

Design and Development of E-Health System

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Abstract The provision of health care has had great improvement in the recent past as a result of innovation in equipment and technology. In keeping with this achievement, there is need to incorporate Information and Communication Technologies in providing health care services in order to have quality, efficient and secure services. In this study an investigation on the problems with the past and current systems has been done then analysed. This led to designing and developing prototype that would greatly contribute in improving the provision of the health care services. The prototype would manage tasks that include scheduling appointments, processing payments, storage of medical records, provide information and processing orders of medicine products. In reducing the unauthorized access of medical records so as to maintain the privacy of every patient, description of the encryption and accessing of pages security plan for the emerging threats is done. The system would be accessed in local and unlimited networks but in the areas where there are challenges of connectivity, high internet costs and poor infrastructure the offline web service and connect only when the service is required and necessary is preferred. The development methodology adopted in the development process phases of the E-Health system is the iterative development methodology. The pilot implementation of the system include both private and public health medical care institutions in selected counties.

Keywords: *medical records, appointments, prototype, payments, orders, privacy, security, iterative development methodology, Information and Communication Technologies*

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1. Introduction

The development of health care and services is in the global agenda with the main objective of reducing poverty in developing and developed countries. In support of this key initiative because of its role in providing human development indicator, the World Health Organization (WHO) has dedicated three of the eight millennium development goals to health [1] that include reduction of child mortality, improving maternal health care and combat diseases (malaria, tuberculosis, cancer, diabetes, measles, stroke, heart attack, pneumonia, and respiratory). In order to achieve these important millennium goals the integration of Information and Communication Technologies (ICT) in the health care provision has a great role to play due to its ability to improve delivery of health care by providing efficient methods and technology for transfer of information and communication. In developing and developed countries there have been introduction of Information and Communication Technologies in delivery of the health care in most of the systems currently in operation but most of these systems have either been ineffective or lack components that fully meet the stakeholder's expectations in delivery and management of health care [2].

1.1. E-Health System

The use of Information and Communication Technologies in provision of health care is referred to as E-Health formally defined as the system that use Information and Communication Technologies (ICT) in providing comprehensive, reliable, quality, accessible, efficient, timely and affordable healthcare locally or at a distance by bringing clinical and non-clinical information, products and services online [3]. This is achieved by cost effective and secure use of information and Communication Technologies in providing and managing health care that include patient registration, storage of medical patients records history, laboratory tests reporting, prescriptions and medical examinations [3]. In designing the E-Health care system, the design of the system that would also be used in the private health care providing institutions and organizations like colleges and universities is considered. In proposed system, it is intended to be affordable and meets the requirements and specifications of the health care users where resources and components are shared by both private and public institutions on agreed policy and security measures. Further, the proposed system is intended to address the concerns that have been witnessed in already existing systems where issues of payments and allowing the individuals to have access to personal health care records, prescription notes, appointments, monitoring

of medicine products in the pharmacy, laboratory test storage and reporting that has not been possible in the past.

1.2. Statement of Problem

The problem in this project is to develop and demonstrate E-Health care system prototype that would store, retrieve and manage medical records of laboratory outcome tests, prescriptions, appointments, payments and orders of medicine products to support health care provision in order to provide quality, secure and affordable health care using appropriate Information and Communication Technologies.

1.3. Objectives

General Objective

Study, analyse, design, test and implement affordable and comprehensive E-Health system in registered medical care institutions.

Specific objectives

- Study, analyse and evaluate existing health care systems.
- Design and develop database managed by Database Management System (DBMS) to store health care data for easy retrieval in providing information for research, decision making during diagnosis and formulating health care policies.
- Design appropriate and effective E-Health care system that would store and integrate health care medical records of appointments, medication, diagnosis and payment for effective delivery of health care services.
- Develop maintainable, dependable, efficient and usable E-Health care system using appropriate object oriented programming language and Database Management System.

1.4. System and Specification Requirements

The user requirements of the proposed E-Health care system that we consider could bridge the gap identified in

the various existing E-Health care systems and eventually evolve a system that meet the user expectations. The system requirements specification define in detail the user system requirements and gives a guide on what exactly ought to be implemented. In the proposed E-Health system the system requirements specification is divided into the functional and non-functional system specification requirements [4].

1.5. Methodology

The selection of the software development process methodology is an important decision that programmers have to make as the methodology lays down the rules that delivers a credible and well-structured working system product. The methodologies that evolve systematically and predictable system software are the waterfall methodology, spiral methodology and iterative methodology [5]. In this study the iterative methodology is considered better methodology and process stages of requirements, specification, analysis, design, implementation, testing, deployment and maintenance are depicted in Figure 1.

The iterative methodology and not the waterfall methodology or spiral methodology has been considered due to its strengths that include, first, it allows the repetitive refinement of the process to include new changes as opposed to the waterfall methodology and spiral methodology that do not allow the repetitive refinement of development process phase where an error would have occurred, secondly, the methodology allows testing of software as need arises as opposed to the waterfall methodology and spiral methodology that only allow testing during the testing phase, thirdly, in iterative methodology there is a variety of E-Health system product versions to the problem and the user would have an option of selecting the better software version product while in the waterfall and spiral methodologies there can only be one possible software product as all the phases have been agreed upon and documented such that there is no provision of having alternative software product versions.

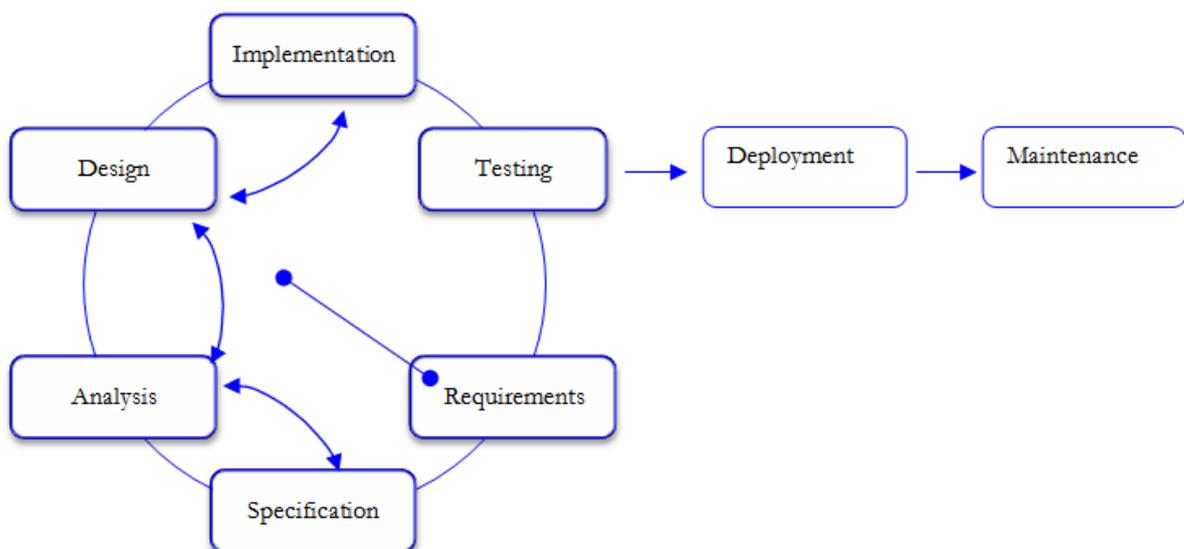


Figure 1. Iterative development methodology

1.6. Operating Systems, Programming Languages and Database Management Systems

The programs that control the execution of application programs and act as an interface between applications and the computer hardware are called Operation Systems [6]. The selection would be from and not limited to Windows, Linux and Mac OS operating systems. The factors that are considered in the selection of a suitable operating system for developing E-Health care system are based on the cost, reliability, security, support of the hardware devices and complexity of the operating system strengths. An operating system that meets these requirements is Linux operating system. First, Linux is an open source operating system, hence no cost required to acquire as compared to operating system like windows. Secondly, Linux is reliable as compared to Windows. Thirdly, Linux is more secure than its competitors, even though it can also be attacked, but overall it is better than the competitors. Fourthly, Linux support a variety of hardware devices even though Windows operating system is still rated high when we consider the usability, easiness and compatibility [7]. The E-Health care system application would be developed in Java object-oriented programming language. The decision on selection of Java programming language has been arrived after considering and comparing core features of Java language and other object-oriented programming languages. The language is rated highly in creating powerful applications with outstanding features that include well structured, well designed, platform independent, secure and robust [8]. The Database Management System (DBMS) that is proposed for development of E-Health care system is PostgreSQL due to reasons that include low cost (open source object-relational database system and therefore no cost required to acquire the system), portable, programming interfaces for a variety of programming languages (C++, Java, Perl, Python, ODBC and JDBC), fast as compared to Oracle and other object-relational database management systems, stable and compliant object-relational database management system, availability, flexibility and has security features that are considered compliant to required standards of secure system.

