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Development of an Automated Healthcare Record Management System

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ABSTRACT

This project focused on the development of an electronic health record management system with a smartcard to improve University of Ilorin health record management service. This represents a transition from the traditional paper-based patient record keeping to a more a sophisticated electronic/computer-based format. The software was created with XAMPP platform and QR code generator was used for the accompanying smart card. MySQL was used to create the database and Hypertext Markup Language (HTML), Hypertext Preprocessor (PHP), CSS and Javascript were used for the design of the interface, styling and sending of queries. The database was connected with the Hypertext Preprocessor (PHP) so that data can be selected and inserted into the database using server-side execution. Either username and password or smart card can be used to log in into various sections of the system. The developed system would see to the improvement in the University of Ilorin's health care record management when fully deployed, which would reduce problems associated with patients' records keeping and also increase the rate at which data is accessed, thus improving healthcare service delivery.

1. INTRODUCTION

Technology has aided the improvement of individual health, healthcare, biomedical research as well as public health through the science of bioinformatics (Shortliffe & Cimino, 2006). Therefore, healthcare institutions are seeking to develop integrated computerbased information-management environments to consolidate the inevitable application of big data to health care (Murdoch & Detsky, 2013). There exist various entry points into the clinical world where computational tools assist patient care matters; reporting results of tests, allowing direct entry of orders or patient information by clinicians, facilitating access to transcribed reports, and in some cases supporting telemedicine applications (Hartswood, Procter, Rouncefield, & Slack, 2003), because disorganized and incomplete patient records pose an obstacle to patient care.

The most common medium by which record of medical history are kept is paper (Mandl, 2001) making data management a serious impediment to productivity. However, the promise of a more efficient hospital service is obvious through the use of electronic health records management systems (Stroetmann et al., 2011).

Electronic health records may be alien to quite a number of health care facilities in Nigeria, but it has been in existence for nearly 50 years as various institutions have experimented since the 60s and 70s with various forms of electronic recordkeeping. Examples of early electronic systems include Health Evaluation through Logical Processing (HELP) (Demner-Fushman, Chapman, & McDonald, 2009), and Multiphase Health Testing System (MHTS), Computer-stored Ambulatory Record (COSTAR) (Barnett et al., 1979).

The increased security, mobility, convenience and speed requirements of modern healthcare information system (HIS) make the

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incorporation of smart cards a progressive possible solution since smart cards can provide security assurance and obviously solve the mobility problem. Smart cards can grant convenient and flexible access to patient data, to both healthcare professionals and patients. Many implementations of smart card-based systems have been theoretically studied; pilot projects have been funded, while some countries have adopted the use of smart cards. Smart cards can, therefore, be used in HIS that aim to keep an Electronic Health Record (EHR) for patients as an identification media (Stroetmann et al., 2011).

From the reconnaissance survey carried out in University of Ilorin Health Service, it is observed that medical records are being kept in physical folders and then placed on cabinets. It was also noted from the record section that patients (students and staff) records are stored in many formats and these results to disorganizations of the records, leading to a higher risk of medical errors, duplicate procedures, and time loss in searching and obtaining information.

Though paper-based records system provides accountability, it has its inherent challenges e.g. difficulty of access, time-consuming to update, it is not secured and it is impossible to swiftly share between different locations and maintain for a very long time without destruction (Amaechi, Agbasonu, & Nwawudu, 2018). An unfortunate disaster like a fire outbreak or damage by water could lead to the permanent loss of valuable patient data whose knock-on effect may be impossible to quantify. A fully electronic, nationalized, health records system could tackle and improve on some of these problems e.g. provide accountability, increase privacy levels since only authorized personnel can access a patient's record as opposed to a paper file, increase efficiency; such that patient data could be retrieved within seconds instead of going through numerous files and provide access to generic patient data using a smartcard (Mandl, 2001).

