception of EHR happened toward the very beginning of 21st century. Which is why there are numerous academic papers discussing about the system from various angle. Here, some relevant finding will be illustrated in this sub-section.

2.3.1 Problems of Analogue Approach

In most of the cases the medical information is still stored on paper. Nazmus & Mohamed, showed current as well as probable future Bangladeshi doctor's perception on EHR solution[20]. At the beginning they pointed out the problems that grow from paper-based way of record keeping. Some of the problems they pointed out are namely, poor accessibility, fragile (require protection from fire or water damage), improper documentation, fragmentation of medical documents, requirement of extra physical storage etc. So, in this analog system getting a complete overview of a patient's medical history is time consuming and tiresome.

Furthermore, there are also other problems looming the traditional approach. For example, a research by Mortazavi and Hajebi, asserts that there are two sorts of prescription errors; the first is when crucial information is omitted from the prescription (this is known as an error of omission), and the second is when information is incorrectly stated in the prescription (this is named as error of commission). He also emphasized that the primary factor contributing to the 18% commission mistake rate in medical prescriptions is misunderstanding of medication interactions[21].

Moreover, Meyer, pointed out in his paper, 15% of medical mistakes are attributed to misunderstood abbreviations, problems with leading and trailing zeros, and illegible handwriting, according to the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP)[22].

On the bright side, various literature suggests using software for better transparency, data management and error reduction. For example, according to a report by Kaushal et al., the deployment of e-Rx (an electronic prescription system) in 2010 reduced prescription mistake rates from 42.5% when the facility only used paper-based system to 6.6% when they started using e-Rx system. This result suggests that using electronic prescription or e-health system can reduce the possibility of any occurrence of a mistreatment which could have be avoided easily.

Nazmus & Mohamed, also suggested using e-health system in the medical sector of Bangladesh. They stated that the situation will be different if EHR is used; it will be quicker, the storage device can be portable, and there won't be any irritation. The paper concluded that possibility of Bangladeshi medical student adopting EHR highly depends on effort expectancy, performance expectancy and social influence[20].

2.3.2 Common functionalities of EHR

Researcher Schabetsberger and his team, demonstrated in their literature about the functionality that should be present in a shared electronic health record system[17]. The functionalities include electronic access to health record, data forwarding using proper transparency, drug ordering, service overview, cost overview, resource management, alert functions, emergency functions, personal annotation (pain dairy, blood pressure dairy) and interpretation function to make sense of the medical terms for the patient (medical dictionary). Furthermore, they also emphasized on the security of the medical information.

2.3.3 Stakeholders of EHR

Previous studies from researcher Schabetsberger et al, have shown that EHR system serves people from multiple avenues. For instance, doctors, pharmacists, patients, researchers, health insurance organizations, etc[17]. There must be a wide range of expectations among all these users for the system. According to the author, patients would like to have access to their basic medical records, which would include a basic glossary of medical words, while medical professionals would want to have access to their patient's whole medical history. The pharmacist, however, would just need to have access to the patient's prescription.

2.3.4 Implementation and Challenges of EHR in Bangladesh

Khan et al, illustrated the possibilities and concerns of EHR implementation in Bangladesh[23]. In their research they interviewed health professional of two different hospitals. One was using an EMR and the other one yet to be implemented. There most interviewees appeared to anticipate that adopting EHR systems would save them time,

be convenient, efficient, and productive, and they believed that doing so may improve their ability to make professional decisions since they would have better access to patient medical histories. Most of the young respondent answered positively toward the EHR system. However, there was a concern for older practitioner as they might find it bothersome to learn a new technology to do the same thing they are doing for years. Furthermore, regarding totally converting to an automated system and keeping no manual records at all, they (older practitioners) seem to have difficulties in trusting the digital approach. They also tend to believe that using new technology with physicians who are older will be less effective.

In their paper, Afrin & Arifuzzaman, assessed the current e-health landscape of Bangladesh[24]. Currently in Bangladesh fully paper-based system is somewhat reduced. Big private hospitals have started using e-health software like EMR systems on their premises. Nevertheless, majority of the private as well as public hospital cannot comprehend the benefits of an E-health system. Which is why most hospitals have little interest in purchasing computers for medical purpose. They believe that paying to reserve data is a waste of money. There is a scarcity of effective data management personnel. Patients are also unaware of the benefits of digitally recording their medical history. These variables together continue to prevent medical record management from being fully digitalized.

2.3.5 Government Initiative of EHR in Bangladesh

In [24], the authors mansion about a project that the MOHFW (Ministry of Health & Family Welfare) is now working on their aims to assess and create a strategy for Bangladesh to embrace EHR. This initiative calls for the implementation of EHR systems in every Bangladeshi hospital. The author also pointed out in order to do that some difficulties have to be acknowledged. Firstly, there is scarcity of skilled human as well as ICT resource. Secondly, people from under privileged background or rural area have knowledge gap and trust issues. And finally, because this strategy requires both people and ICT technology, hospitals are not very optimistic in using it.

In 2009, Bangladesh has adopted DHIS2(District Health Information Software). It is web-based open-source software for collecting medical data. According to [25],the software is only used in DGHS (Directorate General of Health Services) MIS which is

under the MOHFW. However, the majority of data gathering, compilation, and transmission in the DGFP (Directorate General of Family Planning) MIS are done manually and using paper till 2019. According to the latest findings it is anticipated that DHIS2 would be implemented in 40 districts by June 2020 and in all 64 districts of Bangladesh by June 2022[26].

In 2016 DGHS (Directorate General of Health Services) partnered with thoughtworks international software firm and implemented Bahmni[24]. Bahmni is a distribution of OpenMRS. 2015 the system was launched in Kaliganj sub-district (pilot project) and in 2016 it was launched in Gazipur district. At present, sub-district and district hospitals utilize the solution as their clinical system, while community clinics use it as a cloud-hosted CHW (Community Health Worker) application[27].

2.3.6 Private Initiative of EHR in Bangladesh

According to Mukherjee et al, in 2017, SKM an international firm and local computer programmers in Dhaka collaborated to create EMR-BD in a cost effective manner[13]. It was implemented at the National Institute of Neurosciences and Hospital. In their paper they discussed how EMR deployment assisted in identifying several opportunities for improvement in international collaborations and long-term data collecting, which resulted in the creation of a distinct outpatient clinic to enhance follow-up treatment.

2.3.7 Nationwide EHR System

Zhu et al, expressed that the need for national EHR system for a country[15]. They argued that national EHR system and standard format of record keeping will not only reduce administration liability but also reduce miscommunication. for example, only 52% of New Zealand patients surveyed indicated that they knew what their drugs were for. According to estimates, these problems cost New Zealand $222.5 million NZD annually. This might be as a result of medical records being written for professionals rather than patients. Globally, lack of awareness and non-compliance costs $317 billion.

Researcher Charles & Sninky, also agreed about the usefulness of a national EHR system[28]. As information interpretation and exchange is condensed in this manner

the administrational cost is also reduced. Furthermore, employee will not need to learn different EHR system functions and navigations.

Fennelly et al, supported the national EHR initiative by suggesting that by this way new EHR can be pre-adapted to the regulation due to national EHR and global standard[29].

Some countries have also demonstrated the cost decrease. The HealthConnect system in Australia allows participating and approved providers to access patient data. They calculated savings of $300 million AUD annually due to the decrease in mistakes and extra work[30].

2.3.8 Concern of eHealth systems

There are some shortcomings of EMR system. In their paper, Pai et al, have pointed out that EMR system is a kind of silos that keep medical information[31]. Which is why at the point of care, healthcare personnel do not have access to comprehensive health information. Different standards are used for clinical data interchange by siloed vendors. There is no standard access with this method, forcing healthcare users to use numerous EMR apps. Incomplete medical information can have unintended repercussions for patients. As an illustration, fragmented EHR systems make it challenging to gather data for studies[32].