2. Literature Review

The involvement of Information and Communication Technologies in the health sector has remarkably changed the health care in the whole world. In Britain for instance the health care was initially fully paid for by individuals but in July 5th 1948 the National Health Service (NHS) was created to offer free health care. This led to rapid increase of the number of persons seeking health care services that led to an increase of the cost of offering health care due to increased patients, cost of drugs and change of technology as a result of the free health care service. The government managed to bring the cost down by charging patients in some of the services like consultation, prescriptions and dental [9]. The health care provision has faced emerging challenges of high costs, inadequate resources and lack of clinical decision support

tools. In addressing these challenges, the idea of integration of the health care services with Information and Communication Technologies has been considered as the solution to address these challenges in order to improve provision of health care services. This remarkable decision allows health personnel to share resources in both local and wide area networks. The services initially targeted were diagnosis and surgery in well-equipped and recognized hospitals while other services still relied on traditional hard copy file processing systems. In hard copy file system for instance in handling the patient records, the records are stored in folders then arranged in alphabetical order of names in public hospitals or in serial numbers of employees if the health care facility is for employees of an organization or for an academic institution like colleges or universities.

The hard copy file system has several disadvantages that include records are easily destroyed, they take much time to retrieve information or the information stored may not be illegible for the health care providers to obtain the patient medical history that may lead to errors in prescription in some cases as there may be no medical history that would help in making decision especially on the drugs that may not be suitable for patients either by being allergic or may not totally respond to the drug positively. Another major problem associated to this hard copy file system is security. In this file system it takes shorter time to look at people's medical records history or once a folder is lost it may not be possible to recover the information, whereas the storage of record in disks is guaranteed of security and personnel may have the policy of making backup copies that may be used in case of loss of the records due to virus or crash of programs.

In the last decade United Kingdom embarked on national plan for the National Health Service resulting to one of the largest network consisting of the following system components;

- (a) Electronic health records
- (b) Picture archiving and communications systems
- (c) Electronic prescription service
- (d) National health mail service

The aim of the system has been stated as providing patient health care records that are up-to-date, available at all times and reflects the true records of the patient with minimal errors in the local and limitless geographical wide area networks to health care service providers. This system can be faulted as one that has emphasis on the patient records and therefore has not taken into consideration the pharmacy records, personal account records and patient payment records that are important and necessary for monetary and accountability. The inclusion of the pharmacy records subsystem for instance will guide the physician in prescribing the medication that is available and suitable to the patient as opposed to completing the prescription and later recommending for alternative prescription that may compromise the accuracy of the prescription. Further, proposal to incorporate the payment and personal account information from the commercial institution where the government allocates all citizens funds that are accessed through local and international commercial banks need to be incorporated. The subsystem would query the database on the availability of the funds that have a maximum limit and on

exhausting this allocation the individuals would have to seek and fund the health care services from their personal savings. This will then allow the patients to receive medical care services for instance during emergencies or when the medication is expensive and alternative source of funds is required.

In America, the healthcare services provision has had great achievement in integrating ICT in provision of health care services. The health care service providers can now allow the health service beneficiaries to access personal medical records. This provision enable the patients to obtain updated personal medical record has made positive contribution in improving the patients' health as they are now informed of their own health and can be more responsible. However, the opening up of the system for the patients to access medical records information has its disadvantages as some of the records may be misused or may not be in the interest of the patient. There are cases where probably before the release of the patient records report, prior counselling session may be necessary and with such provision of accessing the records, patients may not have the opportunity to have the contact with the health care providers. In proposed system, there would be mechanism and policy of censoring the medical reports before they are accessed by the patients. There would also be proposal on strengthening security and privacy of medical records by using encryption security codes known only by owners of medical reports to avoid unauthorized persons from accessing records.

In the past health providers relied on manuals and text books to make decisions on prescriptions but this has changed in the recent times as a result of the introduction of ICT in the provision of health care. The health service providers can now get updated information on prescriptions, dose and effective drugs in the market by checking the internet during the oral interview and examination. This service is reliable and of higher precision as there is no wastage as a result of giving wrong drug or dose. However, there is the problem of authentication of information available in the internet. In proposed system security and access of health care resources from credible and recognized sources would be top priority and the system will only store and access information from recognized sources. The use of computers to monitor patients pulse, breathing and heart rate is one of the great improvements that has been achieved in the recent past. The health care providers do not rely on the manual system any more where personnel take reading at intervals that is sometimes exposed to errors that may be undetected. The high precision of the computers makes the monitoring of the patients more effective hence the provider's care has a boost that make them more confident in discharging their duties.

In future development, computers will be programmed to be used in dispensing pills, process payment transactions and provide resource tools that will support physicians in making decisions in addition to the already existing subsystems. The inclusion of dispensing pills and all other forms of medication subsystem will greatly reduce the time spent in issuing medication in the pharmacy. First, the computers will be more accurate in

weighing or counting the pills. Secondly, having the machines dispensing the pills will reduce the personnel work load and would then allow the physicians and other medical health care providers more time to attend to the patients' needs especially in countries that have a large ratio of medical personnel to the citizens.

3. Analysis

The analysis of the system plays a major role in developing software as it is the stage where system specifications are modelled. The requirements specifications are commonly modelled using Unified Modelling Language [10] techniques. The commonly used unified modelling language technique in object-oriented analysis is the use case diagram. In collecting and gathering information on the requirements of the E-Health system various methods that are considered for this purpose include the following;

- (a) Interviewing healthcare service providers.
- (b) Interviewing health care beneficiaries.
- (c) Observing and participating in using current operational health care systems.
- (d) Studying and analysing health care systems.
- (e) Studying and analysing health care system documents.

The study of health care documents, interviews of stakeholders and observation of the systems currently in operation in United Kingdom reveal that the systems is inefficient in service delivery and lack subsystems that effectively manage appointment schedules, payment transactions and medicine products monitoring in the pharmacy [11]. The proposed E-Health system is expected to address current system faults and incorporate concerns of the stakeholders, users and sponsors so as to evolve efficient, credible and secure system. The health system described has had some of the components integrated with ICT in order to have an E-Health system but there has never been an E-Health system that is efficient, credible and secure that comprehensively satisfies requirements of stakeholders in many countries as there have been reported complains of inefficient delivery of services due to fault system or lack of some of the important components in the E-Health system.

The individuals and subsystems that interact with the identified use cases are commonly referred to as actors. The actors identified in the E-Health system are widely classified as non-members and members. The specific actors identified in the proposed E-Health system and the use cases are modelled as represented in the use case diagram [12] in Figure 2.

4. Design

The design of the system is the crucial and important phase of system development where system specifications using class diagrams and construction of user interface diagrams are modelled that may be used in capturing new inputs, editing stored data and displaying information of the system.