It is therefore the purpose of this research to develop a smart and secured healthcare record management system for University of Ilorin Health Service that will enable effective creation and management of patient's data, manage doctor's schedule, enable seamless transition of information from one department to the other, handles the accounting business of the health center and accurately archive the patient's information and diagnosis data.

2. METHODOLOGY

The methodology conforms to the following principles in order to design the record management system (Chudinov, Osipova, & Bobrova, 2017):

- The sequential approach in understanding expectative information needs and ability to modify the current descriptions
- Define information need as configurations linked to the typical data formats.
- Declaration of the relationships between data domains.

The database was designed following the steps outlined below:

- 1. Analysis of the system target, which is the representation of the user's information needs as a set of initial entities in the domain area.
- 2. Definition of the relationship between the various data set
- 3. Development of the database in MySQL using tables and allowing "Id" as the primary key

2.1 System target

A proper understudy of the records and process of the Unilorin Health Service was carried out through data gathering from various sources as shown in Table 1 in order to ensure appropriate enumeration of the various target of the system as it affects the various users. This enables the understanding of information needs and assignment of tasks to the various users in the different segments of the hospital (Sun & Jia, 2012).

Method	Data collected
Interview	Doctors and other personnel were interviewed to understand the standard operating procedure of the clinic
Hospital records	The kind of data required for every user was collected towards building the database.
Observation	The service level agreement of the clinic was deduced by careful observation
Literature	Books and Journals were consulted to understand the various need in building management software for the hospital

Table 1:	Methods	of data	collection
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After the various observation and consultation, the following required information is determined to be needed for the system. This determination is fitting to the defined need of the clinic. The information required for the hospital management system database are as follows:

- Patients main information
- Hospital staff main information and roles
- Medical condition
- The drugs dataset, laboratory test dataset and costing information for medical activities

2.2 System Development requirement

The system was designed to keep patients' inventory, drug inventory, test and laboratory inventory, pricing and personnel database with the most useful output being to be able to schedule a patient for consultation, to update medical record and keep a log of activities in various departments of the hospital. Therefore, developing the system entails having some hardware and software as well as a robust procedure (Akomolafe, Timothy, & Ofere, 2014).

2.2.1 Hardware

The hardware requirement refers to the tangible (physical) gadgets used for the development of the system and these are; Personal computer (PC) 4G RAM /240G hard drive with a core i3 processor or higher, cards and the inbuilt system camera was used as the scanner to scan the quick response (QR) code.

2.2.2 Software

Windows 8 operating system software was used. Cross-platform(X), Apache (A), MySQL (M), PHP (P), and Perl (P) (XAMPP) software was used in the project to host the database and makes the system run on a local host. MySQL in the XAMPP software package was used to create the database while the Apache makes the system run on a local host. A sophisticated text editor, Sublime text editor was used for coding and quick responses (QR) code generator was used to generate the QR code for the staff and patients for security and ease of accessibility.

2.2.3 Procedure

The development of the hospital management system was cascaded into three subgroups; application development, generating QR code, writing of QR Code to the card (smart card) and are all presented in the result section.

3. DESIGN, IMPLEMENTATION AND TESTING

3.1 Users and Roles

The designed hospital management system handles the patients experience from start to finish. The system receives input, stores/updates data, and outputs the required information. The primary user targets hosted on the management system are record officer (front desk), patients, doctor, pharmacist, laboratory attendant and account personnel, all of whom have different role assignments, functional requirements and varying interaction levels as depicted in Figure 1.

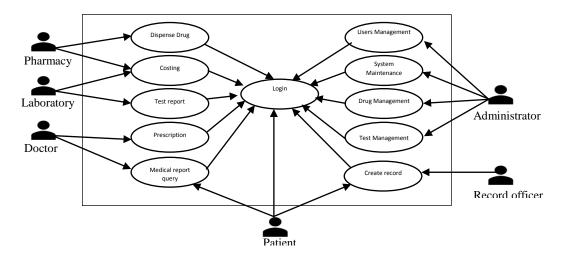


Figure 1: Use case function for the hospital management system

3.1.1 The Administrator

The administrator through the administrative section is the one who controls all of the systems. The administrator is the one that sets instructions to all the staff in the clinic; decides how the work will flow, handles new staff registration, set the functions of each section and their respective limitation, responsible for the drug/test management and the entire system maintenance.