However, EHR also have some shortcomings. These might include changes in workflow, adoption to new technology results in temporary productivity loss, unintended consequences, privacy and security concerns [33]. EHR system is costly which is why implementation and maintenance might requirement more investment then necessary. Especially, for a country like Bangladesh implementing a proprietary world class EHR will be course than a blessing. So, we should build our own system which also will be good from the security perspective as well.

Using application for medical purpose in not new to Bangladeshi people. For example, in 2020, Nazrul et al, have published a paper on the problem of Bangladeshi m-health applications. In their research they found about 234 m-health applications are currently available in Bangladesh[34]. However, the deterrent to widespread use of m-health application can be traced back to unsatisfactory usability of the current applications. Bangladeshi m-health apps aren’t following UI guidelines. This is why UI and UX of the application need to be considered as one of the prime concerns as well.

2.4 Summary

The inception of EMR and EHR under the umbrella term of e-health system was discussed in this section. Furthermore, from the peer review literature overall problems of analogue system, possibility of EHR system was addressed.

Chapter 3

Existing Systems

3.1 Introduction

This chapter will showcase some of the existing e-health systems in Bangladesh. Details of the software information of each of system is distributed among various sub-heading for better understanding.

3.2 Systems

The Bangladeshi healthcare system is operating a lot of different software. Despite the fact that each piece of software has a different purpose. Some of the few are namely, HRIS (Human Resource Information System), eMIS (Electronic Management Information System), eTBM (Electronic Tuberculosis Manager), SHR-HIE (Shared Health Record – Health information Exchange), eLMIS (Electronic Logistics Management Information System), WMIS (Warehouse Management Information System), and UIMS (Upazilla Inventory Management System)[35]. However, these are administrative and organization centric solution rather than patient centric health solution. EHR is the only solution that puts patient information at the center. In Bangladesh various kind of EHR and EMR solution are being used currently. Below, system detail about three for the prominent solution in Bangladesh is written.

3.2.1 Bahmni:

Bahmni is an open source EMR/EHR system that runs on CentOS Linux. Because it is a modular system, users can expand its functions by adding new modules. The main goal of the software was to serve the rural healthcare sector. Currently the solution is serving many countries including Bangladesh. With the intention of promoting standardized practices through the EMR, Bahmni launched in 2018 at 50 facilities, including 40 sub district health clinics and 10 district hospitals[36]. In parallel, Bahmni is being used by two tertiary institutions in Dhaka (Dhaka Medical College, National Institute for Neuroscience and Hospital).

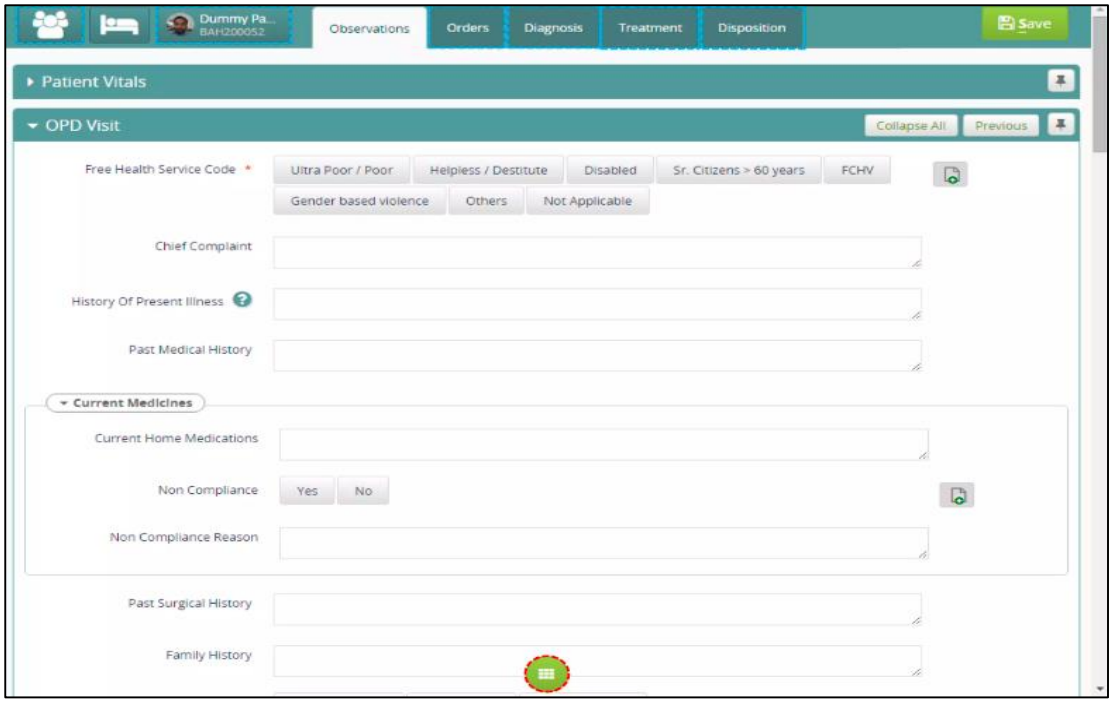

Figure 11. User Interface of Bahmni Software

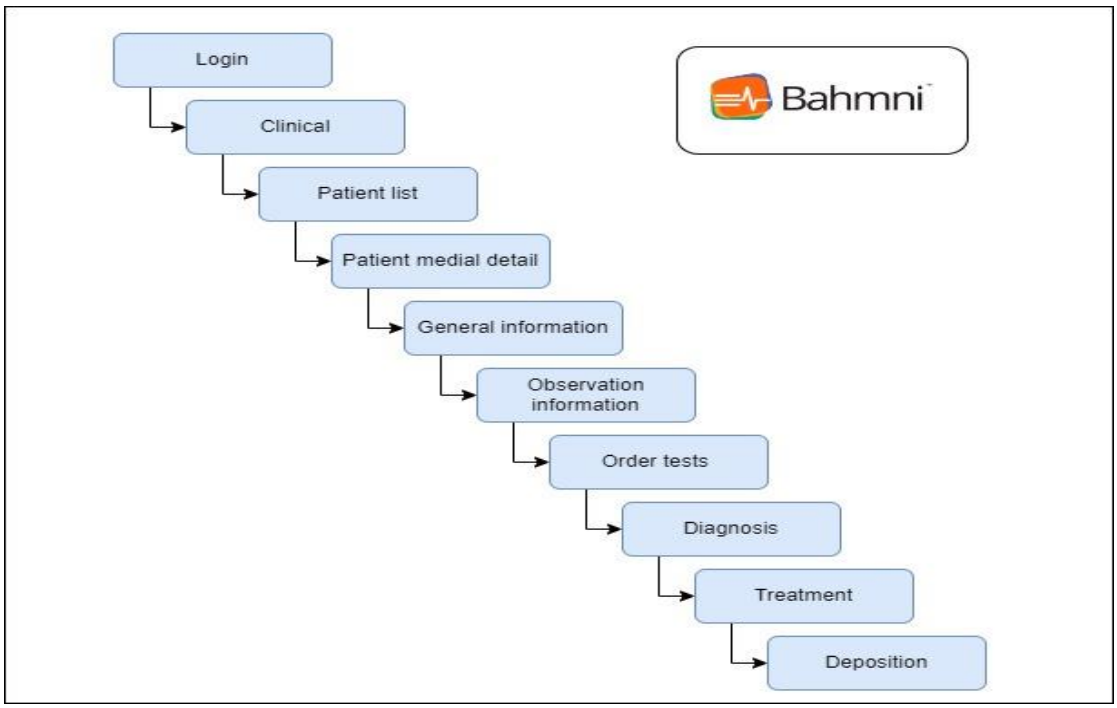

Figure 12. Flow Diagram of Bahmni

Summary (Benefits and limitation)

Benefit

- Modular system so various new function and feature can be added.