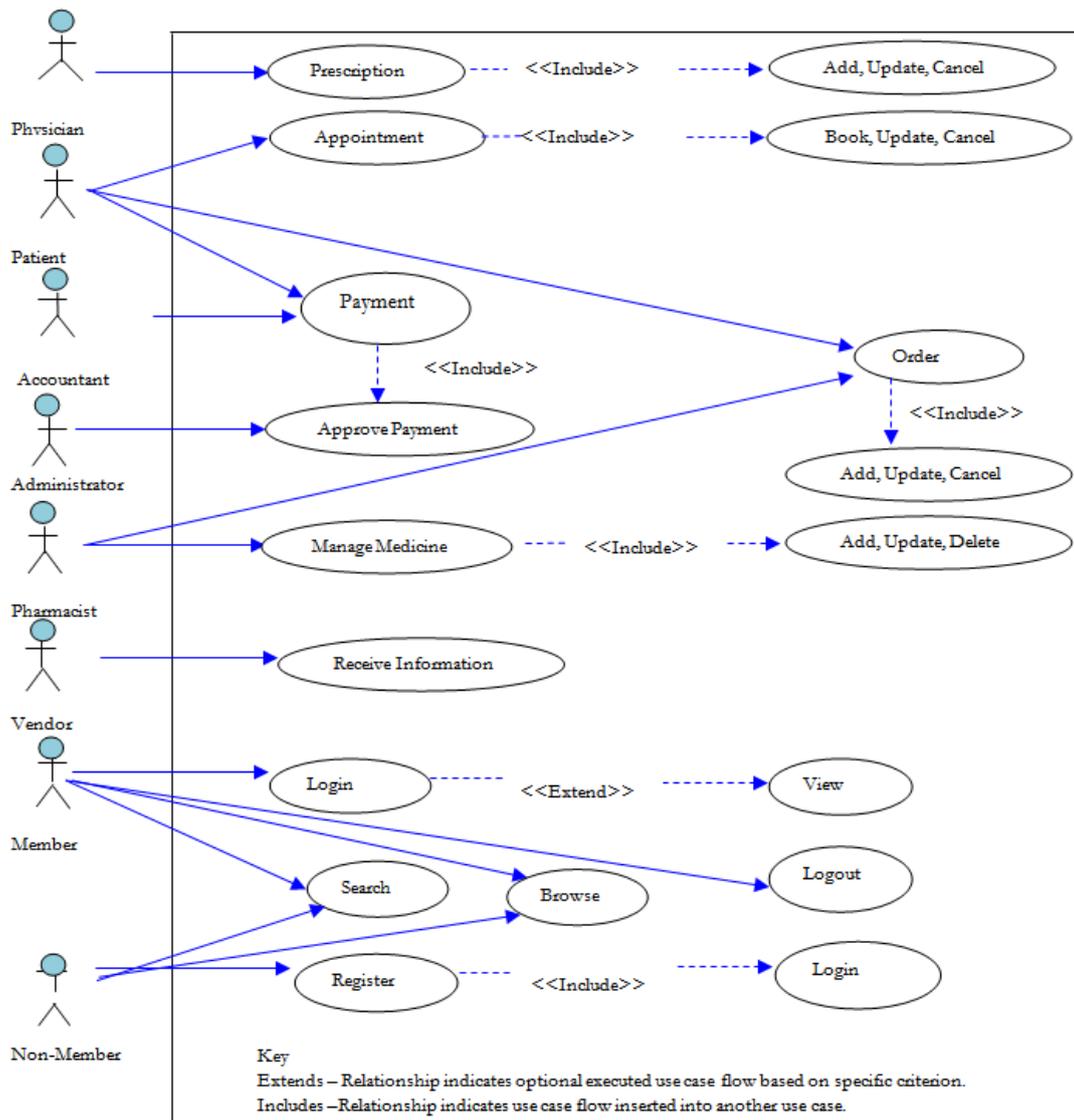


Figure 2. Use case diagram

4.1. Class Diagrams

The system requires storage of data and constructed class diagrams are finally translated into relations while attributes become columns in developing the database. The identified classes, attributes and operations for the health care system are depicted in Figure 3 while issuing of medicine, updating the stock and acquiring new stock for easy monitoring and accounting is depicted in Figure 4.

4.2. Sequence Diagram

The construction of sequence diagram is useful in validating the logic in the description of E-Health care system scenario and help in detecting unforeseen defects in the design. In the proposed E-Health care system the sequence diagrams for validating new member registration, patient login, employee login and supplier login are depicted as shown in Figure 5a, Figure 5b, Figure 5c and Figure 5d.

In Figure 5a new-member request to register as a member by clicking registration button on the home page. The new member then input personal information that

includes name, address, phone and email. The health care system validates the new member information and sends feedback to the new member that may be successful registration or unsuccessful registration in the E-Health care system. In Figure 5b the patient make appointment request by first clicking the login button on the home page, then input the username and password. The system validates the patient login information and gives feedback to patient that may be the main member page or login unsuccessful message. In Figure 5c the employee who may be physician or accountant or pharmacist or administrator or manager or system administrator request patient records information. They first click the login button on the home page and then input the username and password. The system validates the employee login information then gives feedback to the employee that may be main page on successful login or unsuccessful login message in the health care system while in Figure 5d the supplier click login button on the home page then input the username and password. The system validates the login information, and then gives feedback to the supplier that may be the supplier page on successful login or unsuccessful login message if username or password or both were incorrect.



