OULU UNIVERSITY OF
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Keino Eliud

Designing Patient Registry Software for Kenyan Healthcare

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Eliud Keino
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ABSTRACT

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Author(s): Eliud Keino
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Supervisor(s): Alakiuttu Tapani
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This thesis will provide an overview on the current patient registries used in Kenyan healthcare systems where the storage of health records electronically has not been utilized. This paper will try to point out some hypothesis and simple prototype on how to design and implement a patient registry software using Microsoft ASP.NET MVC 3 framework.

The objective of the thesis is to come up with a well-defined way of transforming the current paper based medical records into an electronic medical record that will quicken data collection from multiple centers. Therefore enables clinical officers in tracing their daily activities.

The research methodologies applied are: site observation, data from different source or kinds and interviews with the Kenyan healthcare worker at their work place, visiting health institutions to observe how paper based records were kept. Also own experience as a Kenyan was applied.

The conclusion realized was that most of the Kenyan healthcare systems are not utilizing the use of electronic medical records as expected. Only a few of the private sectors are using software mainly open source software. The result pointed out that the Kenyan Government should incite the healthcare institutions on the significant of software use.

The research was done for a commissioner (Domuset Oy) which is a small scaled healthcare software company. The company is interested in developing healthcare software products in developing country that will be used in monitoring both patients in hospital and at home (home based healthcare).

Keywords: Patient registry, electronic health records, OpenMRS, Kenyan healthcare, IT Infrastructure.

CONTENTS

1 INTRODUCTION

The Patient registry software is software that helps the healthcare professionals in tracking and careering of patients of various diseases. The thesis topic will be focusing on healthcare system, especially the Kenya's healthcare systems. The storage of health records electronically as opposed to the paper-based form is a truly remarkable especially when there is a need of referring to the patient's earlier treatments. Electronic medical record (EMR) will appropriately and systematically update the patient's data.

Kenya, being among the developing countries in Africa, has not fully utilized the use of software in their healthcare field. However, based on this situation, patients moving from government hospitals to private hospitals and vice versa will lead to misplacement of their paper-based health records. Consequently a visit to a different healthcare center will provide different information or a new treatment process resulting to system inefficiency and ineffectiveness.

The government and private healthcare systems sharing patient data will ease the treatment of the patient diseases and help in tracing the trend of their treatment i.e. what kind of treatment and drugs have already been administered and what will be the next treatment plans. This will save cost and well-timed treatment hence avoiding chronic diseases caused by treatment delays.

An automated checking for drugs and allergies interactions with the patients' health will also be recorded as there has been a case where by a patient was administered with drugs that have led to worse health conditions. This happens in a situation where the patient's previous treatment is not taken into consideration as there were no patient history to refer.

The practice of sharing the patient's data will be achieved by developing a common database running in dedicated and trusted server n-tier architecture (multitier architecture) or using ASP.NET MVC 3 and implementing concurrency handling to ensure reliable data security and correctness which will in turn be shared among the healthcare organizations or departments. This common data source will enable the consistency of patient information and thus easing the physician work in managing their patient data and security.

Activities such as diagnosis, prescriptions, laboratory data and clinical notes will be manageable since all the patients' data are stored electronically which are in a retrievable and updatable con-

dition thus facilitating system efficiency. This procedure will ensure treatment and patient care in a given timeframe and therefore a satisfactory and quality achievement.

Kenya enjoys a tropical climate with different seasons each season carrying various diseases patterns. However, most of the Kenya's medical centers do not have patient scheduling instead the rule first come first serve is still under practice except in an emergency or accident situations. This tendency of random visits to the health centers leads to insufficient or lack of treatment at all due to the fact that there is an inverse proportion of physicians to patients. Moreover, this situation will trigger rushing in order to attend or get the work done within the shortest time possible, while lack of treatment is due to the issue that the physicians fails to attend all patients presents at that moment.

Accurate claim processing by health assurance companies is always a problem since they do not have clear explanations or any recorded testimonial data for their client(s), which leads to unsuccessful compensation. The cover handling of a specific client could be easy as the concerned parties will be able to get all the essential information for this process thus avoiding the rise of whatever mistrust.

2 BACKGROUND INFORMATION

Kenya is a country located in the East Africa with a population of 40 million people. The country's population growth rate is 3% per annum. This is according to the National Coordinating Agency for Population and Development (NCAPD) with support from Population Reference Bureau (PRB). However, major achievements in health sector, the population are still facing many challenges with the recent life expectancy estimated to be 51 years for women and 50 years for men. Many women and children still die at birth or within the first 5 years of their life this is according to the World Health Organization (WHO). (Population and housing census 2008/09)

Tropical diseases especially malaria and also human immunodeficiency disease (HIV) has constantly been the major public health problem in the country. Due to its lager population and healthcare issues, Kenya has to transition approach of managing patients from the commonly used paper-based method and utilize the available technology in storing the patient data electronically which is simpler and flexible. This approach will enable the medical practitioners to share the already recorded data from one department to another within the multilevel sector.

The current situation in handling the patient records varies depending on the level of the healthcare institution, for example most of the larger private institutions have adopted the use of electronic medical records (EMR) but others have not attained even single computer within their organization. Those without the computers are using a pen and some special books to record their patients' data which is rather simple and cheaper for the institution. (Some photos showing how the abovementioned book registers and their storage are shown in the appendix 2.

A specific patient will be identified by his or her Kenya national identity card number which is legally attained at the age of 18 years, or otherwise in case of a missing or not having an identity card at all, the patient will use the identity of a close relative(s) for example parents, children or couples.

Most of the systems have no patient scheduling system where patients can reserve time in prior to visiting a physician or a laboratory test. In this case the patients will just visit the healthcare institution by trial and error he or she will have a higher chances of returning home unattended due to unexpected crowd of patients at the health center. If this kind of hospitals could implement

this e-recoding system, then the healthcare time management will be efficient leading to a quality healthcare.

As far as business is a concern, billing is an essential and unavoidable part of every organization, the hospital accountancy is a fundamental part that will maintain its financial stability. The aim is to have an embedded accounting module in the functional patient registry software to enable tracking institutional monetary issues. This software will also ease generating bills to patient on time hence avoiding payment delays and negligence that can cost a given organization.

Further, other tools i.e. hospital inventory management can be included as part of the software as it will enable organizations stock tracking via barcode that contains a complete description of a specific stock by category. Upon any drop in inventory the management will automatically be informed of this situation hence avoiding stock shortage especially in pharmacies. This has been a major problem in most of the Kenya's healthcare providers, pharmacies and laboratories.

The aforementioned will apparently provide useful information to financing systems which include: The Kenya Ministry of Health, The World Bank and non-governmental organizations e.g. United Nations Children's Fund (UNICEF) and United States Agency for International Development (USAID) who believes in their quote "A working health system improves health since it delivers a right volume and distribution of services using good provider-client interactions". Hence, based on analyzable information using patient registry software, it will be vital to the government especially when carrying on with their healthcare budget.

3 THEORETICAL STUDY

As Information communication and technologies (ICT) is a concern, many national governments are allocating funds on electronic medical records (EMR) software systems as a method of reducing cost and increasing efficiency and effectiveness on regional entities and healthcare providers. Electronic medical record (EMR) is a computerized system that facilitate physicians and medical professional with a real-time management of patient files, in this case data within a given organization. As quality assurance and safety of humankind is important, some standards have been involved to have supervision on every development process of this software category.

3.1 Medical software

According to the World Health Organization (WHO) the authors argue: “The availability at the time of consultation of high-quality medical records is essential to continuity of care”.

Medical software is a branch of software engineering that provides the applications used in many healthcare organizations. The devices used in monitoring and controlling patients with various diseases many contain these software category. This software is frequently monitored and must comply with the local and regional laws. In European Union Medical Device Directives (MDD), and in the United States, The Food and Drug Administration (FDA) have been involved in reviewing the development of medical device software from mid-1980s, where cording errors in radiation therapy device resulted in overdose of patients. The above mentioned bodies MDD and FDA are focusing on a regulatory oversight on medical devices software development processes and systems-level testing. The International Electrotechnical Commission (IEC) is now the benchmark standard for the development of medical software. (Council Directives 93/42/EEC of 14 June 1993)

3.2 Computer-base system

A system is a collection of different elements that together produce a result not obtained by elements alone. These elements include: people, software, hardware and documentation; requirements used to produce system-level standards i.e. functions and performance these elements are

organized to accomplished some predefined goals by processing information. The aforementioned elements are then simply defined as:

- Software: A computer program, data structure and a related work product that serves to affect the logical method, procedure or control that is required
- Hardware: Is any device that provides computing capability i.e. Telecommunication devices
- People: These are users and operators of hardware and software
- Database: This refers to organized and constant information that is accessed via software
- Documentation: Information that describes the use of the system this can be paper based or other kind of material
- Procedure: This includes all the steps followed when defining the specific use of each element

The combination of these elements in some way will transform information e.g. information systems creation to assist healthcare departments. (Pressman, Roger S. 2001, 155-156)

3.3 System engineering hierarchy

System engineering process begins with a "world view" which represents the entire organization which is examined to ensure a proper establishment of technology; World view is refined to focus on a specific domain of interest. The need for targeted system element is analyzed and finally its analysis, design and construction are initialized. At the top of the hierarchy a broad context is established and at the bottom detailed technical activities are performed by the relevant engineering disciplines for example software engineering is conducted.