- Have local and remote synchronization mechanism for loss of internet connection.
- The software does not require high system requirements for resources.

Limitation

- Requires experienced Linux user and coder to install the application
- Requires experienced Linux user for maintenance purposes as well.

3.2.2 DHIS2

In 2008 the University of Oslo developed DHIS2. It is a web-based and open-source system that collects, analyses, validates, and showcases individual as well as aggregated medical data[37]. It has gained acceptance as a national platform for health information technology all around the world[25].

From the starting of DHIS2's journey in Bangladesh in 2009 till now, it has become a well-known system in most the public health institution in Bangladesh. Users of DHIS2 enter data at the community level and conduct reliable health data analysis at the national, state, and district levels. DHIS2 stores public health information for health research and health surveillance.

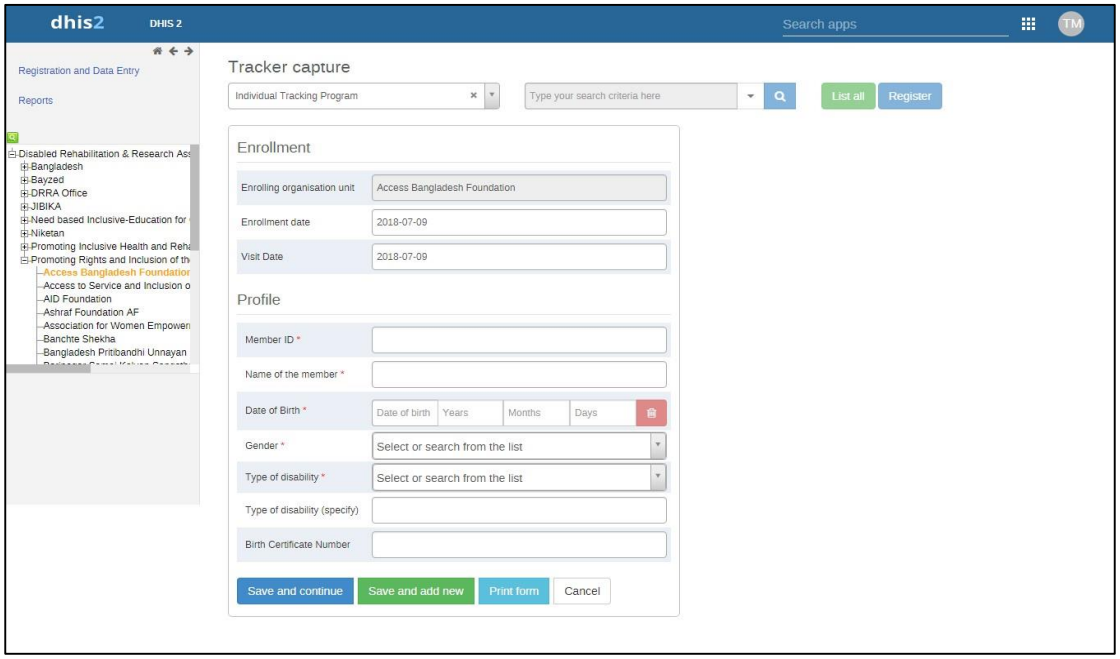

Figure 13. User Interface of DHIS 2

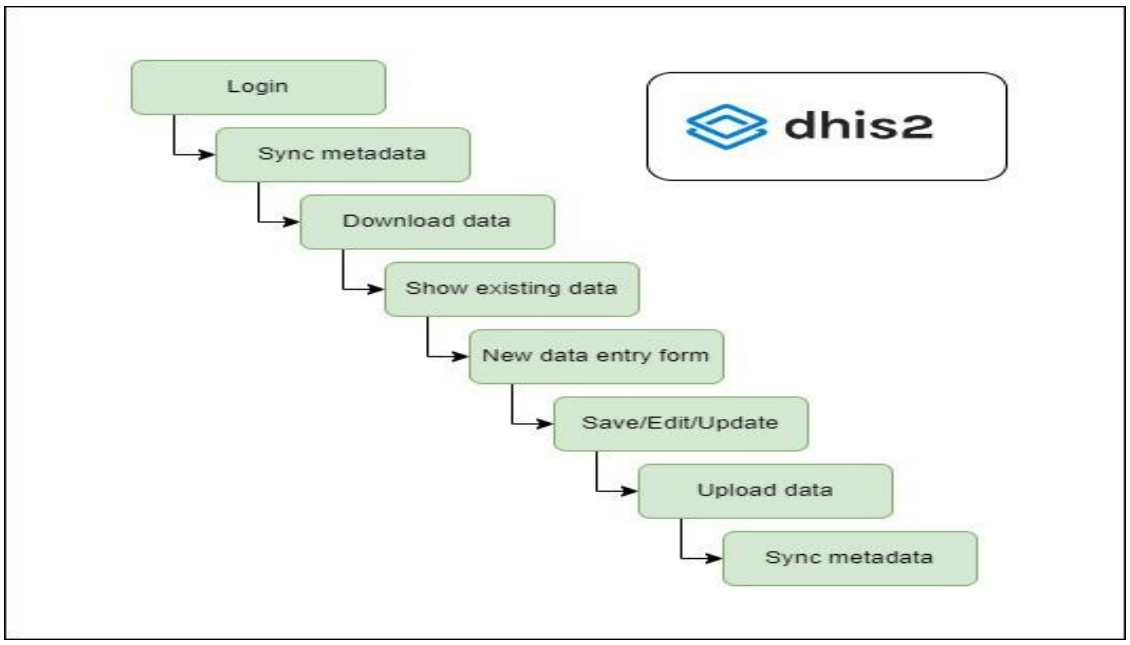

Figure 14. Flow Diagram of DHIS2

Summary (Benefits and limitation)

Benefit

- It covers 75% of public health facility in Bangladesh. So, currently it is the only software in Bangladesh that can give birds eye view of national health status.
- It is scalable and customizable according to local or national needs.
- Strong international community support.

Limitation

- Organizational health information management rather than patient oriented health system.
- No prescription writing functionality.

3.2.3 SJ EMR

This is a new software relative to other system mentioned before. This is mainly a web-based application with patient portal app. This is a proprietary software which is why it is not an open-source system. It was created by SJ Innovation IT firm in Bangladesh. Some private hospitals are currently using this application.

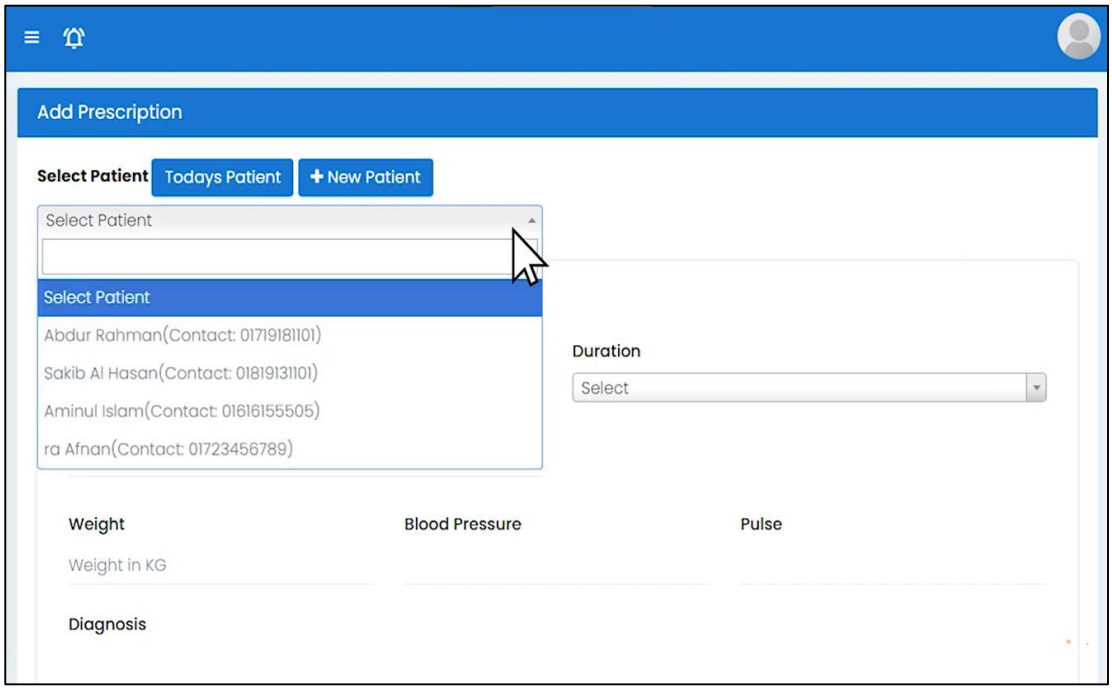

Figure 15. User Interface of SJ EMR.