Figure 3. Class diagram showing classes and relationships

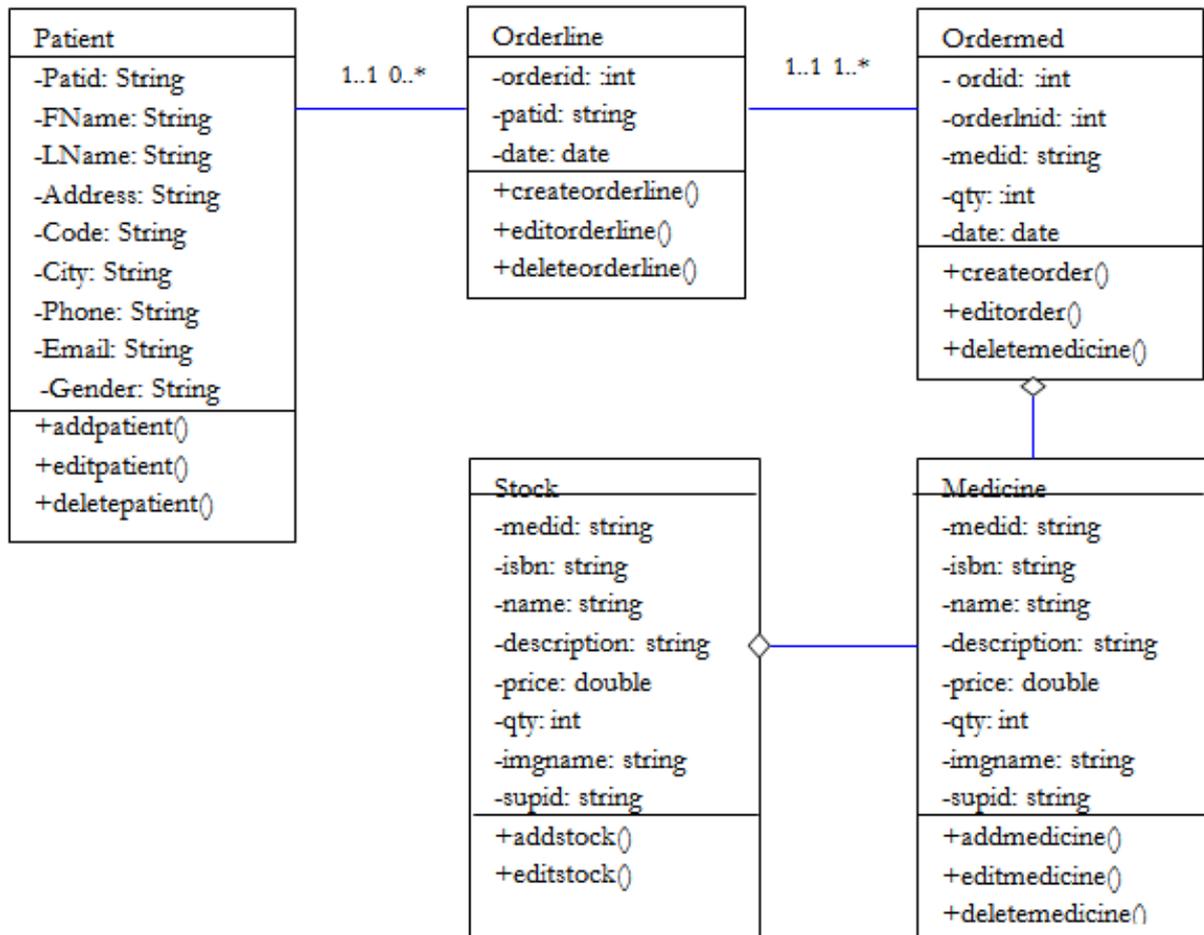


Figure 4. Class diagram for medicine products order processing

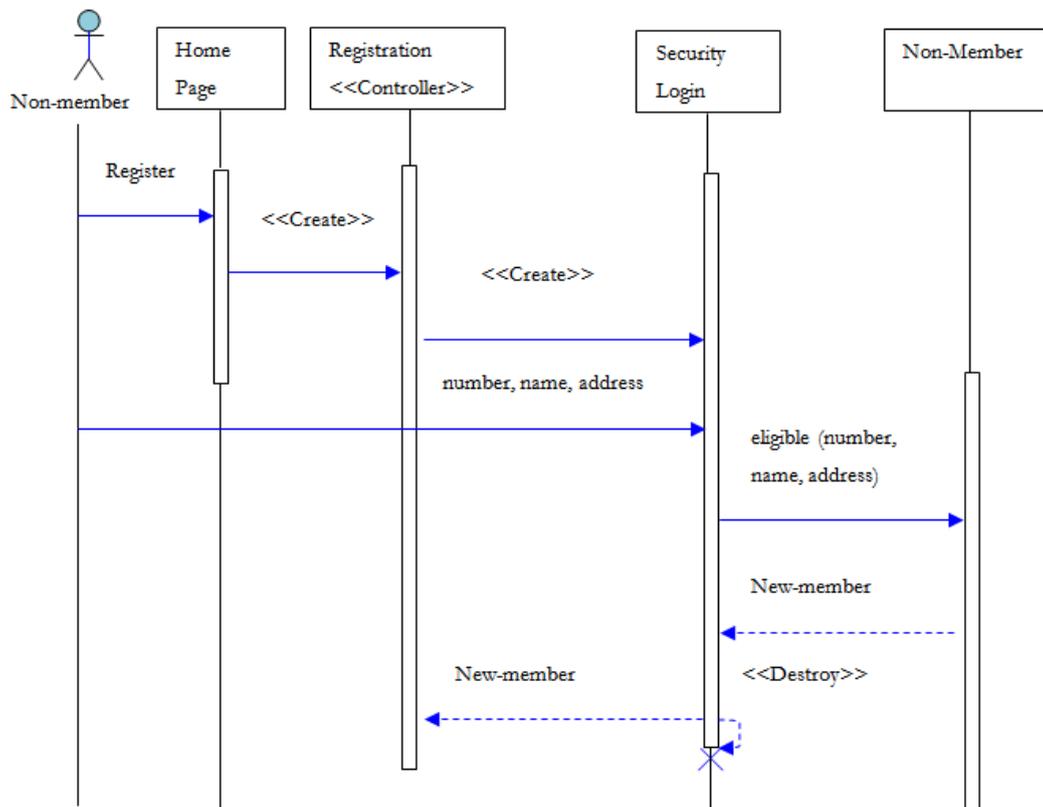


Figure 5a. New-member registration sequence diagram

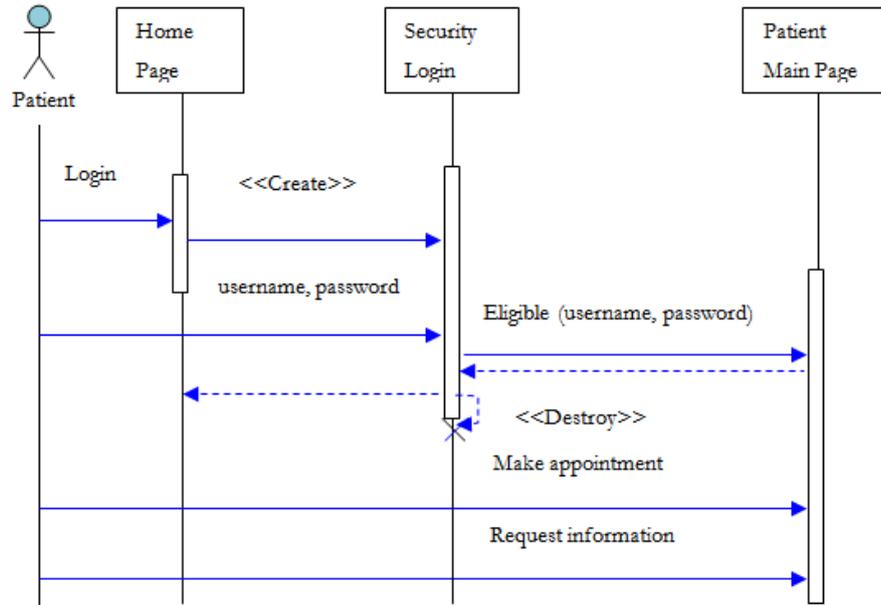


Figure 5b. Patient login sequence diagram

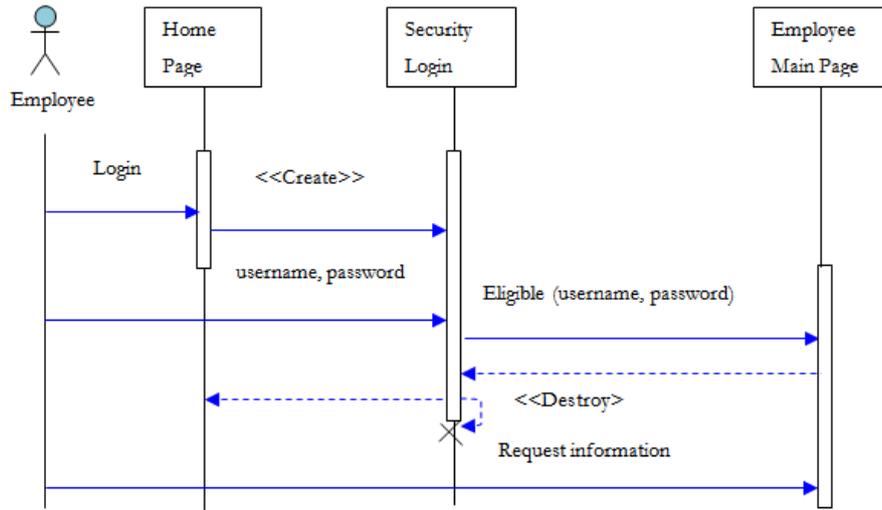


Figure 5c. Employee login sequence diagram

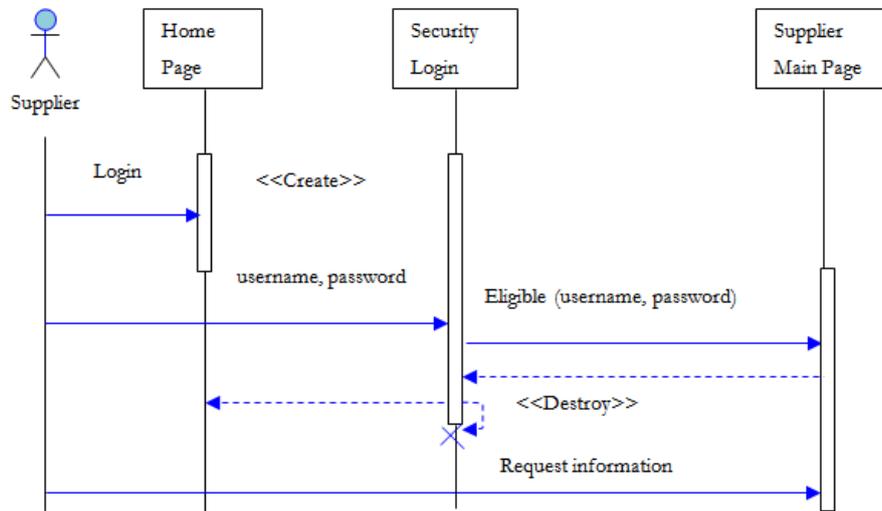


Figure 5d. Supplier login sequence diagram

4.3. Database Development Design

The development of the database is an important process that requires well planned, properly set rules and standards so as to evolve quality, consistent, secure and well-structured E-Health care system. A poorly designed database may lead to data inconsistency, breach of privacy,

storage of redundant data and loss of business if the database does not meet the system specifications and objectives for which it is designed, that are broadly given as the ability to support relationships among the relations, provide solution to problems for which they are designed, impose data integrity, improve data efficiency and accommodate emerging changes.