The World View (WV) consists of set of domains (D_1) that is a system or system of systems in its own right.

WV= {$D_1, D_2, D_3 \ldots D_n$}

Each domain consist of specific elements (E_j) serving a role in accomplishing the objective I of a domain component.

D_1= {$E_1, E_2, E_3 \ldots E_m$}

Finally elements by specific technical components (C_k)

$E_j = \{C_1, C2_2, C_3 \ldots C_k\}$

In some context a component represent a computer program, a reusable program, a module, a class or an object.

3.4 Requirement engineering

Requirement engineering provides a framework for understanding the purpose of system and its intended usability and needs. The aim of product engineering e.g. business process engineering is to translate user's desire for a set of defined capabilities into a working. The distinct components e.g. software, hardware, data and people, a support infrastructure is established and includes the technology required to tie the components together and the information i.e. documentation that is used in support of the components. The world view is achieved through requirements engineering elicited from the customer. The requirements consist of information and control needs, product function and behavior, product performance, design and interfacing construct and other needs.

After the requirements are known, the allocation to functions and behavior of each component is done and the system components engineering is commenced, these are system engineering, human engineering, and database engineering. The role of requirements engineering is to establish the interfacing mechanism.

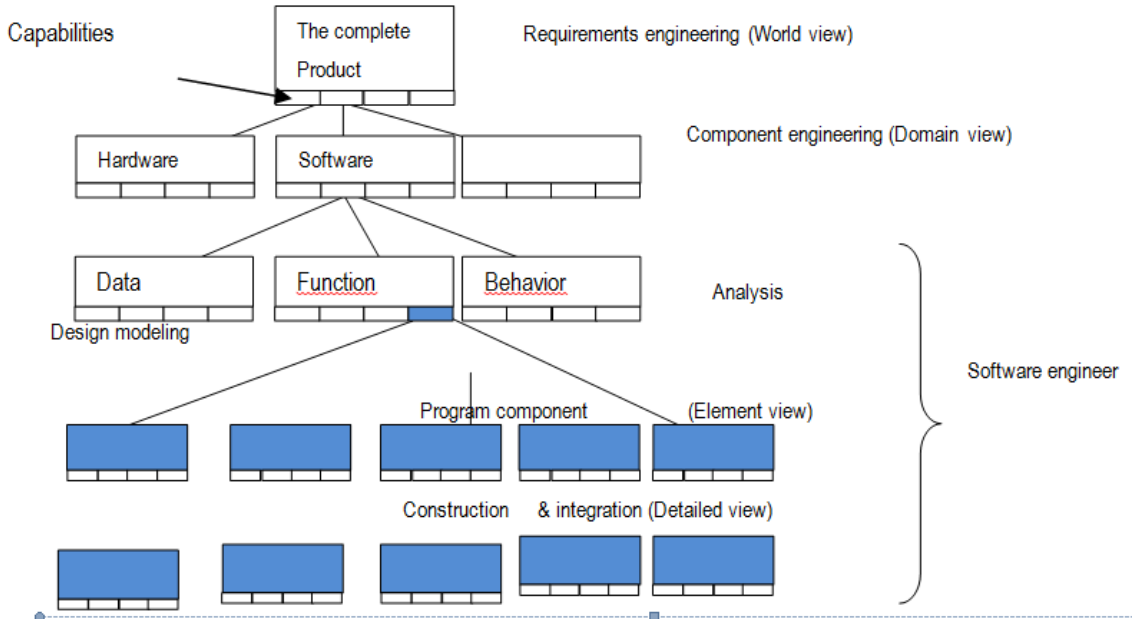

Figure 1 Showing the product engineering hierarchy (Pressman, Roger S. 2001, 163)

4 RESEARCH PROCESS

The empirical study conducted was site visiting to observe the operations and to interview the Kenya's healthcare professionals within the organization. The visits were carried out according to the selected healthcare providers and these were categorized into: National hospitals, provincial hospitals, district hospitals, health centers and private hospitals or nursing homes.

4.1 Research objectives

The objective of this research is to develop a scaled down patient registry software (prototype) using Microsoft technologies ASP.NET MVC3 Framework. This framework is designed to fulfill the listed objectives below:

- A consistent object-oriented programming environment whether object code is stored and executed locally, executed locally but Internet-distributed or executed remotely
- Code-execution environment that minimizes software deployment and versioning conflicts
- Eliminates performance problems of scripted or interpreted environments
- Consistent developer experience across widely varying types of applications e.g. Windows-based applications and web-based applications

The application will be developed based on the overview of the Kenya's healthcare systems i.e. analyzing the current Information Technology infrastructure in the country. The idea is based on the author's interest in the field of software engineering, as well as the commissioner (Domuset Oy) which is a healthcare software company that is motivated in designing electronic medical software in developing countries where Kenya is among. The site visiting and interviews carried out were made to find out the following:

- To understand the Kenyan situation especially in handling the patient's data and its security
- To analyze the methods used by the healthcare providers in performing operations e.g. collecting, storing and retrieval
- To transfer the awareness and use of electronic medical records (EMR) in simplifying healthcare activities e.g. patients tracking
- To find out what is the opinion of utilizing and integrating healthcare technologies within the entire existing healthcare systems

4.2 Research methods

As mentioned earlier, selected health centers were visited with a number of pre-set questionnaire and in accordance with the permission by the visited healthcare providers, as healthcare in Kenya is divided into National, provincial, district, sub-districts and privates and nursing homes. This means that all the hospitals in each category could not be visited individually, instead a representative of in each category was chosen. In this case, five individual health centers were visited in practice.

The requests for carrying out these interviews were arranged by phone where a specific date, time and venue were given according to the institutional schedule. The questions were asked to the interviewee who was in this case either a records administrator, a doctor who is the user of the system, a nurse or the information technology support of that institution.

The findings or answers to the questionnaire were noted down for analysis purposes. This practice was repeated for each and every hospital that was visited. The purpose was to get a clear understanding of how activities were running within these different levels of healthcare operators and more on the kind of their computerization if any, and if they had none, then what was their opinion on electronic medical recording systems.

5 RESULTS

5.1 Electronic medical records (EMR)

Electronic medical records software is a systematic collection of health information of individual patients or population. It is theoretically capable of being shared across different healthcare settings e.g. by way of network connection. Electronic medical records software consists of a range of data including demographic, medical history, medication and allergies immunization status, laboratory test results, radiology images, vital signs, personal status e.g. age and weight, and billing information.

5.2 Electronic medical records (EMR) Categories

- Monitoring: This software is used in interpreting the sensor information in monitoring hearth rate, blood pleasure and breathing rate as it displays it in a mining full way
- Medication pumps: It is useful in controlling many aspects of treatment procedure
- Analysis: It helps practitioners and clinicians in making decisions for diagnostic and therapeutic purposes
- Experts
- Therapy delivery: This is used in implantable pacemakers and defibrillators provide fault-tolerance, real-time, mission-critical monitoring of cardiac rhythms and associated monitoring delivery
- Medical information: This is a type of software used for information aspects of medicine, this includes (EMR) practice management

5.3 Government point of view on electronic records

The Kenyan governments have proposed a five year plan that will aim at improving the health infrastructure, the issue now in practice.

Laws

According to the current Kenyan constitution on healthcare it says “Every person has the right to the highest attainable standard of health, which includes the right to healthcare services “. The government of Kenya has tried to build health systems that can effectively and efficiently deliver quality services. Moreover, they make sure that all the healthcare providers currently using electronic medical records are following the policies and International standards

Budget

The Kenyan government is responsible for meeting the largest percentage of the budget or maintenance and the running cost in the government healthcare centers. The Ministry of Health has planned to incite the Kenyan citizens to actively participate in contributing to the National Social Health Fund (NSHF) which will aid the government in maintaining these sectors too. Furthermore, none governmental organization can be involved in the budget i.e. World Bank etc.

Future needs

The Kenyan government needs to involve and invest more in developing and implementing electronic medical records as this will ease the daily activities of healthcare providing organizations in handling patient’s data in several ways such as:

- Improved patient care and service quality
- Promote sustainability with value added services - by offering region wide client registry that manages multiple entities e.g. person, organization
- Integrations with new and existing systems to enable real time information sharing
- Achieves operational efficiencies and reduce costs

5.4 Medical records information in Kenya

As mentioned before, Kenya has not utilized the use of electronic medical records system. Some few healthcare providers, especially in the private category, have adopted this technology in practice. However, adoption of this software and its usefulness has not been fully utilized. Some of the reasons include; firstly the lack of computer or software skills among the healthcare practitioners, secondly negligence, and thirdly is the consideration that typing is a waste of time.

Most of the healthcare organizations are still using some special booklets in storing their patient's data. This works in a way that patient enters the registration room and gives his/her general data to the registrar of patients of a given hospital. The book's identification number (ID) combined with the patient's full name or a national ID will be used in tracking the patient. The data will be copied to the hospitals master books and finally the book will be given to the patient, or in some cases this book will reside at the hospitals' records store, where it will be managed by the records officers.