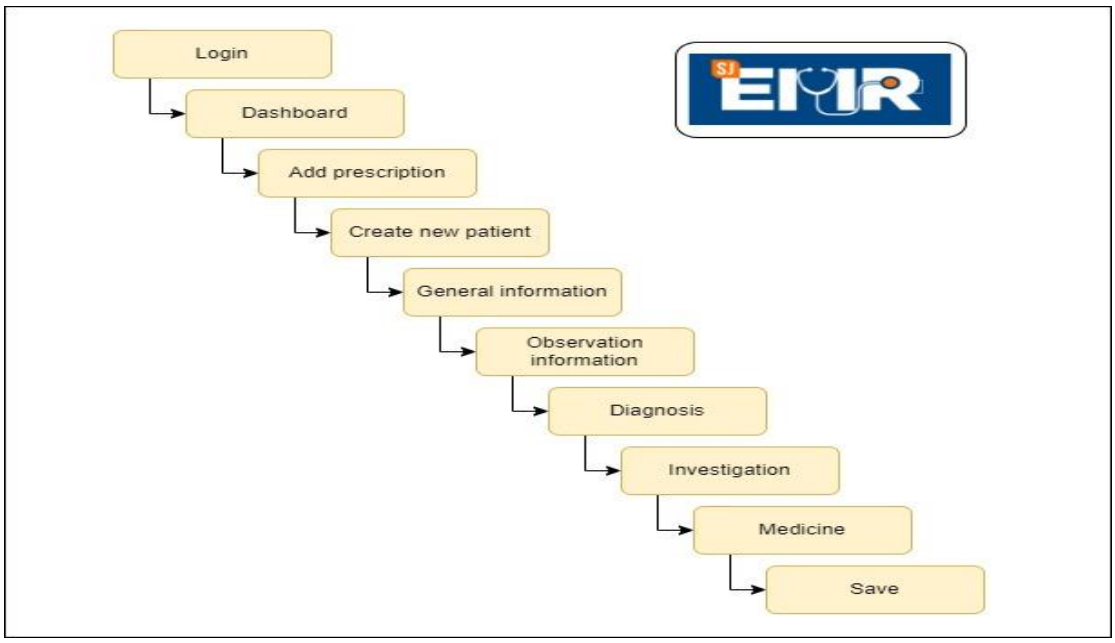

Figure 16. Flow Diagram of SJ EMR

Summary (Benefits and limitation)

Benefit

- It has a more modern UI and UX implementation.
- Less complexity and easy navigation.

Limitation

- Very limited functionality.
- Optimized for small to medium size clinics only.

3.3 Summary

The entire idea of the current systems has been depicted from software description to concluding notes indicating strengths and weaknesses. In this way, the state of e-health in Bangladesh was briefly illustrated.

Chapter 4

Proposed Model

4.1 Introduction

The proposed EHR system will have many features and functionalities. These functionality includes a web application that will have E-Prescription System, Appointment System, Blog and Journal, Dashboard, Payment module, DSS (Decision Support System), Personal dairy module, Medicine ordering module, sharing module, and Medicine library using API.

Additionally, even though the web application will have a patient portal, there will be a separate mobile application in both Android and iOS platform. This mobile application will be geared towards patient. The application will have additional local application functionalities which are typically not feasible for web apps.

These functionalities might include offline feature-sets such as medicine alarm, push notifications, local repository for medical information, in app dairy, medical dictionary; native device functionality for example virtual video checkup (using mobile camera, microphone, sensor etc); and emergency location sharing to ambulance or hospital authority (using GPS and location service) to name a few.

Apart from the functional requirement of the application, there will also be non-functional aspects as well. These will give focus to the application, Usability, Accessibility, Reliability, Performance, Scalability, Security (encryption, digital signature, access control), Modifiability, Platform Independence, Operative Independence etc.

The system will store patient data up to 50 to 60 years then auto delete the information after notifying the patient.

In this section, the main use case of the application will be discussed and illustrated using appropriate diagrams. Starting from a patient searching a doctor and getting an appointment, to completing the prescription with encryption and getting the finished invoice.

4.2 Description

The web application will introduce a doctor or practitioner to the system via a login page. The system will authenticate and authorize the practitioner depending on his/her credentials. Authenticated and authorized practitioners will be able to see the dashboard showing various information in a statistical format (for example, prescription completed this month, total patient number, new patient this month, treatment completed, total patient in care, etc.). The solution will not only render a seamless UI (User Interface) but also assist with simple navigation using well-known icons and tooltips for better usability. The system will enable the practitioner to check appointments and select the appointed patient. In the case of the old patients, system will prompt the practitioner to request access to the patient's medical information. Upon approval by the patient full or limited part of medical information will be shown to the practitioner. This is because a patient can hide certain information from their medical history which cannot be seen by any practitioner. There will be another option for patients who do not have an account in the EHR system. For them, the practitioner will be able to register the new patient to the application. Here, system will authenticate the new user using an OTP (one-time pin) through SMS. The system will also send a temporary username and password to the new patient's cell number and email address. The new patient will be able to login into the account using the given credential (username & password) and the system will prompt the patient to change their user name (optional) and password (compulsory). The new patient account will be assigned a user id that will be derived from patients NID. Going back to the main use case, when prescribing the patient, the practitioner will be able to record all the vital signs (Heart Rate, Blood glucose, Blood Pressure, etc.) along with patient complaints and record them into the system for future reference. Furthermore, practitioner will be able to select the required tests (Blood, COVID, X-RAY, CT Scan, biopsies, etc.) for the patient. In the future when a patient collects the test report he/she can upload pictures of those reports to the diagnosis section of the electronic prescription. This can be done through the EHR web (patient portal) or mobile application. System will enable practitioner to create a treatment plan by specifying what medicine to take and what things to avoid in the treatment session. Here, medicine library can be used to select commonly known

medicines or the practitioner can add new medicine. In the backend decision support system will also help to avoid both DDI (Drug-Drug-Interaction) as well as professional exception (for example, if a patient is vehicle driver by profession system should flag a medicine which have sleepiness side effect). The practitioner will be able to finish the prescribing session by adding his digital signature (hashing, practitioner's private key) and encrypting the medical information using the patient's public key. Thus, a secure electronic prescription will be generated for the patient to use. At this stage if patient wants, practitioner will be able to print the prescription. Upon completion, the system will notify the user of the related invoice.