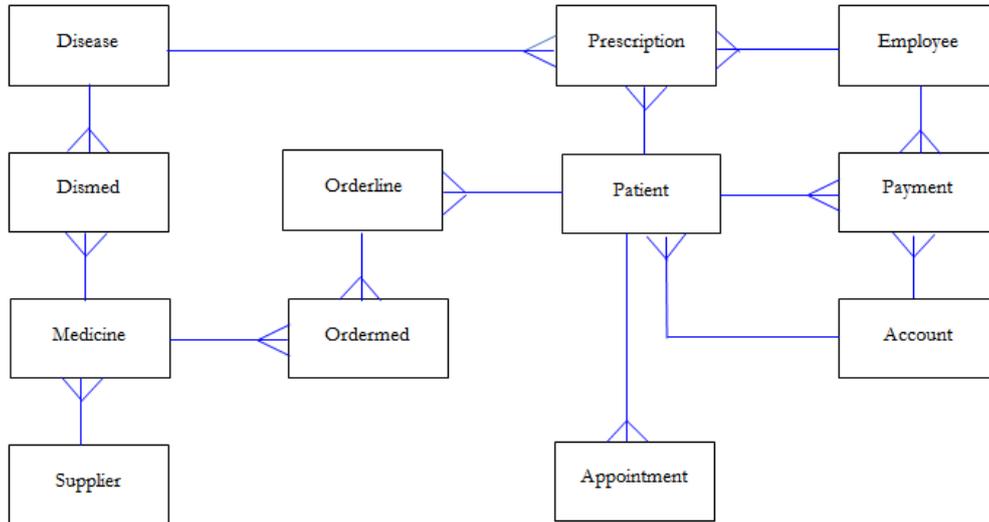


Figure 6. Entity-relationship diagram

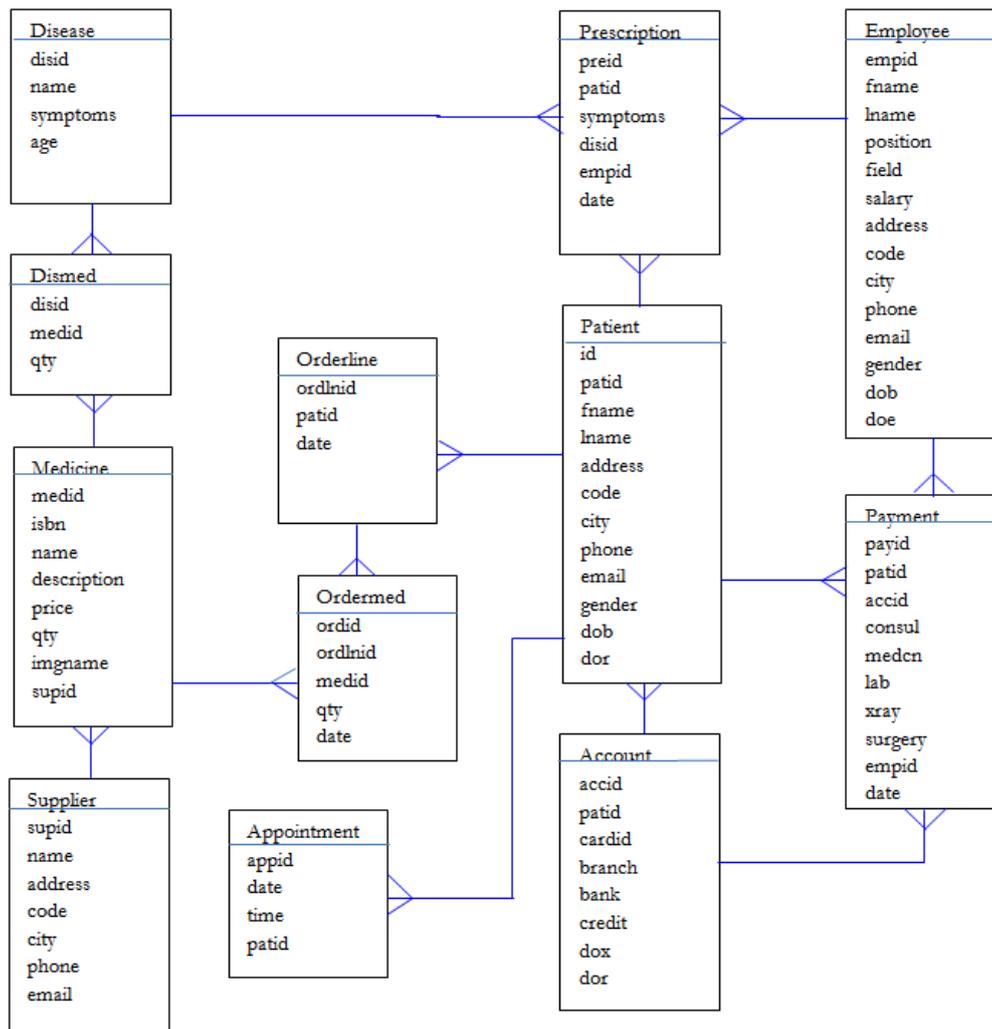


Figure 7. Conceptual model

The three main database models that have been developed in the past commonly used in managing data in various organizations include hierarchical, network, relational database and object-oriented relational database models. In this study, the relational database model for database development is selected as opposed to hierarchical and network models due to its strengths that include enables storage of data in standardized format and allows users to simultaneously access consistent data, requires less memory due to storage of data free of redundancy and incorporating data integrity features in its design that that are adequately enforced as compared to the other models. The database development process is systematically carried in two major stages that involve logical design and physical design [13]. The entity relation diagram is depicted in Figure 6.

The importance of the entity relationship diagram is to relate and validate the relationships between the relations that will guide in making decision on whether additional relations or discarding relations is appropriate. The

relations that are normally discarded are ones that have one-to-one relationship while the relations with many-to-many relationships are modelled to include additional relations since the many-to-many may lead to undesirable effects in the design of the database. The modelling of relations, attributes and relationships between the relations is represented in the conceptual model as shown in Figure 7. The design of the representation of the data in the storage medium or the physical representation of the logical design is referred to as the physical design. The first task in the physical design is to identify attributes that are unique for every row in the relations. Then based on personal preference and convenience the primary key is selected for each of the relations from attributes of the relations. In instances where there are more than one candidate key, one of them is randomly picked, but if there is no unique candidate key, then explore the possibility of combining two or more attributes or including a new attribute in the relation that will have the unique property for every row or record.