Table 1 Some of the data to be stored and their short descriptions

Data	**Descriptions**
Demographic	population or total number of registered patients
Medical history: patient's history	patient's history
Medication	current and previous visits
Allergies	Patients allergies
Immunization status	Immunization type date and time
Laboratory test	Lab results
Radiology images	x-rays etc
Vital observations	inspection
Personal data	general information
Scheduling	visiting hours
Discharge summary	clinical notes
Billing information	hospital fee

5.5 Common diagnosis

Kenya is located along both the equator and tropics and therefore is prone to several types of tropical diseases. Below is a table of diagnosis, causative agents, causative organisms and types of organisms which are common in the Kenyan healthcare systems.

Table 2 Showing common diagnosis, causative agent, causative organism, and type of organism

Diagnosis	**Causative agent**	**Causative organism**	**Type of organism**
Malaria	Anopheles mosquito	Plasmodium	Protozoa parasite
Tuberculosis	Communicable	Tubercle bacillus	Bacteria
Schistosomiasis	Snails	Flatworm	Parasitic
Onchocerciasis	Blackflies	Onchocerca volvulus	Parasitic
Leishmaniasis	Phlebotomine sandflies	Leishmania	Protozoa
Elephantiasis		Wuchereria bancrofti	Parasitic
Trypanosomiasis	Tsetse fly (glossina genus)	Trypanosome-brucei gambiense	Protozoa
Dengue	Aedes mosquito		Viral

Table 3 Essential data elements HIV care. (Standards and guideline for electronic medical records in Kenyan and health information policy and strategic plan 2009-2014)

Demographic Information

- Unique ID number, patient clinic ID number
- Name, sex, date of birth, age at registration, marital status
- Address, telephone, contact information

HIV Care and Family Status

a) Date and location confirmed HIV-positive, HIV subtype
b) Entry point into HIV care
c) Current health facility, district, district clinician/team
d) Treatment supporter(s) name/address/contact information
e) If family members/partners: name, HIV status, HIV care status, unique ID number, date of birth/age at
registration
f) Drug allergies

ART Summary

- ART history prior to entry
- ART START date/treatment cohort:
- Date medically eligible to start ART
  - Why medically eligible; baseline CD4, clinical stage
  - Date medically eligible AND ready to start ART
  - Date medically eligible, ready AND selected to start ART
  - Functional status, clinical stage and weight at ART start
  - First-line regimen
    - Original first-line regimen (list drugs)
    - If SUBSTITUTE within first-line regimen: dates, reasons, new regimens
  - If SWITCH to or SUBSTITUTE within second-line regimen or higher: dates, reasons, new regimens
  - ART interruptions: dates, reasons
    - STOP ART: dates, reasons
    - LOST (temporarily): dates
    - RESTART: dates
  - Transfer In, Transfer Out: date, facility transferred from or to
  - DROP: dates
  - DEAD: date

Encounter Information

1. Encounter date, whether scheduled or not, next scheduled follow-up visit date
2. Months on current regimen
3. Current functional status, clinical stage, weight, height (for children)
4. TB status, TB treatment start/stop dates
5. Pregnancy status, estimated date of delivery (EDD), family planning method(s), prevention of mother-tochild transmission of HIV (PMTCT) referral/provision
6. Possible side-effects (including drug allergies), severity
7. New symptoms/diagnoses/OIs
8. Laboratory test dates and results

9. Prophylaxis: medication, dose dispensed, start/stop dates, reason for discontinuation
10. ART dispensed: regimen code, dose dispensed, (start/stop dates)
11. Adherence assessment (pill count, self-report, other) and reasons for both ART and prophylaxis no adherence
12. Referral or link to other clinical or supportive care
13. Hospital days since last outpatient visit

5.6 Classification of the Kenyan healthcare providers

Healthcare providers include organizations and actors that deliver healthcare services as their main activity. These organizations vary in their legal, accounting, organizational and operational structures.

The objective of the classification of health providers and actors is to ensure that all the providers are structured by their main characteristics which will ease the healthcare financing. Moreover, they are classified in a way that will help both data compilers and data users in matching organizations.

Classification includes:

- National Hospitals: These are the national referral hospital offering the best care. They provide diagnostic, therapeutic and rehabilitative services
- Provincial Hospitals: These are located in each of eight provinces in Kenya and they operate as the referral point for the district hospitals. They are specialized in intensive care and provide consultations and support
- District Hospitals: These are located in each of the districts in the country. These hospitals coordinate with provincial hospitals in providing referral to sub-districts hospitals
- Health centers / Dispensaries: These are small units which provide caesarian section and other procedures
- Private Hospitals / Nursing Homes: These hospitals are owned privately or by churches and they provide services just like either of the categories in the government hospital, they depend on their sizes and location.

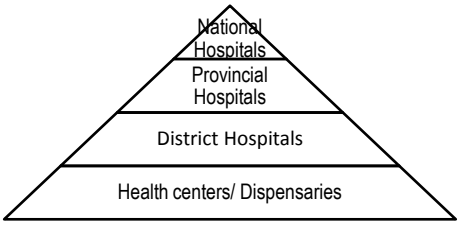

Figure 2. The hierarchy showing the above sectors

5.7 IT infrastructure

Information communication and technology (ICT) in Kenya is evolving rapidly as it has got a number of infrastructure companies e.g. Communication Commission of Kenya (CCK) which is a licensing company, Kenya Data Networks (KDN) which is Kenya's largest data carrier, Safaricom Ltd. which is the largest mobile network provider in the country. Safaricom Ltd. provides services including:

Cloud computing

Providing online-based computing that enables sharing of common resources such as information and other device on demand.

Data centre services this includes:

Email centric services, back-up-as services, monitoring, server co-location, dedicated server services and data storage and replication e.g.

- Hosting services
- Hosted Microsoft exchange
- Mobile email solution
- Hosted share point services
- Windows share point services (WSS)

The above listed services offer effectiveness and efficiency as it supports interactive and collaborative working within an organization.

Types of computers needed or used

Computers used in healthcare organization are mainly workstations as they require moderate amount of computing power. These computers are chosen owing to their relatively high-resolution graphic capabilities, large amount of memories (RAM), mass storage devices e.g. disc drives, build in network support, and graphical user interface. These computers are running on Windows operating system and they are always linked together forming a local-area network (LAN). In networking, workstation refers to any computer connected to a local-area network.

5.8 Networking

Computer networks

Kenya Data Networks (KDN), Telecom Kenya, Jamii Telcom(JTL) and Safaricom Kenya are among the leading providers of networking in the country. Jamii Telcom, being the largest share investor in fiber optic cable network, provides broadband Internet services across the Kenyan cities. Services provided that can be exploited by the healthcare organizations include:

- Wide area network (WAN)
- Wireless local area network (WLAN)
- Local area network (LAN)
- Metropolitan area network (MAN)
- Personal area network (PAN)
- Campus area network (CAN)

Mobile networks

These services are provided by Safaricom Kenya which is fully controlled by Kenya Post and Telecommunication Corporation (KPTC). Safaricom Kenya among others services provides the country with mobile networks. This enhances efficient and effective intercommunication of their users.

Technical skills of the system users needed in Kenya:

- Medical Information management
- These skills will ensure the proper capture of data that will be meaningful in future
- System administrator In order to install, maintain the servers, networking, data backups and ICT infrastructure.
- Software development skills for further customization to meet specific or organizational needs

5.9 OpenMRS

OpenMRS is a collaborative open source project to develop software to support the delivery of healthcare in developing countries. The software became more famous due to the need of scaling up the treatment of HIV in Africa. In 2004, Paul Biondich and Burke Mamlin form the Regenstrief Indiana came up with the prototype idea of software during the AMPATH project in Eldoret Kenya. The OpenMRS was founded on the principle of openness and sharing of ideas, software and

strategies for development and use. The objective was to develop a platform that can be adopted and modified by many organizations without the need of developing it from the scratch. (AMPATH and PIH-EMR)

OpenMRS design

The development is based on a concept dictionary that describes all the data items that can be stored in the system this including clinical findings and laboratory test results. OpenMRS is a web-based and cross platform software.

Features

- Built on the MySQL database
- Programmed in Java
- Built-in tools for data export and reporting
- Supports open standards for medical data exchange including HL7

Deployments

The first deployment was in Eldoret healthcare and AMPATH centers (academic model providing access to healthcare) which is under national category. Kenya started using it in 2006, followed shortly by Rwanda and South Africa. The system is now being used in at least 23 developing countries in Africa as of March 2010 where it has been said to have records from over 1 million patients around the world.

Support

OpenMRS is supported by the core team from Partners in health, Regenstrief Institute, the South African Medical research council and others.

Figure 3. OpenMRS clinical and research locations as of 2011. (OpenMrs guide)

This figure shows the popularity of OpenMRS globally. It portrays that most of the healthcare providers has already utilized its functionality especially in Africa.