4.3 Block Diagram

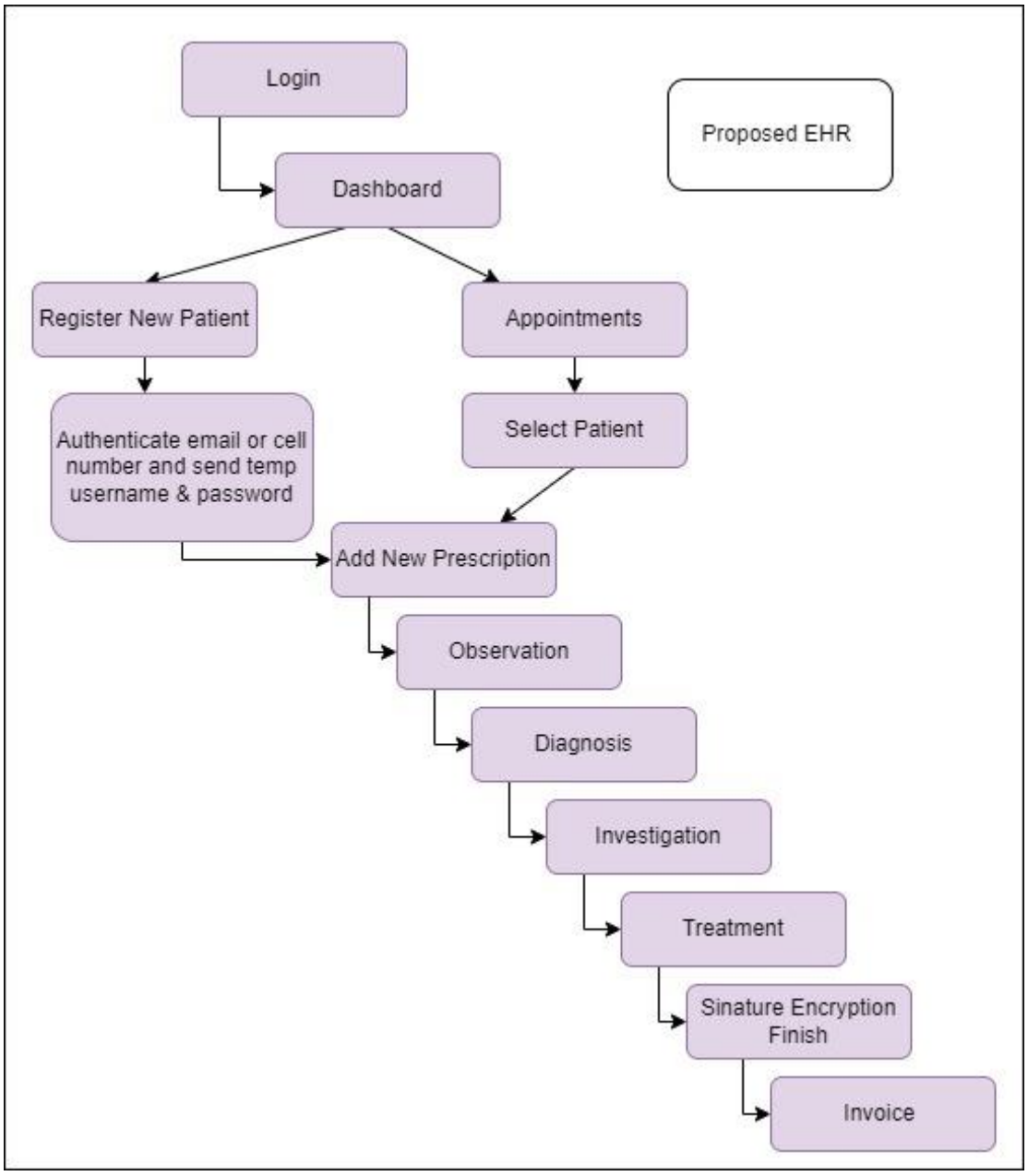

Figure 17. Flow Diagram of Proposed EHR.

4.4 Algorithm Approach

The system's use begins with the authentication procedure and ends with the conclusion of a specific patient's session. As discussed earlier that a patient might not have an account in the system. So, I will be articulating the algorithm as though the patient has no account in the system.

The sequencing steps of the software is written below,

1. Login to the system as practitioner.
2. System authenticates and authorizes the practitioner.
3. Show practitioner dashboard.
4. If patient have an appointment in the application, then Choose the patient and ask for their medical history. And go to step 9. Else, go to next step.
5. Create new patient account.
6. Authenticate the patient cell phone number or email via OTP (One Time PIN).
7. Register user information by assigning a unique ID and sending one-time password via email or SMS.
8. Enter observational data which includes information about patient complains, vital signs etc.
9. Enter the diagnostic details. Indicating whether they are proven or just assumed.
10. If test is needed, then go to the investigation section and order test; else go to the next step.
11. Select medicine for the patient in the treatment section along with dosage and duration information.
12. If the medicine is not available in the API database than enter the medicine name by typing.
13. Flag an alert message, if there is a DDI(drug-drug-interaction) among the selected medicine as well as medicines that are already running.
14. Flag an alert message, if the side effect of a medicine will create an issue for the patient.
15. Give advice on what to do and what not to do during the treatment session and conclude prescription summary.
16. Attach the digital signature of the practitioner to the document.
17. Print or go to the next step.
18. Encrypt the prescription using patients public key.
19. Send payment invoice to the patient account.
20. Logout from the application.