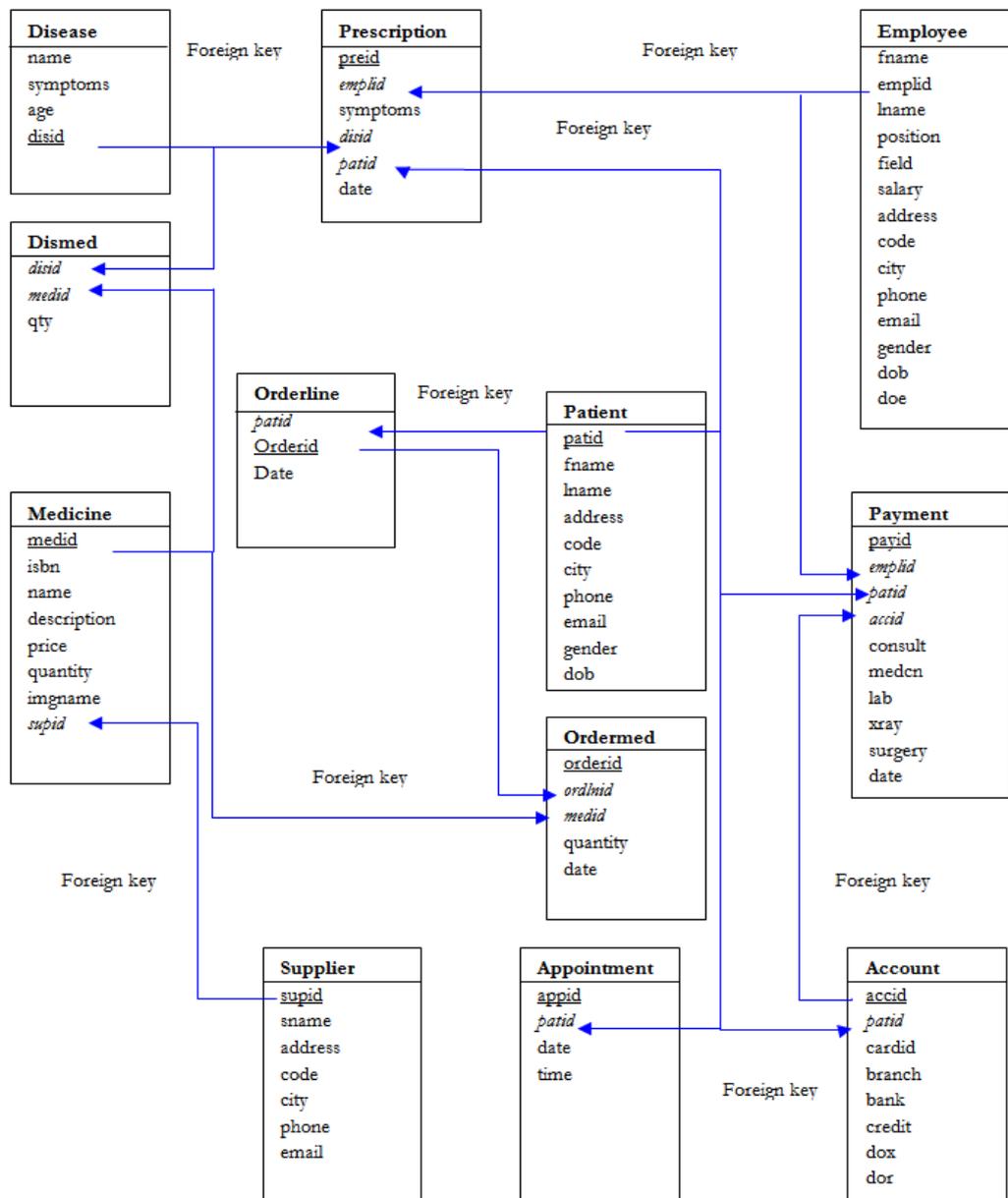


Figure 8. Schema diagram

In order to relate the relations, the primary key attribute of a relation is included in relation or relations in which the relations are to be related. This would enable the user to extract related information more efficiently from relations where it is currently being held. The representation of the relations, primary keys and foreign keys depicted as schema diagram shown in Figure 8. The relations names are in bold, primary keys are underlined while the foreign keys are in italic.

4.4. User Interface Design

The design of user interface requires skills and input from graphic artist, requirements analysts, system designer, programmer, engineers, medical personnel, accountants, managers and stakeholders [14]. In this study user interface is developed based on the requirement analysis and programmer point of view. The main factors considered when designing the interfaces include navigation, accessibility, visibility, usefulness and feedback [15]. In the initial stages of developing the user interface, sketches are drawn based on the use cases of login, search, add, update and display information of products, persons and services. Since the actors have different privileges, pages are designed for different categories of users that are classified as non-members and

members. The members are further categorised as patients, suppliers, physicians, pharmacists, accountants, administrators, manager and system administrators. The actors are assigned the necessary and appropriate interface as one of the measures of making the data secure so as to reduce the chances of unauthorised access to stored medical records and information. In the home page normally accessed by both the non-members and members, the user is allowed to browse, search medicine products, register or login. Once the person has registered then the person can access the main using the provided individual access security codes. The design of the pages is as shown in Figure 9.

The user home page sketch in Figure 9 would then be designed so that final home page that the user would use to search, browse, login or access the home page menu where the user can click buttons to display registration form that can be used for registration as patient, supplier or employee as shown in Figure 10.

If the user wishes to register as member, then he/she would click the register button to access an electronic registration form shown in Figure 11 where the user would fill the personal information of first name, last name, address and contact information. On completion, the user would then click the register button to submit personal information or click cancel to discard the filled information.