3.1.2 The Record officer

The record officer mans the record section. This section is the first point of call when a patient visits the health centre. It is the first place the patient will go to when he/she goes to the clinic either as new patients or returning patients. The record officer can create new patient record and/approve the record created by a patient. Also, patients can book an appointment at the record section with their smartcard. After scanning by the scanner, the QR Code is authenticated, and thereafter the patient is added to the queue until a doctor picks up the patient from the waiting list. The queue list has three comments, which are: waiting - which means the patient is waiting for the pickup by the doctor; progress - which means the patient is still with the doctor and finished – which means the doctor is done with the patient.

3.1.3 The patient

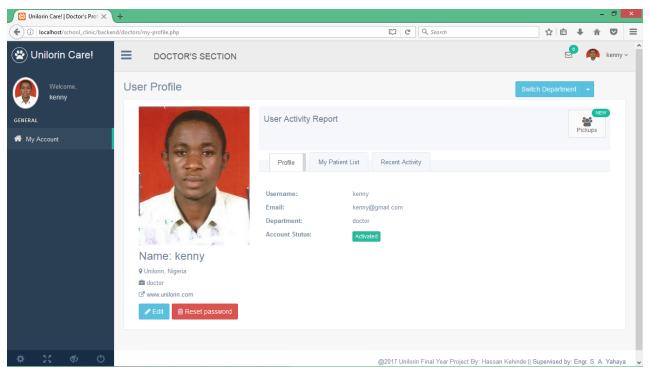
The patients are the primary clients of the health centre. The registration interface as shown in Figure 2 allows the patient to create new record if they are first time users. This section is used for registration where all the patients' data are collected and saved in the database. However, this would need approval from the record officer. Also, the record officer can create a record for patients who cannot use the self-service. The patient can also independently log in into the system to view reports.

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Figure 2: Registration interface

3.1.4 The Doctor' section

The section is the next section after the patient has made appointments from the record section. The doctor selects the patient from the queue, after which the patient's smartcard would be required to login to the patient's account and consultation would resume. The doctor would not be able to resume consultation session if there is no patient on the queue, or if the patient's smartcard is not available. The doctor can progress with consultation, make a request for tests or give drug prescription by clicking the relevant buttons e.g. laboratory request form or the medication button to prescribe a drug.



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Figure 3: Doctor's interface

3.1.5 Account section

This section handles the charges from every unit in the clinic. Pharmacists and laboratory attendants post the relevant bills to be paid by a patient. The section is designed in such a way that patients cannot proceed for a test or collect medications without visiting the section and settling the bills as contained on their account.

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Figure 4: Account section payment list interface

3.1.6 Laboratory section

This section is designed specifically for the laboratory attendant to administer. The doctor's request for a test is posted to this section, where billing is done, and a report is made available after the patient has made the required payments and undergone requested tests

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	3	Dr. kenny	Dada fisayowa	blood Test	Hepatitis Test	1 month ago	Posted	Waiting Confirmation	l
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Figure 5: laboratory interface when a test request is sent by the doctor

3.1.7 Pharmacy section

Pharmacy section is designed in such a way that the patient will have to visit the section after a prescription has been made by the doctor to collect the relevant medication. This section allows the pharmacist to post the cost of prescriptions to the patient's account, and medications would only be dispensed after payment. The pharmacy module display consists of the doctor's name the patient, medication date, payment and action. The payment row has two comments; 'posted' and 'paid'. The 'posted' is when the price of the drug has been posted to the account section and when the patient pays for the prescriptions the comment will change to 'paid'. For the action row, the 'waiting for confirmation' means the drug has not been dispatched to the patient and if that is done the comment will change to 'item collected'.