OpenMrs User Interface screen shorts taken from MTRH Eldoret Kenya

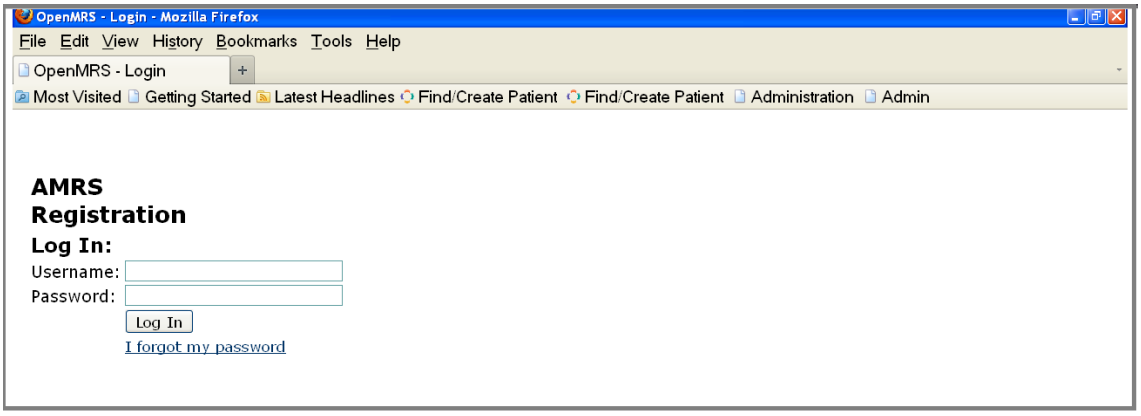

Figure 4. OpenMRS login screen where the users can either login of retrieve their passwords.

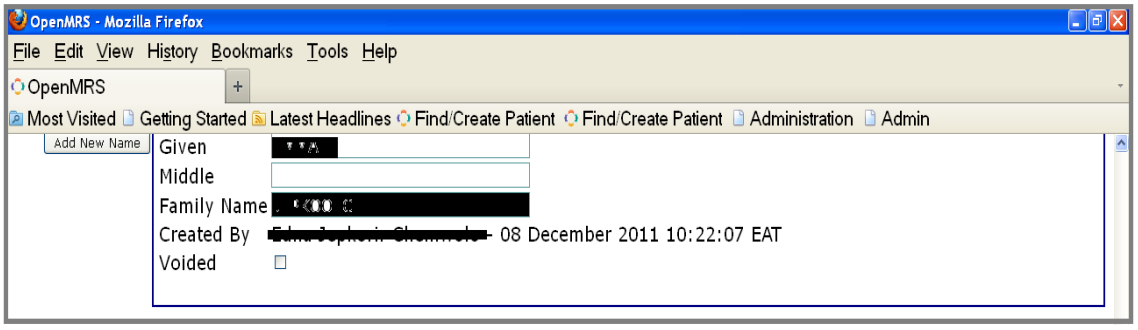

Figure 5. OpenMrs window showing how to add a new patient creation

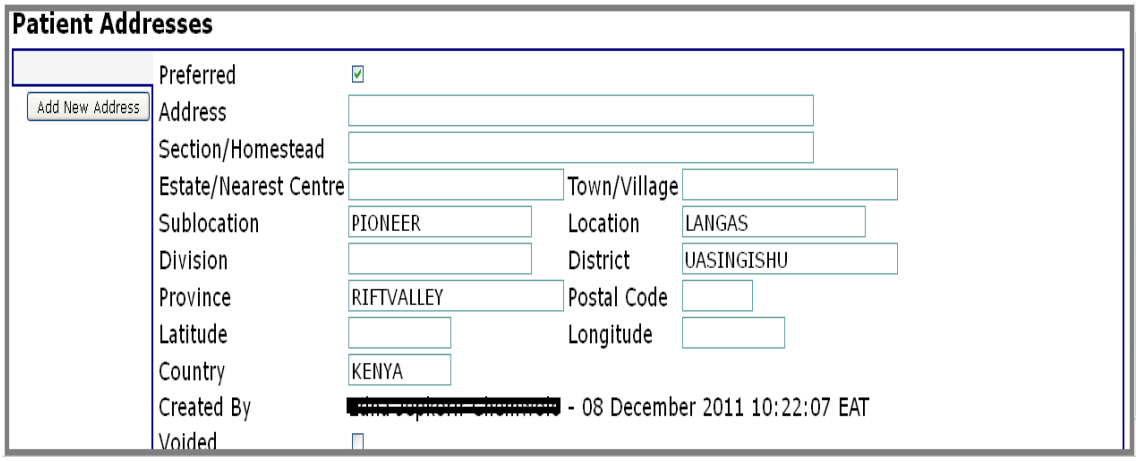

Figure 6. OpenMrs window showing patient data to be entered

Additional OpenMrs user Interface screen shorts taken from OpenMrs online guide

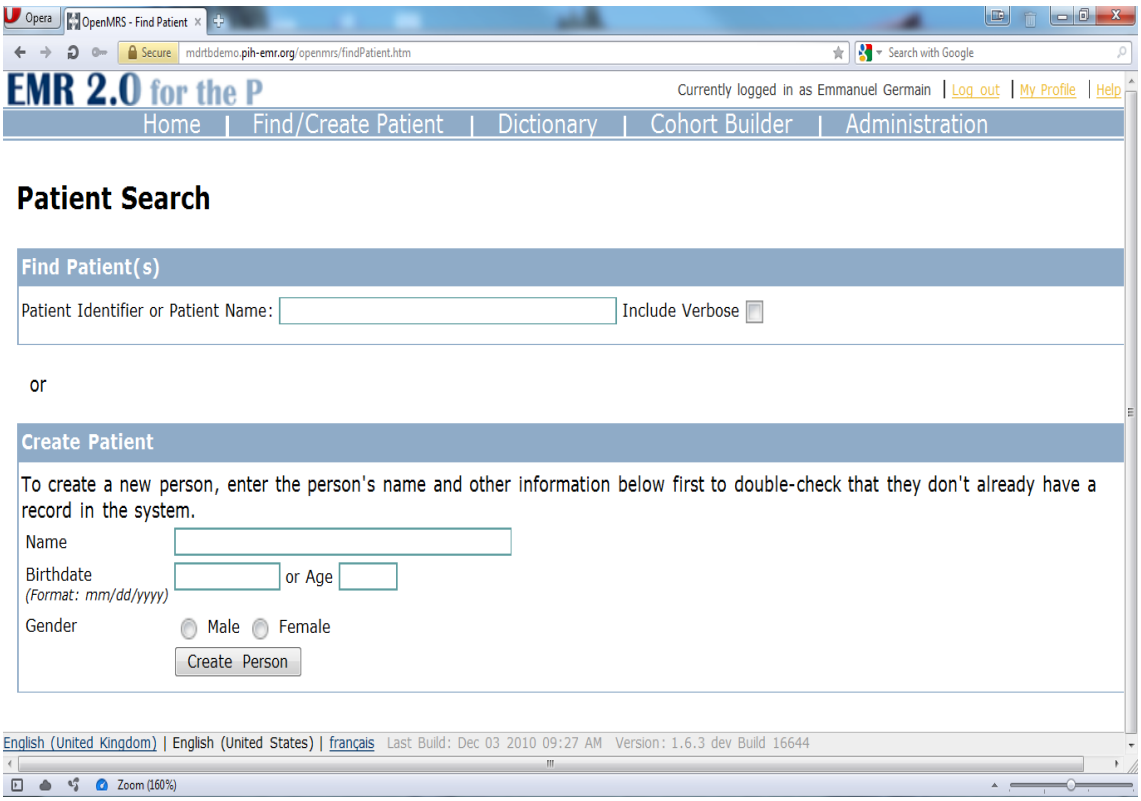

Figure 7. OpenMrs Tasks Window

This window has a menu that enables the users to manage tasks such as:

1. Finding or creating patients
2. Browse dictionaries
3. Cohort builder
4. Administration

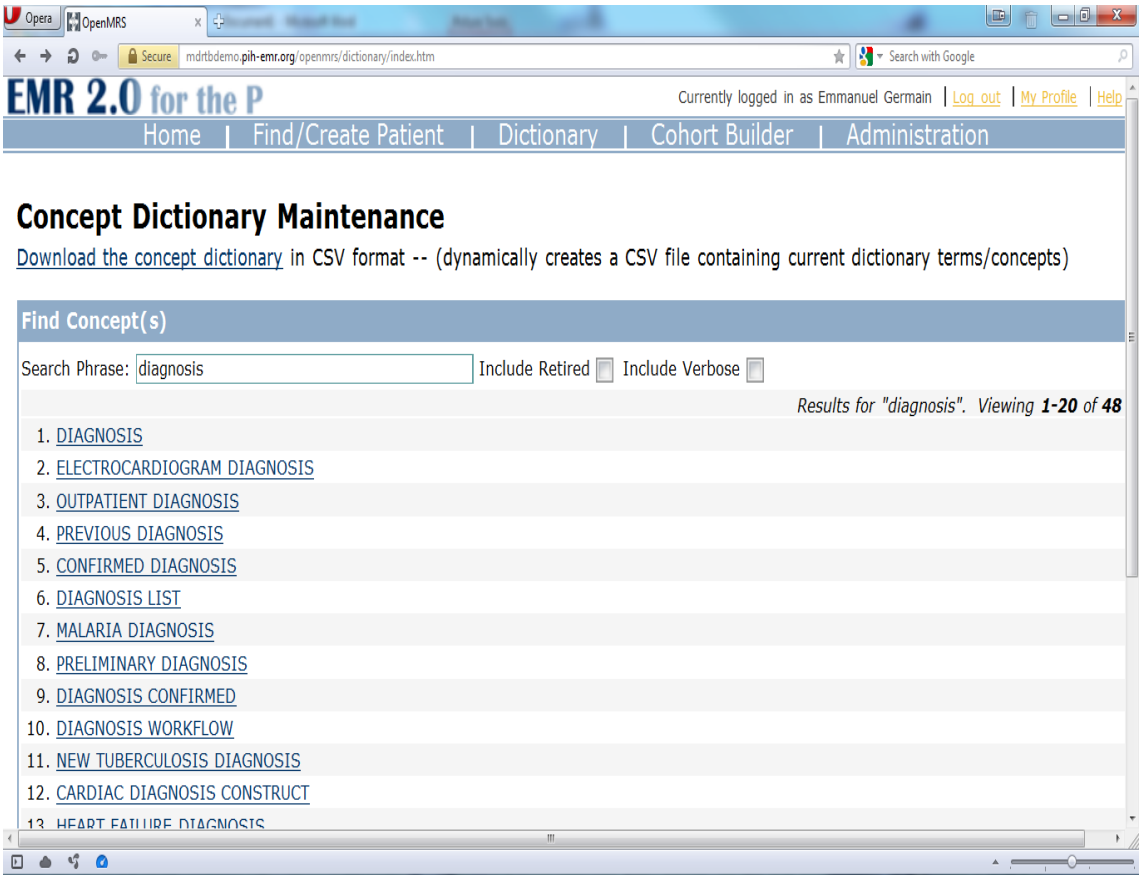

Figure 8.Dictionaries window showing list of terms by search term Diagnosis

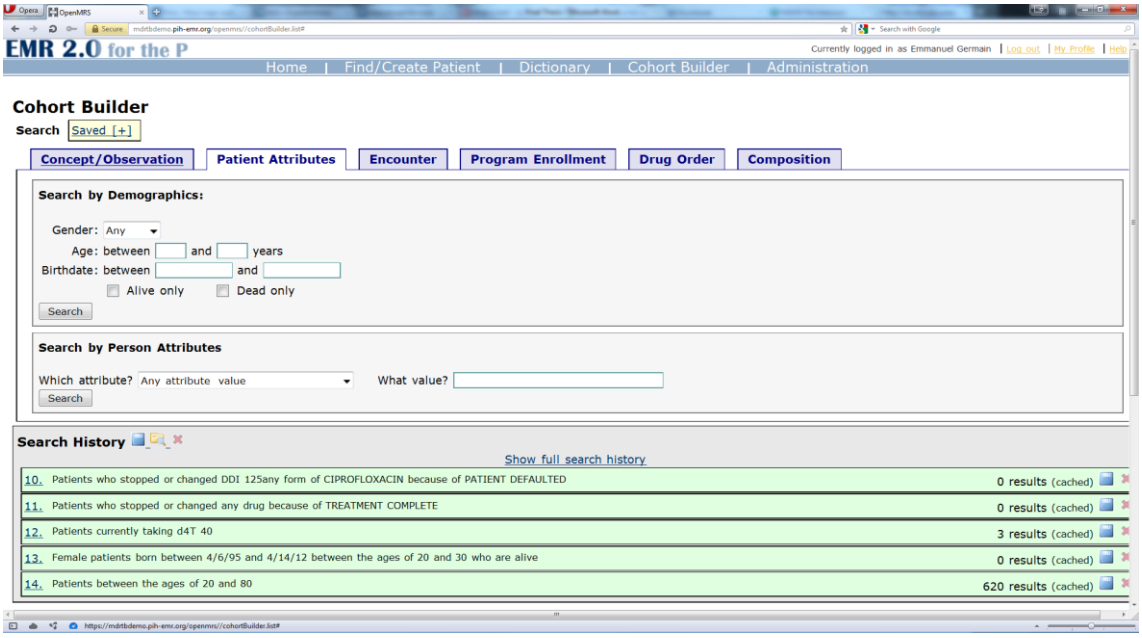

Figure 9. Cohort builder consists of other menu: observation, patient attributes encounters, program enrolment, and drug order composition.

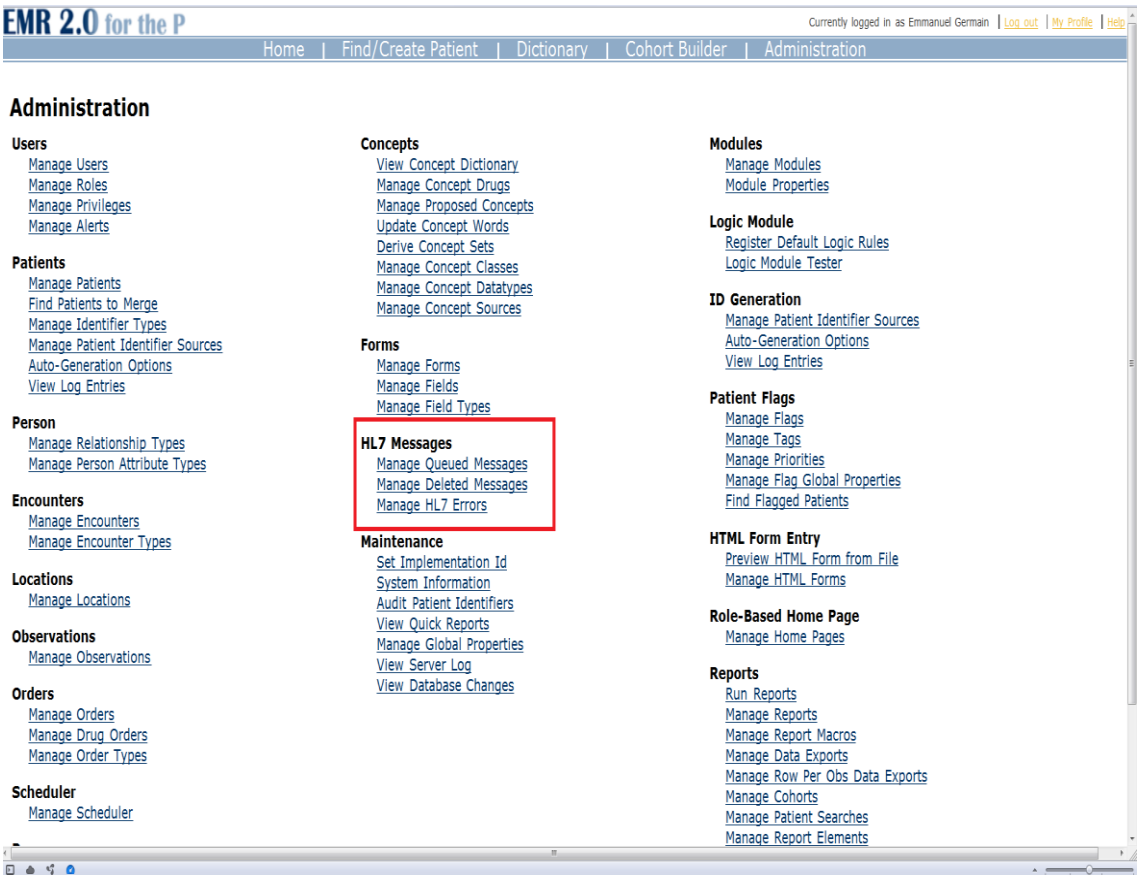

Figure 10. Administration window showing that the software supports Healthcare Level 7 (HL7)

6 PROTOTYPE OF THE KENYA MEDICAL RECORDS SOFTWARE (KMR)

This chapter will give a simple design and some functional requirements to be used in demonstrating a prototype of Kenya Medical Records (KMR). Asp.NET MVC 3 will be used as discussed before. The Model View Controller (MVC) architectural pattern separates an application into the following three main components:

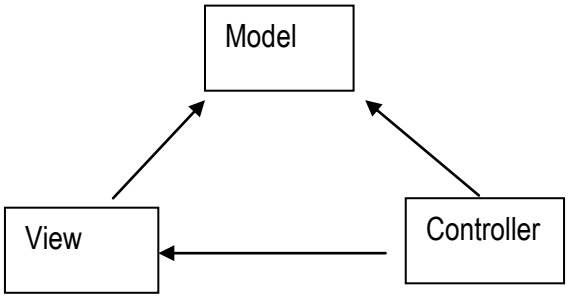

Figure 11.showing MVC design pattern

- Models: They are the parts of the application that implement the logic for the applications data domain; they often store and retrieve model state in a database.
- Views: They are the component that displays the application's user interface and are created from the model data. The view only displays information.
- Controllers: Controllers are the components that handle user interactions, they work with the model and select a view to render that displays UI. Controllers handle query-string values and pass these values into the model, which then uses these values to query the database.(Microsoft ASP.NET)

6.1 Designing

Below is a visual design based on the common activities done by healthcare providers as it was observed during site visiting and interviews in Kenya.