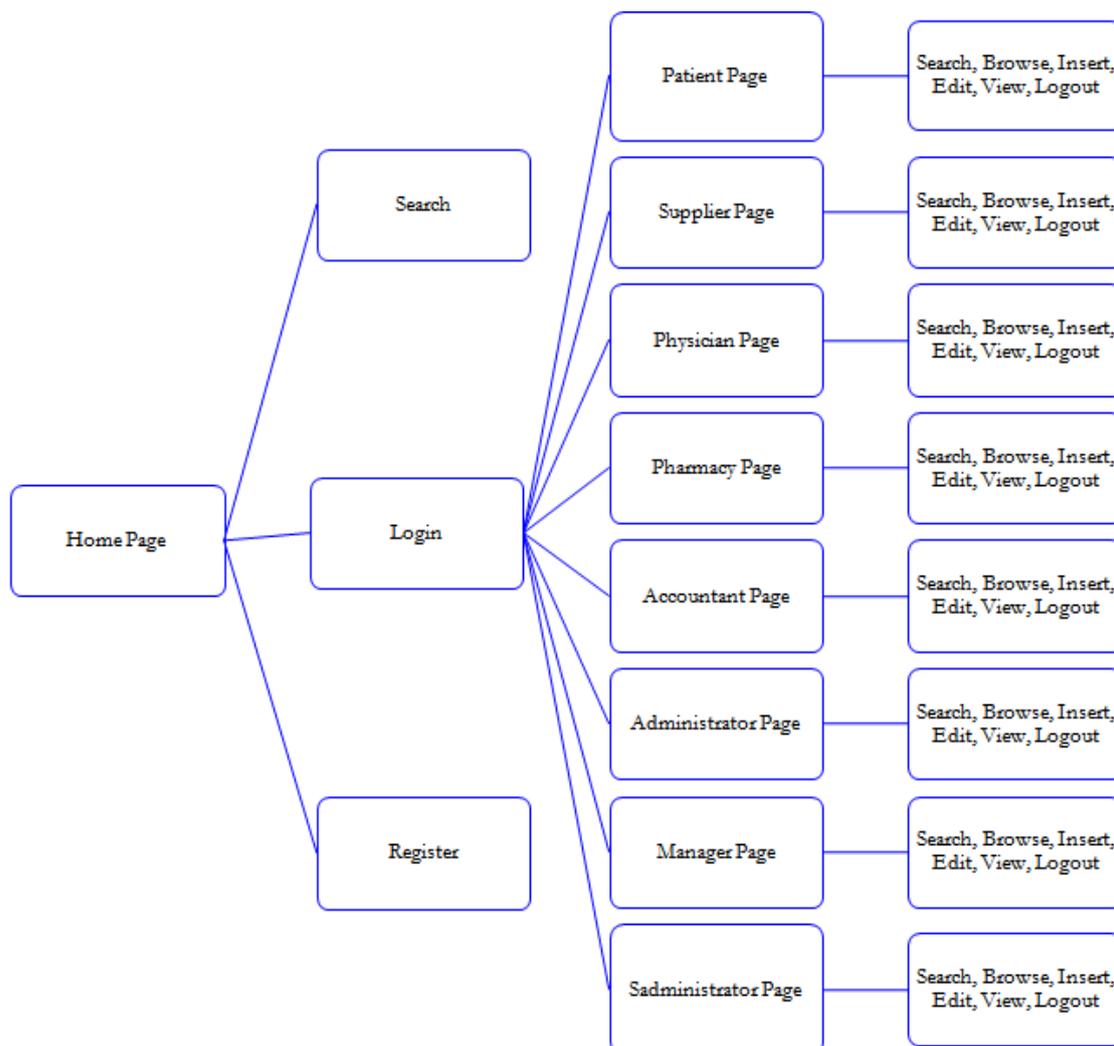


Figure 9. Page design

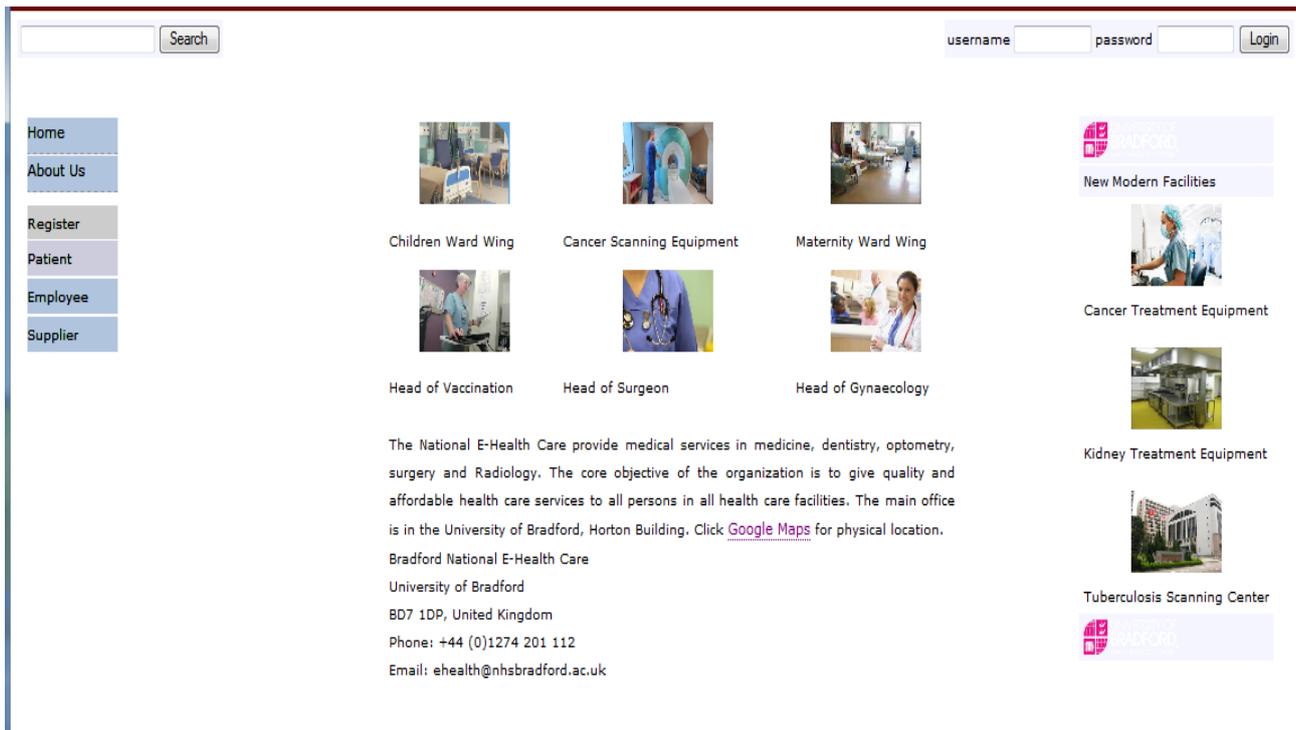


Figure 10. Home page interface

New Patient Registration Form:

First Name:	<input type="text"/>	*Last Name:	<input type="text"/>
Address:	<input type="text"/>	Code:	<input type="text"/>
City:	<input type="text"/>	Phone:	<input type="text"/>
*Email:	<input type="text"/>		
DOB:	<input type="text"/>	Gender:	<input type="radio"/> Female <input type="radio"/> Male

Date Format: yyyy-mm-dd

Figure 11. Registration form

If all the information is correct and complete, the user would be sent a notification of successful registration otherwise the user would be notified of unsuccessful registration. The correct information would then be processed by the administrator who will accept or reject the request of registration. If the administrator approves the request, the user would be notified of the acceptance of registration and would also be sent the identification number, username and password through the email address that would be used in subsequent system login, identification and reference whenever the user seeks health care services. If the user completes the electronic registration form and receives identification number, username and password, then he/she can login to the system to access health care information and services. In order to login the user need to click the login button on the home page, then types username and password and click login. If the username and password are correctly filled, the user will access the patient page or employee page or supplier or manager page or system administrator page if the login was as patient, employee, supplier,

manager or system administrator respectively as depicted in Figure 12.

When the user login is successful he/she will have main page that will have options of search, logout and main menu depending on the user login identification that may be as patient, physician, accountant, pharmacist, supplier, administrator, manager or system administrator. The main menu has options of inserting new records, editing, deleting or displaying of records as depicted in Figure 13a for the main menu of system administrator or manager. If login was the system administrator, then the system administrator would have the medicine submenu where medicine products can be inserted, updated, deleted or viewed.

If the system administrator wish to add or edit or delete or display then he/she need to click the appropriate option that may be insert or update or delete or display. The interface for insert, update, delete, display of all medicine products and display of the stock of medicine products are as shown in Figure 13b, Figure 13c, Figure 13d, Figure 13e and Figure 13f respectively.