4.5 Implementing Algorithm

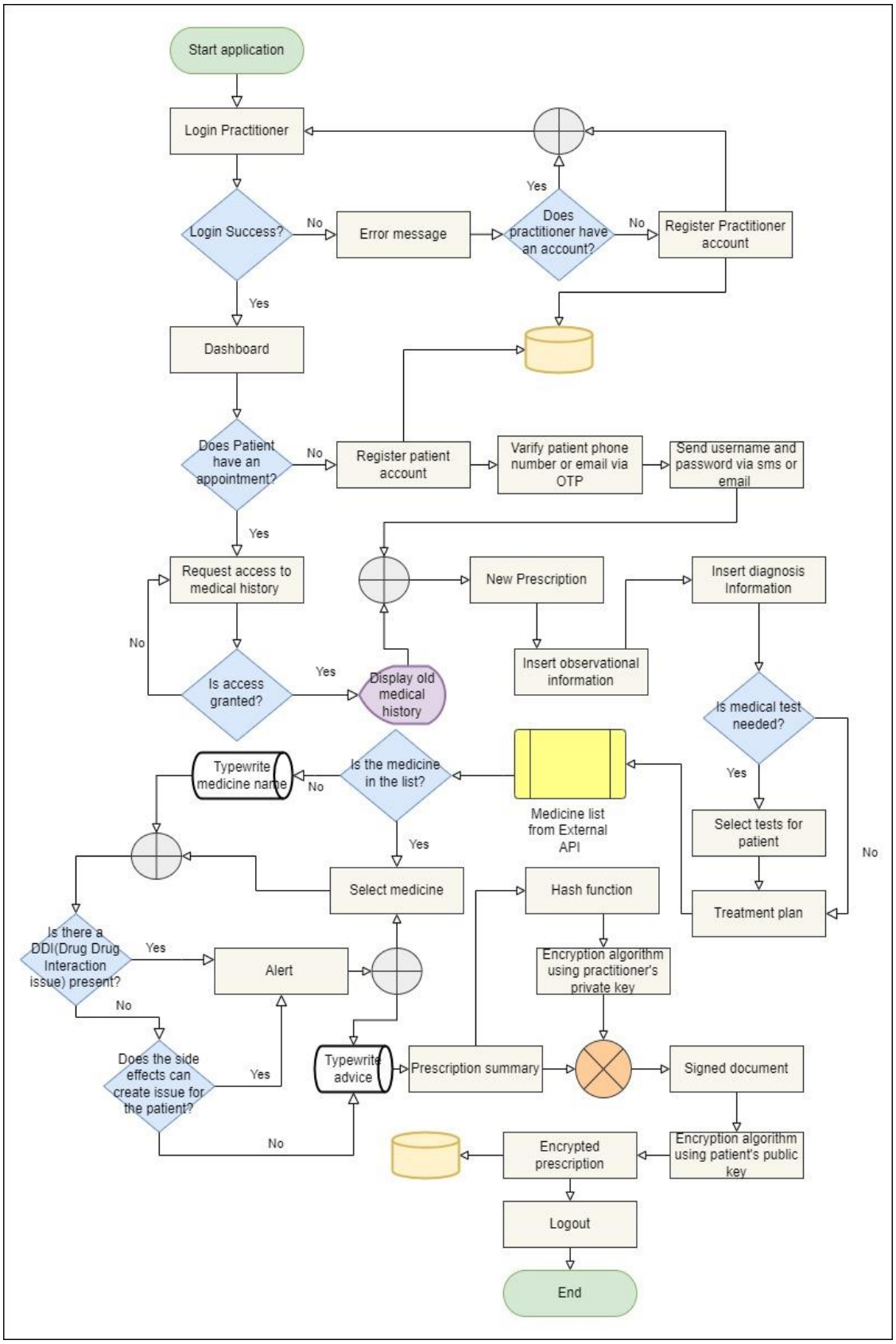

Figure 18. Flow Chart of the Proposed Model

4.6 Summerly

Overall idea of the proposed system was addressed by informing about the software environment, the functionalities, and processes of the proposed system. Thus, articulating the proposed conceptual model of the system.

Chapter 5

Output Analysis

5.1 Introduction

This chapter will portray what society or people in general will be getting from the solution after it is launched in a health institution. This will be done by listing potential consequences and the limitation of the proposed EHR.

5.2 Possible Outcomes

For example, there is a health center which did not had any electronic medical record system. Now the possible outcome the might be seen after the implementation of the proposed system in written below,

1. From the perspective of management, all the things are now clearly visible. In the old way of record keeping there was a matter of hide and seek about treatment related information now there is no room for that.
2. Now, anytime a patient can access their medical information if they only have the NID number or user id or phone number with them. They do not have to consider the problem or possibility of losing important document. They can find copy of everything in the system altogether.
3. Any client that will use this system will get the sense of reliability because the system will give medical history along with related artifacts (test reports) and invoices of their medical events.
4. Now a patient does not have to remember the doctor, the treatment, the duration of the treatment session etc. Their medical history will have all the details in a systematic and sequential order.
5. Doctors can now give more personalized treatment rather than general treatment. Because by the virtue of possessing overall health records, precise treatment can be assured.
6. With the help of the proposed system medical error can be reduced and efficient care can be established. This is due to the fact that, now there will be no mistreatment due to prescription ambiguity. The internal DSS system will assist

in alerting both wrong medication and medicine having DDI (Drug-Drug Interaction) issues. Furthermore, patient having adverse side effect previously can be addressed and treatment using old or incorrect test report can be avoided altogether.

7. Patient does not have to go through unnecessary repetitive tests just because they lost their test report.
8. Now it will be very easily to find any mistreatment happening in the past.
9. By keeping a note, patient will be able to know more about their medical condition themselves. They can discuss those matters in their next visit to a doctor. Thus, promoting more personalized treatment.
10. The proposed system will be able to help population health information system such as DHIS2 as a backend raw data supplier for identifying potential demographic trends in sickness over a specific period of time. Filtering out the propensity of a future epidemic or pandemic.
11. Now, observing patient, analyzing medical history, ordering test, prescribing treatment, ordering medicine and even billing can be done form a single platform. This will alleviate major burdens from patient, practitioner and reducing the bottleneck of the overall medical process.
12. The system can assist researcher by giving access to anonymous demographic patient data trough tag and keywords which were written by patient in the note module. This will act as a perpetual resource material for researchers to come. Thus, opening a new dimension in medical research and development.

5.3 Limitations

After the implementation some uncertain outcome might happen which cannot be predicted. Below written are the limitation of the solution that might transpire after the adoption of the system.

1. Initially the system might not support every functionality. With the passage of time, we will be able to see what more assistance could be required and what the software will be able to provide. Time will also reveal which features will be unnecessary in the future, that we deem necessary currently.

2. In the initial stages after the implementation, lack of work efficiency can be seen. This is due to the change of workflow in the practice. After few days of using the system it will become the new normal.
3. It might require training for practitioner to efficiently use the system. Some practitioner might find the system challenging.
4. Update of international guidelines and security acts such UK's GDPR (General Data Protection Regulation) might require some additional changes to the software in the future[38].
5. Similarly, Future policies supporting ethical code of conduct might require the solution to be readjusted so that it can adapt to change.

5.5 Summary

Possible outcome of the system was portrayed in this section. Thus, giving a better understanding of what people will be getting from the system.

Chapter 6

Comparative Analysis

6.1 Introduction

In order to conduct a comparison study, the features of various systems will be examined in this part. By doing so, it will be clear how the new system will be bridging the gap left by the current one.

6.2 Comparison

Table 2. Feature-wise Comparison Among Different System.

Systems / Features	Bahmni	DHIS2	SJ EMR	Proposed System
Store health information	✓	✓	✓	✓
Access to personal medical information	✓	✕	✓	✓
Appointment Module	✓	✕	✓	✓
E-Prescribing	✓	✕	✓	✓
Payment module	✓	✕	✕	✓
Medical dictionary	✓	✕	✕	✓
WHO health data toolkit	✕	✓	✕	✕
Medicine ordering	✓	✕	✕	✓
Data sharing module	✓	✓	✕	✓
DSS	✕	✕	✕	✓
Personal Health dairy	✕	✕	✕	✓

6.3 Description

In the table, we can see each of the aforementioned applications with their respective functionalities. Starting from storing medical information. This is present in all the applications. However, in the second row of the table, we find that access to personal information is not supported by DHIS2. This is due to the fact that DHIS2 is a public health data management system. It is also the same reason why DHIS2 does not support appointments as well as e-prescribing functionality. Payment module is missing on DHIS2 and SJ EMR system. On the other hand, Bahmni has a built-in accounting and billing module. Similarly, the proposed system will also have a payment module including options for digital payment (Bkash, Nagad etc.) using SSLCOMMERZ payment gateway[39]. From the table, we can also observe that, medical dictionary is not supported by most of the systems. At a cursory glance, it might seem to be unnecessary or nice to have functionality. However, this is a very important functionality, especially for patients. Because patients will benefit from being aware of medical words and acronyms relating to their disease and course of therapy. There will be more openness and less possibility for error or misunderstanding. Ergo, it will be supported by the proposed system. Among the systems health data toolkit of WHO can be found only on DHIS2. The toolkit is used by DHIS2 to enhance data quality and strengthen data utilization on a national and worldwide scale[40]. Medicine ordering functionality is present on Bahmni and it will be available in the proposed system as well. Apart from SJ EMR, other systems including the proposed model will support sharing medical information with other system. In most cases the sharing functionality is incorporated with international standard. Bahmni, for instance, can exchange electronic health records using HL7 (Health Level Seven) interoperability standards and protocols. The proposed system will also incorporate the latest version of HL7 (version 2.9) which is based on RESTful API. The proposed system will have Decision support system alerting for example DDI (Drug Drug Interaction) alert. Appropriate logic and data-set will be implemented for this purpose. This DSS (Decision Support System) functionality is currently not present on any of the mentioned existing systems. Lastly we can also find that, the proposed system will have a noting functionality. Here user can note their experience during the treatment session. Patient will be able to use appropriate tags for referencing their notes. Built-in tags such as side-effect tags can be used as a portal for researcher to uncover new findings.

6.4 Summary

This section compares and contrasts the additional features that the proposed system will have with those that it will lack. Thus, giving a correct image of the system in comparison.