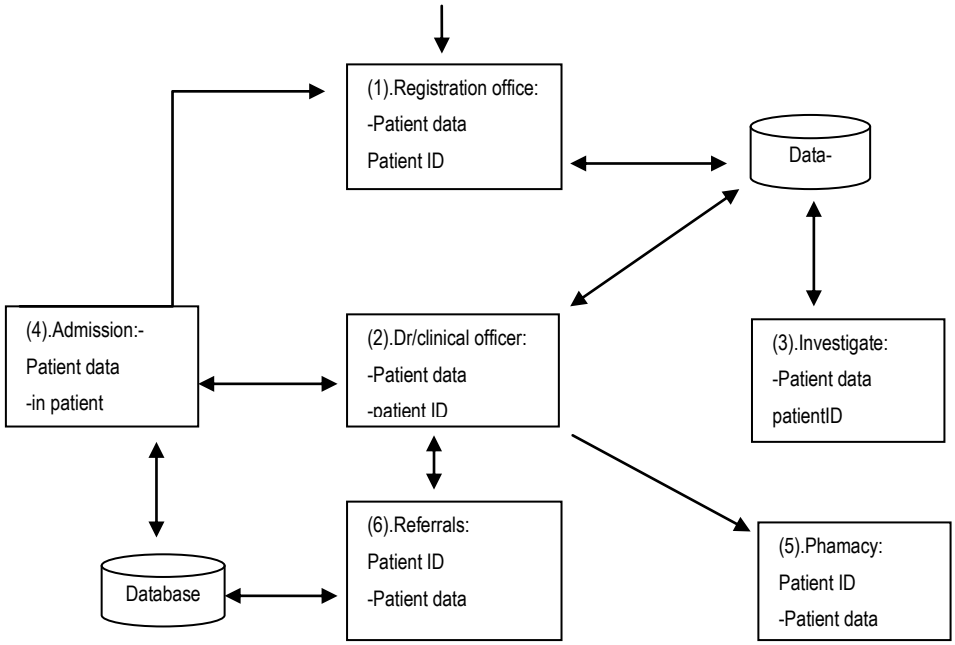

Figure 12. Showing common activities carried out by Kenyan healthcare providers

The design defines the system into six parts whereby each part can be used as a model when building the system using ASP.NET MVC as following:

1. Scheduling / Registration office – this is the first entry where patients are required to register by giving their general data to the records office. This data will be saved in a database.
2. Doctor or clinical officer / treatment - the patient's general data is then passed to the doctor(s) where the patient will be examined. Doctors will decide whether the patient will be sent to admissions, pharmacy, investigation (lab test) and finally referrals or special clinics.
3. Investigations – the patient will be tested and results will be sent to the doctor for further decision making.
4. Admissions – the patient will be admitted if his/her state is too serious and close monitoring is required.
5. Pharmacy - the patient will be sent to the pharmacy if state is not serious, patient Identification number will be required to access patient's prescription by the pharmacist.

6. Referrals / Special clinics - doctors will refer a patient to other sophisticated healthcare providers if the case is complicated.

6.2 Development guidance

Health Level Seven International (HL7)

Health level seven international, refer to the seventh level of the international organizational standards (ISO) and seven-layer communication model for open system interconnection (OSI) - the application layer. Health level seven international is a standards developing organization that is providing comprehensive framework and related standards for the exchange, integration, sharing, and retrieval for electronic health information that support clinical practice and management, delivery and evaluation of health services. Its vision is to create the best and most widely used standards in healthcare.

Health Level Seven International provides standards for interoperability that improves care delivery, optimize workflow and enhance knowledge among stakeholders including healthcare providers and patients. (Health Level Seven International)

Capability Maturity Model Integration (CMMI)

This refers to a process improvements approach that provides organizations with the essential elements of effective process. It helps integrate traditionally separate organizational function, set process improvement goals and priorities, provide guidance for quality processes into innovation management process.

6.3 Implementation

This prototype will consist of five models that will be implemented into working software; the class diagram below using Unified Modeling Language (UML) shows the software database to be implemented.

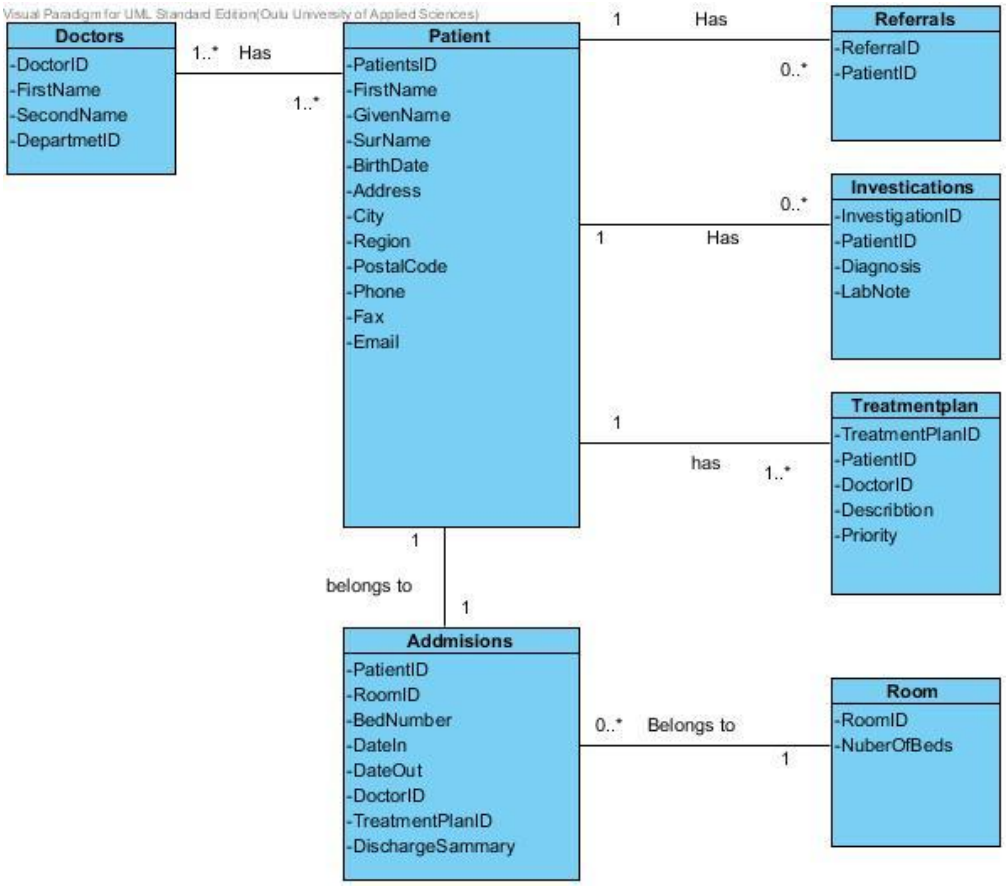

Figure 13. Is a class for the database to be implemented

These classes also represent the models to be implemented in this prototype i.e.

- patientScheduling
- Investigations
- TreatmentPlan
- Admissions
- Referrals
- Room
- Doctors/ employees

Software model source code

These are the parts of the application that implements the logic of the application data domain; they store and retrieve model state in a database.

Patient Scheduling model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class PatientScheduling
    {
        public int PatientId { get; set;}
        public String FirstName { get; set; }
        public String GivenName { get; set; }
        public String SurName { get; set; }
        public DateTime BirthDate { get; set;}
        public String Address { get; set; }
        public String City { get; set; }
        public String Region { get; set; }
        public String PostalCode { get; set; }
        public String Phone { get; set; }
        public String Fax { get; set; }
        public String Email { get; set;}
        public DateTime Timestamp { get; set; }

    }
}
```

Treatment Plan model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class TreatmentPlan
    {
        public int TreatmentPlanID { get; set; }
        public int PatientId { get; set; }
        public String Description { get; set; }
        public String Priority { get; set; }


    }
}
```

Investigations model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class Investigations
    {
        public int InvestigationID {get; set;}
        public int PatientID  {get; set;}
        public String Diagnosis {get; set;}
        public String LabNotes { get; set; }

    }
}
```

Admissions model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class Admissions
    {
        public int AdmissionsID { get; set; }
        public int PatientID { get; set; }
        public int RoomID { get; set; }
        public int BedNumber { get; set; }
        public int DoctorID { get; set; }
        public DateTime DateIn { get; set; }
        public DateTime Dateout { get; set; }
        public int TreatmentPlanID { get; set; }

    }
}
```

Referrals model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;


namespace KenyaMedicalRecord.Models
{
    public class Referrals
    {
        public int ReferralID { get; set; }
        public int PatientID { get; set; }
        public DateTime Timestamp { get; set; }
    }
}
```

Room Model

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class Room
    {
        public int RoomId { get; set; }
        public int NumberOfBeds { get; set; }
    }
}
```