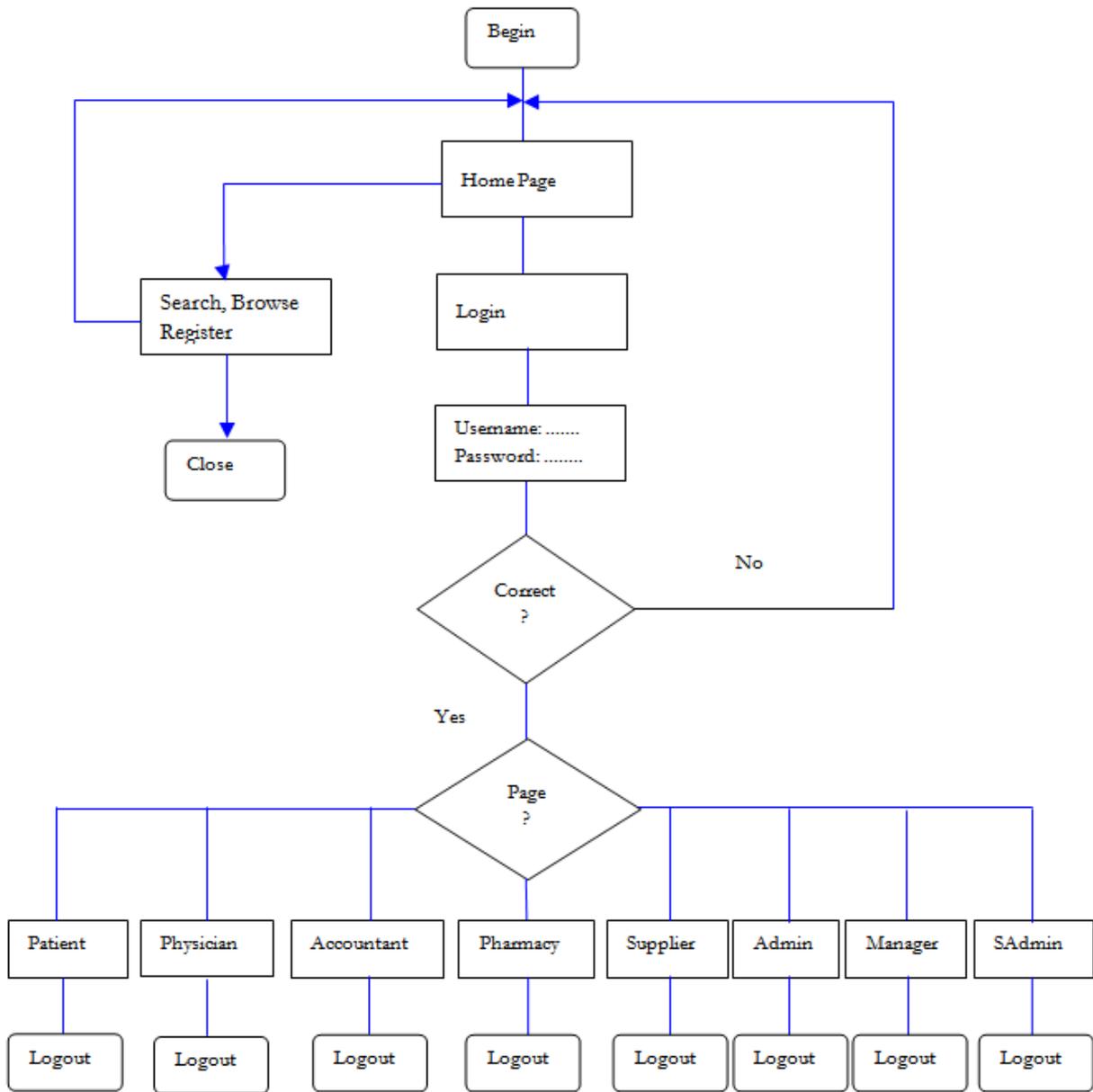


Figure 12. Login design

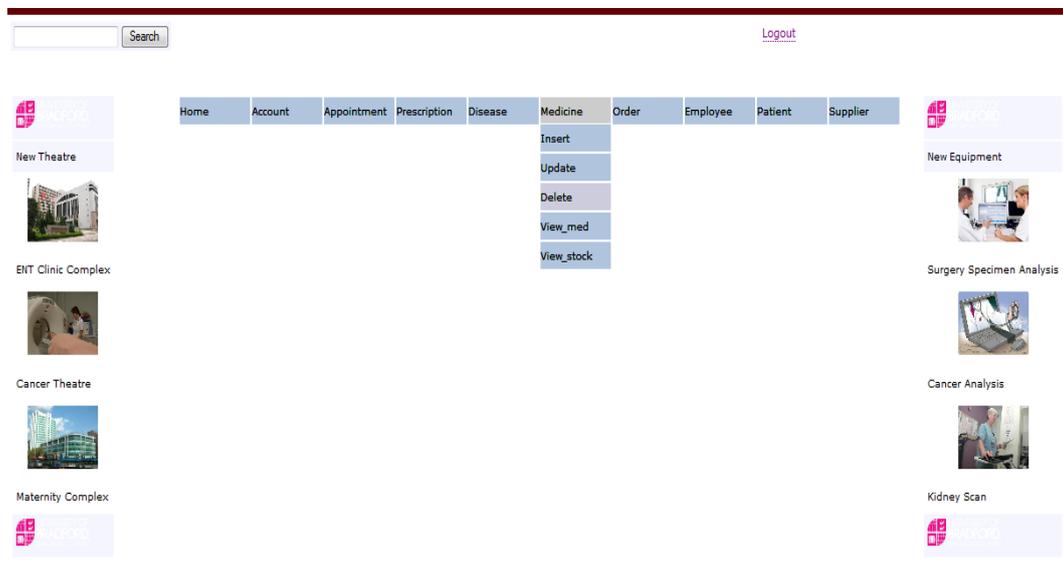


Figure 13a. Member mainpage interface

Insert New Medicine Information:

*Medicine ID: *ISBN:

*Name: *Description:

Price(£): 0.01 Quantity:

Imgname: Supplier ID:

Figure 13b. Insert medicineproduct record

Update Medicine Information:

*Medicine ID: *ISBN:

*Name: Price(1+-x%):

Quantity:

Figure 13c. Edit medicine product record

Delete Medicine Information

*Medicine ID:

*ISBN:

*Name:

Figure 13d. Delete medicine product record

All Medicine Products in the Pharmacy						
MedID	ISBN	Name	Description	Price	Qty	Image
M101	020-101-0	Atovaquone	Malaria tablet 100g	£0.01	800	
M102	020-102-0	Atovaquone	Malaria tablet 250g	£0.02	900	
M103	020-103-0	Proguanil	Malaria tablet 100g	£0.02	900	
M104	020-104-0	Mefloquine	Malaria tablet 100g	£0.01	800	
M105	020-105-0	Chloroquine	Malaria syrup 100ml	£0.05	905	

Figure 13e. Display of all records of medicine products

Stock of Medicine Products in the Pharmacy							
MedID	ISBN	Name	Description	Price	Qty	Orderqty	Remqty
M101	020-101-0	Atovaquone	Malaria tablet 100g	£0.01	800	10	790
M102	020-102-0	Atovaquone	Malaria tablet 250g	£0.02	900	10	890
M103	020-103-0	Proguanil	Malaria tablet 100g	£0.02	900	10	890
M104	020-104-0	Mefloquine	Malaria tablet 100g	£0.01	800	5	795
M105	020-105-0	Chloroquine	Malaria syrup 100ml	£0.05	905	30	875

Figure 13f. Display the stock of medicine products

5. Implementation, Testing, Security, Deployment and Maintenance

5.1. Implementation

Implementation in the E-Health care system developments involves the writing of the algorithms and source codes for the design that has been developed. The algorithms developed in this section include Search, validation, registration, insert, edit, delete and display algorithms.

5.2. Testing plan

The testing strategy of the system is testing each option of the menu using appropriate set of test data. This stage is necessary since it validates how the system performs its functions as per the specifications to the satisfaction of the intended users.

5.3. Security

The developed system would store and allow retrieval of medical records and information transmitted across networks in health care institutions and homes that need to be protected from unauthorised individuals or virus attacks. In protecting the stored medical records data, the first measure is to have people trained in Information Communication Technology and ensure they are aware of dangers and effects of virus attacks. They would also be encouraged to use better and updated antivirus software and make backup copies of medical records data regularly that would be used in the event of virus attack. Secondly, dissemination of health care information written in simple language free of medical jargon to avoid instances of persons seeking for help in interpretation of information. Thirdly, there is need to have all people use personalized access codes to access the information and records in the system. This will eliminate instances of other persons having information on access codes especially employees of health care institutions. Fourthly, in order to protect data in the networks, there would be need to have digital encryption and decryption. This will enable data and information transferred safely over the network and only accessed by intended recipients. The developed encryption algorithms include substitution, transposition, XOR logic and RSA (Rivest, Shamir Adleman) and have been considered appropriate methods of encryption in the system. However, RSA algorithm is more secure encryption standard than the substitution, transposition and XOR algorithms because of its large key size ranges and factorization of large numbers based on number theory. In addition to encryption, information sent across networks would have digital certification that would enable recipients to receive and access medical records information only from known and authorised sources.

5.4. Deployment

The deployment of the E-Health care system product involves the distribution and installation of the product in the workplace. The first step in the deployment process phase is to carefully plan the deployment strategy for

marketing and installing the software product. This involves preparing the software product copies, licenses and setting up a team of persons with good Information Communication Technology skills to market the E-Health care software product. The plan would also include the strategy on how to identify potential institutions and organizations that are currently in need of the product to improve health care that would include private hospitals, public hospitals, chemists or clinics. Once this planning is complete and deployment readiness determined, the deployment phase process plan is then executed.

5.5. Maintenance

The maintenance of the software is the identification of the identification of the faults in the software and modifying the software after it has been deployed. Since the software would have been prepared without the input of all stakeholders, the maintenance process is inevitable and the faults may either result from the design of the software or interference with other existing software or hardware. In the developed E-Health care system, the maintenance would be a continuous process and will be an iterative process where the design may be modified or the requirements and specification revisited to correct any anomalies that might interfere and contribute in the poor performance of the product.

6. Conclusion and Further Research

6.1. Conclusion

In this research it has been demonstrated how Information and Communication Technologies can be beneficial to the health care and services provision. In particular, E-Health system prototype has been designed and developed that could be used in improving and managing health care records and services. The prototype designed, developed and implemented would manage the following tasks;

- (a) Allow registration of persons who wish to seek health care services in medical institutions.
- (b) Manage medical, medicine products, accounts and payment records.
- (c) Allow patients to make and cancel appointments where the members log into the system and conveniently arrangements to visit the medical personnel at a convenient and appropriate time.
- (d) Has a provision of connecting to the local commercial institution to access credit for payment of medicine products and health care services.

6.2. Further Research

In advancement and innovation in Information and Communication Technology it is proposed that the following technology need to be incorporated in future E-Health care systems;

- (a) The patients would have devices inserted into bodies to monitor pulse rate, fever and heart complications. The information would then be monitored twenty four hours by health care providers.

- (b) Sponsors of health care projects and services would hold funds in controlled accounts and funds would be accessed electronically by beneficiaries whenever projects in progress or health care service provided are approved and payment ought to be made for the project or service. This would control and curb misuse and embezzlement of funds meant for needy and less fortunate persons in society.
- (c) All the systems would be integrated and data collected and updated regularly for researchers to analyse and disseminate timely results that would provide indicators for the following;
 - (i) Identify the outbreak of known and unknown diseases that may cause loss of life and seen as threat to human population for quick action measures to reduce further spread and harm to human population.
 - (ii) Monitor the trend of diseases and effectiveness of the medication as there is continued mutation of viruses and bacteria that cause or transmit diseases.

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