Chapter 7

Conclusion

7.1 Summary

Starting from the top, the rationale of the thesis has been explained by portraying what are the objectives, what are the motivations, and what is to be expected as the outcome of this thesis. A clear understanding of the concept of e-health systems such as EMR and EHR has been thoroughly discussed. In order to help people attaining a clearer perception of the system, illustrations on its functionality, users, and other elements have been conveyed. Possibilities of the EHR is given by showcasing the global market status of the EHR which is expected to grow exceedingly in the upcoming decade. Along with these, findings from the pieces of literature have been addressed to envisage recommended approach of the proposed system. The current systems which are serving in Bangladeshi medical settings has been explored. Illuminating the services, the current systems are providing. Subsequently, the proposed model has been articulated and discussed. The logic, understanding, process, and flow of work have been presented and examined in detail. The outcome of the proposed model is predicted from both a possibility and limitation standpoint. Thus, giving a clear idea about the aftermath of the envisioned system. Comparative study has been carried out to provide a clear image of the functional gap that the existing system exhibits. Thus, identifying the precise region that was missed by the existing alternative systems. Finally, the overall outcome of the thesis is summarized and future work in the study as well as the system is indicated.

7.2 Conclusion

As of 2022, Bangladesh has achieved the digital Bangladesh goal (2016-2021). However, in the medical sector there still remains work to be done. Using paper-based system in medical sector is still common in this country. In some settings only the accounting information is kept on digital format whereas the medical information is still recorded in analogue approach. In other settings parallel system (digital and analogue) is supporting the medical institution. Creating more room for error and confusion. Some medical institution has started using EMR systems. However, EMR

does not have the functionality for interoperability or data sharing facility. Newer evolution of the EMR system is EHR system, which are interoperable between different institution. It gives support to patient oriented care rather than general care. This is why, in most of the developed countries the use of national EHR can be seen commonly. Some developing countries are also started adopting the system.

In this thesis I have articulated a model of EHR system that can be used as the guideline for developing the software in context of Bangladesh. Peer-reviewed literatures were used to pinpoint the issues specific to Bangladesh and to explain the suggested procedure for developing the intended model. The proposed model will support both the record keeping functionality and other associated aspects that goes hand in hand with the medical procedure. Furthermore, it will also lessen issue with the paper-based as well as the existing systems. Resulting in a seamless and transparent process for people on both side of the stethoscope.

In a related matter it should be noted that, in Bangladesh, individual family covers 67% of the Total Health Expenditure via OOP (out-of-pocket) expenses [41]. Furthermore, WHO (World Health Organization), showed that Bangladesh only uses 3% of its annual GDP in medical sector. Moreover, the government's spending on health is only 0.69 percent of GDP[41]. So only individual initiative will not result in a fruitful outcome. Here, the support of government, PPP (Private-Public-Partnership) initiative and international investment is required. If every sector is working together to achieve the goal, only than the result can be attained and sustained.

7.3 Future scope

The proposed model is articulated in this paper. The probable next step will be to develop the software in contrast to the current trend in the technological world. As of now the dynamics have been shifted from digital Bangladesh to Smart Bangladesh. which is why there is a fresh initiative in Bangladesh about AI, BlockChain, 5G internet, etc. So, in the near future, these technical trends should also be included in the system. Written below are the probable future steps for the EHR model.

- The development of the software. Both in web application and mobile application platform (android & iOS). And adjust the system according to latest legal and ethical guideline.
- Research of Blockchain technology in light of EHR system. Implementing digital ledger in payment as well as record keeping functionalities.
- Research on AI for implementing assistive functionalities in the future. AI will help the practitioner with decision making, speak-to-text functionality, voice command, transcribing handwritten message of practitioner to digital written format for better readability etc. to name a few.
- With the blessing of faster internet (5G) the system can incorporate AR (Augmented Reality) and VR (Virtual Reality) support. In remote settings, practitioner will be able to see a hologram of patient or interact with the avatar of the patient to give more precise care in those situation.
- Incorporating the use of Health Card which will store all medical information of the card user. As of now, the Planning Commission of Bangladesh has already received a project on the National Health Card for approval[42]. When the card will be available, users of the proposed EHR will be able to insert their information to the card which they previously stored. This will start a new chapter in the medical sector of Bangladesh.

Reference

[1] J. E. Affeldt, "The new quality assurance standard of the Joint Commission on Accreditation of Hospitals," *West. J. Med.*, vol. 132, no. 2, pp. 166–170, Feb. 1980.

[2] J. R. Wright, "The American College of Surgeons, Minimum Standards for Hospitals, and the Provision of High-Quality Laboratory Services," *Arch. Pathol. Lab. Med.*, vol. 141, no. 5, pp. 704–717, May 2017, doi: 10.5858/arpa.2016-0348-HP.

[3] M. Amatayakul, *Electronic Health Records: A Practical Guide for Professionals and Organizations*. American Health Information Management Association, 2007.

[4] H. Takeda, "What has Changed after Dr. Lawrence Weed's paper in 1968? (Reflections on L.L. Weed´s paper: Medical Records that Guide and Teach)," *Yearb. Med. Inform.*, no. 1, pp. 218–220, 1999.

[5] S. Lohr, "The 'Miracle' of Digital Health Records, 50 Years Ago," *Bits Blog*, 1329509155. https://archive.nytimes.com/bits.blogs.nytimes.com/2012/02/17/the-miracle-of-digital-health-records-50-years-ago/ (accessed Dec. 18, 2022).

[6] S. Jaroudi and J. D. Payne, "Remembering Lawrence Weed: A Pioneer of the SOAP Note," *Acad. Med.*, vol. 94, no. 1, p. 11, Jan. 2019, doi: 10.1097/ACM.0000000000002483.

[7] W. R. Hersh, "The electronic medical record: Promises and problems," *J. Am. Soc. Inf. Sci. Technol.*, vol. 46, no. 10, pp. 772–776, 1995, doi: 10.1002/(SICI)1097-4571(199512)46:10<772::AID-ASI9>3.0.CO;2-0.

[8] Institute of Medicine (US) Committee on Improving the Patient Record, *The Computer-Based Patient Record: Revised Edition: An Essential Technology for Health Care*. Washington (DC): National Academies Press (US), 1997. Accessed: Dec. 18, 2022. [Online]. Available: http://www.ncbi.nlm.nih.gov/books/NBK233047/

[9] Institute of Medicine (US) Committee on Quality of Health Care in America, *To Err is Human: Building a Safer Health System*. Washington (DC): National Academies Press (US), 2000. Accessed: Dec. 18, 2022. [Online]. Available: http://www.ncbi.nlm.nih.gov/books/NBK225182/

[10] M. Gold and C. McLAUGHLIN, "Assessing HITECH Implementation and Lessons: 5 Years Later," *Milbank Q.*, vol. 94, no. 3, pp. 654–687, Sep. 2016, doi: 10.1111/1468-0009.12214.

[11] S. Doyle-Lindrud, "The evolution of the electronic health record," *Clin. J. Oncol. Nurs.*, vol. 19, no. 2, pp. 153–154, Apr. 2015, doi: 10.1188/15.CJON.153-154.

[12] L. D. Serbanati, "Health digital state and Smart EHR systems," *Inform. Med. Unlocked*, vol. 21, p. 100494, 2020, doi: 10.1016/j.imu.2020.100494.

[13] S. K. Mukherjee *et al.*, "EMR adoption in Dhaka, Bangladesh: a template to index pediatric central nervous system tumor care and a review of preliminary neuro-oncologic observations," *Childs Nerv. Syst.*, vol. 38, no. 8, pp. 1497–1504, Aug. 2022, doi: 10.1007/s00381-022-05450-6.

[14] A. Mukherjee, "Implementing Electronic Health Records in India: Status, Issues & Way Forward," *Biomed. J. Sci. Tech. Res.*, vol. 33, no. 2, Jan. 2021, doi: 10.26717/BJSTR.2021.33.005378.