Doctor module / this can also be Employees

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace KenyaMedicalRecord.Models
{
    public class Employee
    {
        public int DoctorsID { get; set; }
        public int FirstName { get; set; }
        public int SecondName { get; set; }
        public int DepartmentID { get; set; }
    }
}
```

The following are the screen shorts of a prototype, Kenya medical records software (KMR) implementation as functional software.

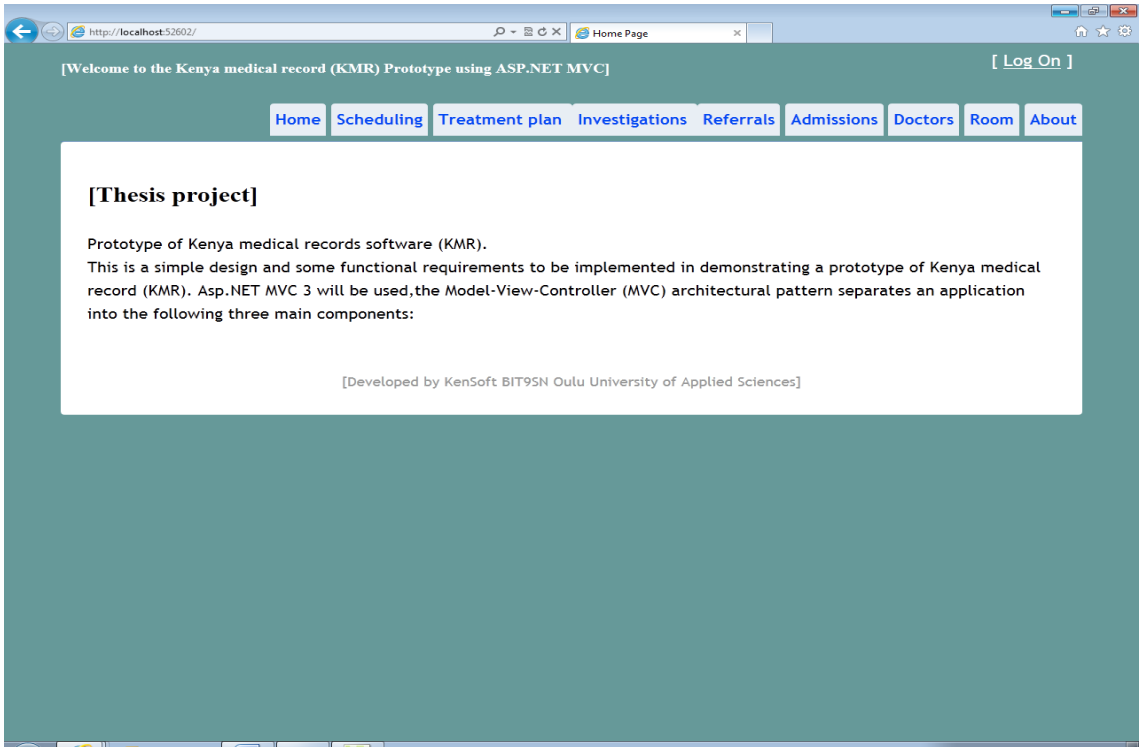

Figure 14. Showing Kenya medical records prototype as functional software

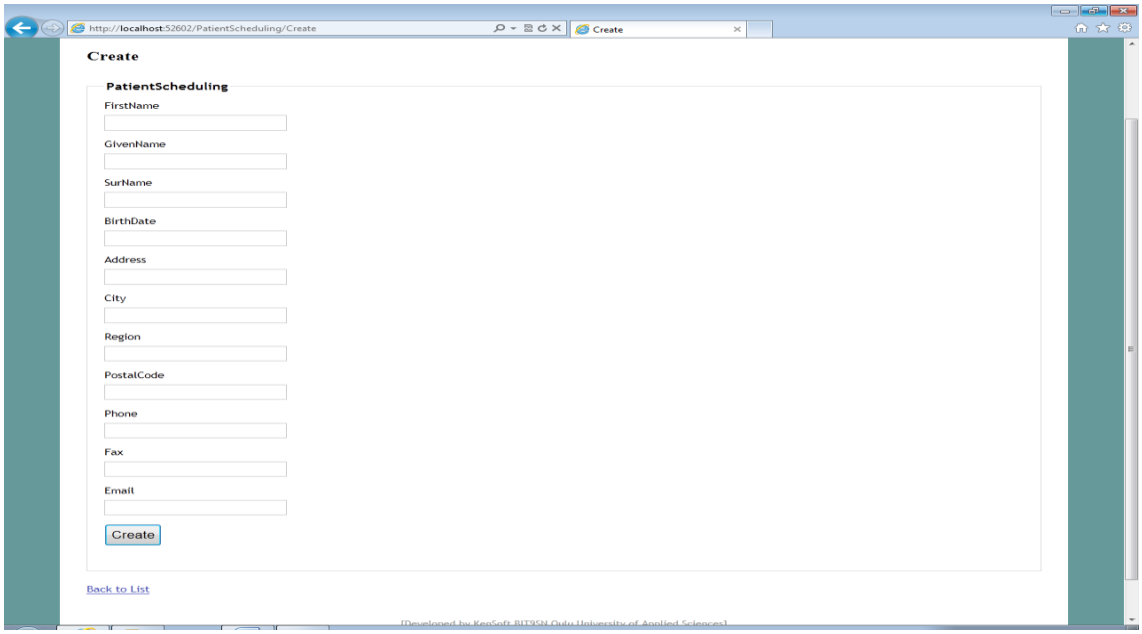

Figure 15. Patient scheduling window

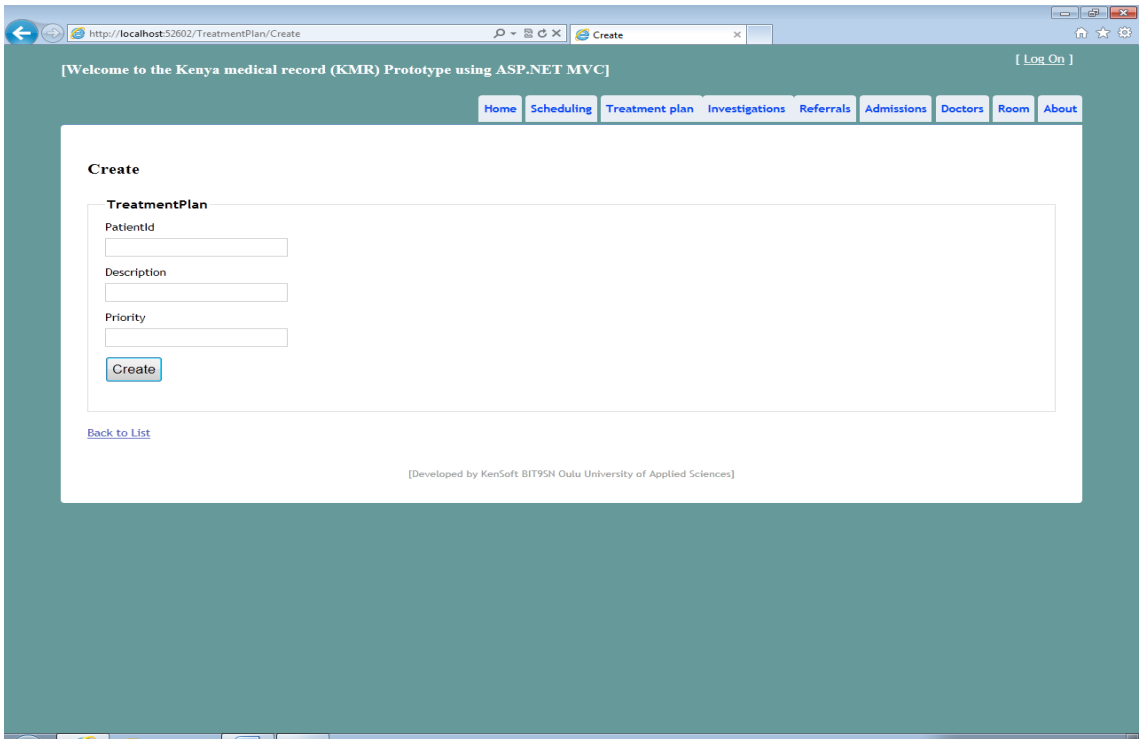

Figure 16.Treatment plan window

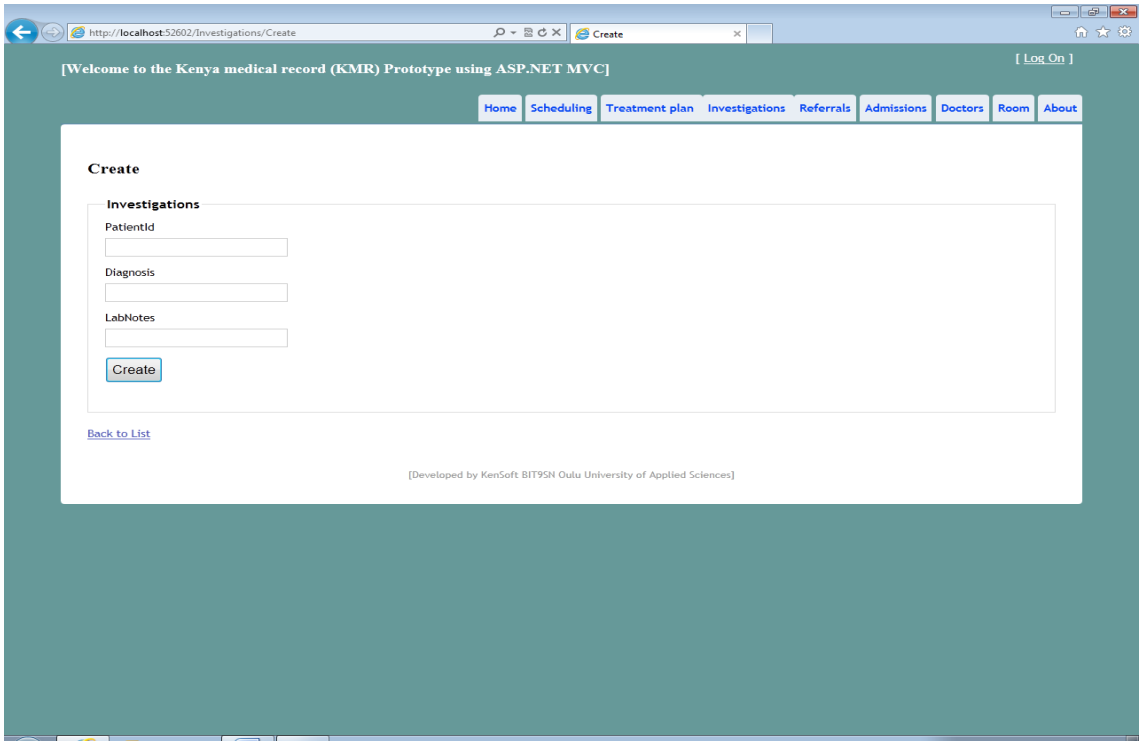

Figure 17. The investigation window where Patient ID diagnosis and laboratory notes will be captured and saved

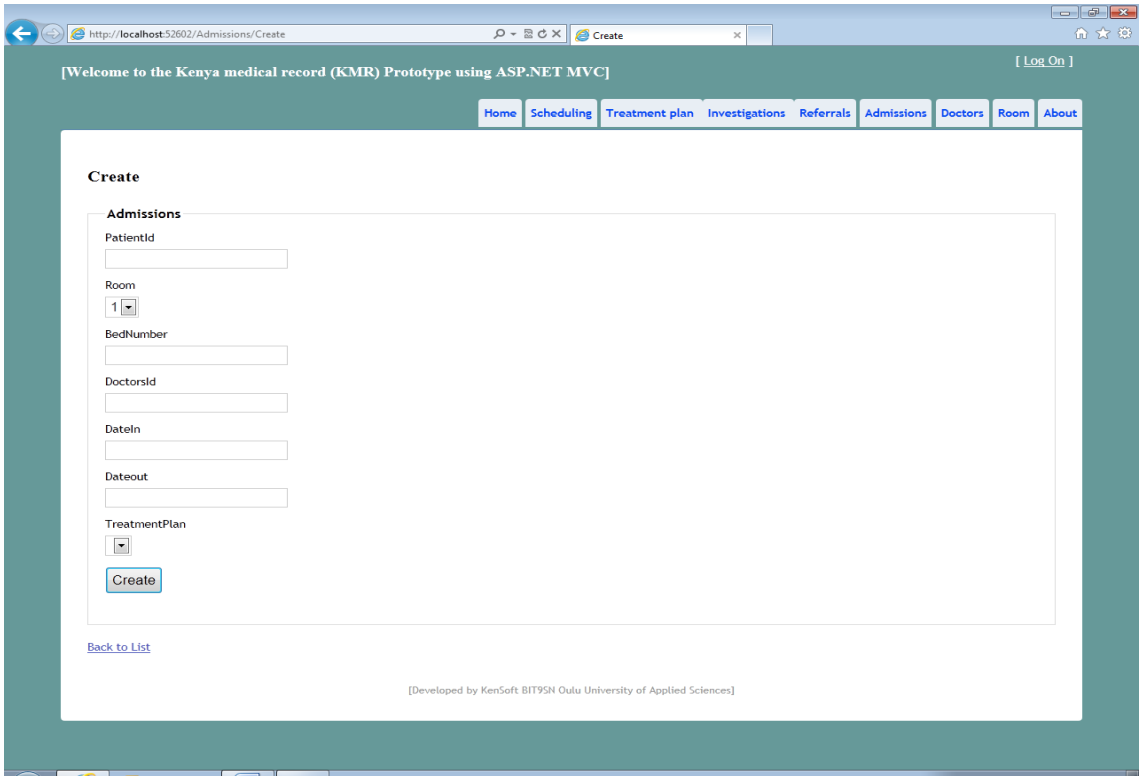

Figure 18.Admissions window where all the patients admitted will be recorded

7 CONCLUSION

This project has pointed out some of the current problems faced by the Kenyan healthcare organizations in storing patient's data using the paper based method. This approach is obsolete and time consuming though the paper work cannot be totally avoided since some but a few activities are still based on paper.

The research has shown that not all of the Kenyan health providers are utilizing the computerization approach in their entire activities as they rely on paper work. This makes the healthcare inefficient since a lot of time will be consumed especially when writing some new data on a paper based patient register where by the same data will intern be copied to other hospital book registers to be stored in the institutions records offices.

Management of this paper based registers it difficult as compared to the electronic format. It would be easier to update and customize the database to meet the user's need as compared to the process of changing data in paper based. Security is another fundamental issue when dealing with patient's data, the data should always be reliable to the healthcare practitioners. Data reliability will easy and improve the care quality as doctors/nurses and the patient will not be disappointed due to their data lose.

As far as Information Communication Technology (ICT) is a concern all the organization and institutions in our current society are focusing on technology trends in order to be up to date. By building information system that simplifies the organizations working techniques. These systems will facilitate real time information sharing within a given system or inter systems. Information correctness will also be achieved through data validation when capturing this data and this is achieved by building software that will be able to capture any possible errors before data storage into the database e.g. In Asp.net MVC 3 handling concurrency and exception handling implementation in the program code, these examples will provide the user with hints of some possible errors.

Implementation of a computerized system will improve the effectiveness of the system since all the healthcare activities will be running as expected.

All the processes running from patient scheduling, Admissions, Investigations, referrals and in some cases pharmacy will be achieved with ease and at a required speed too. If the healthcare activities can be achieved within the required time frame without errors then the organization's cost of running will be reduced

Computerized system is more flexible as compared to the paper base method of data storage. In this way the software can be customized to satisfy specific organizational needs, for example if there is a need to extend the system by embedding some additional models and utilizing applications development practices necessary.

As indicated by the research work most of the Kenyan healthcare providers using paper based methods will finally need a lot of storage space to keep their daily paper work. If these organizations will adopt the electronic medical records then they will be able to avoid the storage problem and thus utilizing their premises for other purposes. Records management will also be easier and cheaper because if will require some few personnel to maintain it. This practice will improve the data quality assurance and correctness that will create confidence in sharing and retrieving the data at any time as needed. The system will also be reliable as it holds all the fundamental information for the system to function as expected.

8 DISCUSSION

Working on this thesis topic has given me a broad view of my field of studies, it has enable me to understand software development processes for example research, requirements gathering, analysis, design, implementation and testing. The paper was a good start for real life software and database designing since the software development lifecycle was used or at least was covered. Moreover application designing tools e.g. Unified modeling language (UML) and application programming interphase e.g. Visual studio 2010 was used, and thus improving knowledge and skills learned during my course studies.

Asp.Net MVC 3 was chosen due to its flexibility as the software can still be modified as required for example adding and removing some models. This method could be expensive in some way to some organizations as the software will need regular updates. Otherwise some other technologies could be used as well as long as it will solve the on-going problem of patient data storage by replacing the paper based method with electronic medical records (EMR) that will satisfy and simplify the users need.

Due to the current rapid and ever changing of information technology organization should be able to adapt the technology trends and utilize them in storing, retrieving and sharing of information. By adopting some of the next generation technologies like cloud computing, this approach enables users of the system to share consistent data over a given network.

The thesis work was initiated in June 2011 but it was delayed till April 2012 this was due the fact that the research work was supposed to be done in Kenya as it was focusing on the Kenyan healthcare systems. During the research the data was not accessed in some targeted healthcare providers as expected due to Kenyan Institutional research ethics committee (IEC) recurring that for one to carry out a research work s/he has to apply by presenting the research proposals 15 day before the actual research date. This was a barrier to further research as time was limited, and thus the findings are based on those healthcare providers which were accessible.

Healthcare sector being a very wide field all the functionalities was not exhausted as it requires time and more system knowledge and further research as well as working with the system users. Thus this thesis gives an idea on how to implementing a scaled down version of the software using Asp.Net MVC 3 that can be used for simple activities.

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INTERVIEW QUESTIONS **APPENDIX 1**

Research questions on Kenyan healthcare systems.

1. Is your healthcare provider organization familiar with electronic patient record
2. What is your point of view on Electronic Medical Records in Kenya?
3. What is the Kenyan Government point of view on Electronic Medical Records based on, Laws and Budget?
4. What are the Patients comments on their data to be saved?
5. How does the personal services at home carried out i.e. home based care?
6. What are the future needs on Electronic Medical Records?
7. If electronic medical records currently exist in Kenya how does the following works?
    a. Handling Patient's data.
    b. Investigation and Diagnosis.
    c. Drugs use monitoring.
8. How do you save, retrieval and share the patient's data within the organization?
9. How do you report your activities and clinical Notes?
10. Is there any plan of implementing electronic medical records in your organization?
11. What other requirements are needed in healthcare systems i.e.
    a. Computer skills of the system users
    b. Types of computers used or preferred
    c. The Computers and networks in Kenya
    d. Mobile networks and Computer networks

A PHOTO OF BOOK REGISTER USED IN PRACTICE IN KEEPING PATIENTS DATA BY THE KENYAN HEALTHCARE PROVIDERS. **APPENDIX 2**

This is to clarify how things work.

Shows the paper based patient register

Showing the records store