[15] A. Zhu, H. Tadros, J. Lee, and A. Hariharan, “National Electronic Health Records with HealthEPin”.
[16] Practice Fusion, “EHR vs. EMR Definition, Benefits & EHR Usage Trends,” *EHR (electronic health record) vs. EMR (electronic medical record)*, May 21, 2021. https://www.practicefusion.com/blog/ehr-vs-emr/ (accessed Dec. 31, 2022).
[17] T. Schabetsberger *et al.*, “What are Functional Requirements of Future Shared Electronic Health Records?,” *Connect. Med. Inform. Bio-Inform.*, Jan. 2005.
[18] WHO, “Electronic health records,” World Health Organization, 2016. Accessed: Jan. 10, 2023. [Online]. Available: https://www.jstor.org/stable/resrep33201.11
[19] “Electronic Health Records Market Size to Hit USD 30.84 Bn by 2030.” https://www.precedenceresearch.com/electronic-health-records-market (accessed Jan. 10, 2023).
[20] M. N. Sakib, M. Jaladeen, and M. Razi, “Electronic Health Record System (EHR) Adoption: From Bangaladesh Medical Students’ Perspective,” in *2015 4th International Conference on Advanced Computer Science Applications and Technologies (ACSAT)*, Kuala Lumpur, Malaysia, Dec. 2015, pp. 234–238. doi: 10.1109/ACSAT.2015.44.
[21] S. Mortazavi and G. Hajebi, “An Investigation on the Nature and Extent of Occurrence of Errors of Commission in Hospital Prescriptions,” *Iran. J. Pharm. Res.*, vol. Volume 2, no. Number 2, Apr. 2003, doi: 10.22037/ijpr.2010.17.
[22] T. A. Meyer, “Improving the quality of the order-writing process for inpatient orders and outpatient prescriptions,” *Am. J. Health. Syst. Pharm.*, vol. 57, no. suppl_4, pp. S18–S22, Dec. 2000, doi: 10.1093/ajhp/57.suppl_4.S18.
[23] S. Khan, Z. Shahid, K. Hedström, and A. Andersson, “Hopes and Fears in Implementation of Electronic Health Records in Bangladesh,” *Electron. J. Inf. Syst. Dev. Ctries.*, vol. 54, Oct. 2012, doi: 10.1002/j.1681-4835.2012.tb00387.x.
[24] S. Afrin and M. Arifuzzaman, “e-Health in Developing Countries: Bangladeshi Perspective,” *Int. J. Eng. Adv. Technol. IJEAT*, vol. 9, no. 3, pp. 908–914, Feb. 2020, doi: 10.35940/ijeat.A1837.029320.
[25] T. Begum *et al.*, *Using DHIS 2 Software to Collect Health Data in Bangladesh*. Chapel Hill: MEASURE Evaluation, 2019. [Online]. Available: https://www.measureevaluation.org/resources/publications/wp-19-226/at_download/document
[26] MEASURE Evaluation, “Family Planning Data Collaboration Advances DHIS 2 for Improved Program Data — MEASURE Evaluation,” Apr. 09, 2019. Accessed: Dec. 26, 2022. [Online]. Available: https://www.measureevaluation.org/resources/newsroom/news/family-planning-data-collaboration-advances-dhis-2-for-improved-program-data.html
[27] Thoughtworks, “Advancing Universal Health Coverage in Bangladesh,” *Advancing universal health coverage with electronic health records*. https://www.thoughtworks.com/clients/dghs-bangladesh (accessed Dec. 26, 2022).
[28] S. Charles A, “Developing universal electronic medical records,” *Gastroenterol. Hepatol.*, vol. 4, no. 3, pp. 193–195, Mar. 2008.
[29] O. Fennelly *et al.*, “Successfully implementing a national electronic health record: a rapid umbrella review,” *Int. J. Med. Inf.*, vol. 144, p. 104281, Dec. 2020, doi: 10.1016/j.ijmedinf.2020.104281.
[30] T. D. Gunter and N. P. Terry, “The Emergence of National Electronic Health Record Architectures in the United States and Australia: Models, Costs, and

Questions," *J. Med. Internet Res.*, vol. 7, no. 1, p. e3, Mar. 2005, doi: 10.2196/jmir.7.1.e3.
[31] M. M. M. Pai, R. Ganiga, R. M. Pai, and R. K. Sinha, "Standard electronic health record (EHR) framework for Indian healthcare system," *Health Serv. Outcomes Res. Methodol.*, vol. 21, no. 3, pp. 339–362, Sep. 2021, doi: 10.1007/s10742-020-00238-0.
[32] S. Franzén *et al.*, "Evaluation of the use of Swedish integrated electronic health records and register health care data as support clinical trials in severe asthma: the PACEHR study," *Respir. Res.*, vol. 17, no. 1, p. 152, Nov. 2016, doi: 10.1186/s12931-016-0461-1.
[33] N. Menachemi and Collum, "Benefits and drawbacks of electronic health record systems," *Risk Manag. Healthc. Policy*, p. 47, May 2011, doi: 10.2147/RMHP.S12985.
[34] M. N. Islam, Md. M. Karim, T. T. Inan, and A. K. M. N. Islam, "Investigating usability of mobile health applications in Bangladesh," *BMC Med. Inform. Decis. Mak.*, vol. 20, no. 1, p. 19, Dec. 2020, doi: 10.1186/s12911-020-1033-3.
[35] M. J. Sujan, A. Saha, O. Titlestad, D. Banskota, J. Ferdous, and D. Azad, *Assessment and guidelines/plan for DHIS2 interoperability with other systems in Bangladesh*. 2018. doi: 10.13140/RG.2.2.36437.55526.
[36] Bahmni, "Implementations," *Bahmni™*, 2022. https://www.bahmni.org/implementations (accessed Dec. 27, 2022).
[37] S. Manoj *et al.*, "Implementation of District Health Information Software 2 (DHIS2) in Sri Lanka," *Sri Lanka J. Bio-Med. Inform.*, vol. 3, no. 4, p. 109, May 2013, doi: 10.4038/sljbmi.v3i4.5431.
[38] "Art. 33 GDPR – Notification of a personal data breach to the supervisory authority," *General Data Protection Regulation (GDPR)*. https://gdpr-info.eu/art-33-gdpr/ (accessed Jan. 14, 2023).
[39] SSLCOMMERZ, "Payment Gateway," *SSLCOMMERZ*. https://www.sslcommerz.com/ (accessed Jan. 08, 2023).
[40] WHO, "WHO Packages," *DHIS2*. https://dhis2.org/who/ (accessed Jan. 08, 2023).
[41] WHO, "Bangladesh National Health Accounts, an overview on the public and private expenditures in health sector," *Bangladesh National Health Accounts, an overview on the public and private expenditures in health sector*, May 10, 2017. https://www.who.int/bangladesh/news/detail/05-10-2017-bangladesh-national-health-accounts-an-overview-on-the-public-and-private-expenditures-in-health-sector (accessed Dec. 22, 2022).
[42] T. F. Express, "Health cards for all to receive medical service," *The Financial Express*. https://thefinancialexpress.com.bd/views/health-cards-for-all-to-receive-medical-service-1673538410 (accessed Jan. 13, 2023).
[43] M. Aktar and M. S. Rahman, "Implementation of E-learning Technology in the Healthcare Sector of Bangladesh: A Brief Review," *MedEdPublish*, vol. 9, p. 185, Aug. 2020, doi: 10.15694/mep.2020.000185.1.

A Conceptual Model of an Ideal EHR (Electronic Health Recorder) System in the Context of Bangladesh

ORIGINALITY REPORT

4%	3%	0%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Daffodil International University Student Paper	2%
2	Submitted to OTHM Qualifications Student Paper	1%
3	Submitted to University Politehnica of Bucharest Student Paper	<1%
4	www.reportsanddata.com Internet Source	<1%
5	measureevaluation.org Internet Source	<1%
6	www.scielo.br Internet Source	<1%
7	presidencybusinessschool.org Internet Source	<1%
8	www.frontiersin.org Internet Source	<1%
	www.jmir.org	