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Figure 6: Pharmacy section interface

3.2 Implementation

This phase consists of the source code, together with documentation to make the code more readable. The various interfaces were built where the patients, record officer, the doctor, pharmacist, laboratory attendants, account personnel interact with one another. The flowchart is given in Figure 7.

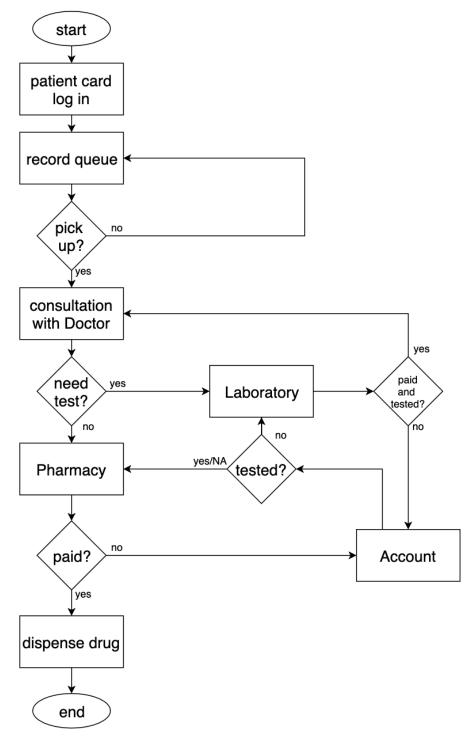


Figure 7: Flowchart for the designed hospital management system

3.2 Application Development

Developing the application entails the creation of the database, the creation of a graphical user interface and generating quick response (QR) code. The database for the university health clinic was created with MySQL software.

3.2.1 Designing the graphic user interface

The graphic user interface section was designed with HTML, JavaScript, CSS and PHP. These provided a friendly user interface for all users to input records or read information without coding. Being what the user sees on the screen, it was designed to be as simple as possible for ease of use.

3.2.2 Generating Quick Response (QR) Code

The QR code for patients and the staff in the clinic was generated with the QR code generator by inserting the required content that defined each user. For the patients, the user name and their matric number or staff identification number were used in the generation of their QR Codes, while for the staffs in the clinic their respective username and password were used. The generated QR Code was then printed to the back of the patients and clinic staff (Doctor, Pharmacist, accountant, and laboratory attendant and the records section) cards for easy accessibility to their various sections.

3.2.3 Database creation

The creation of the database aids the clinic to save and secure all the patients (staff and student) medical records. Tables were created to house the rows and columns where the patient's records were orderly saved. It was arranged in a row and column format which represents a field and the collections of the fields makes the records, while the collection of records created tables, the collection of tables formed the database. The database is very important in this system since one of the aims of the project is to secure patients record for a very long time compared to the paper-based system. The database can only be accessed by the administrator.

Database was created with SQL command mysql> "CREATE DATABASE databaseName"; The database name for the project is "unilocare" So, this was created as mysql> "CREATE DATABASE unilocare";

To create my 'patient profile' table:

mysql> CREATE TABLE patients'profile (

id	INT,
Title	VARCHAR,
First name	VARCHAR,
Middle name	VARCHAR,
Last name	VARCHAR.
Sex	VARCHAR,
Date of birth	VARCHAR,
PRIMARY KEY	(id)
);	

The primary key used in the table was the "id" which was the one that distinguished between the patients. Every table contained a primary key. The input design for patient data entry record is given in Table 2.

S/N	Field	Data Type	Relationship	Description
1	Patient_id	Varchar(30)	Primary keys	Access
2	Patient _first name	Varchar(30)	Not NULL	Patient first name
3	Patient _last name	Varchar(30)	Not NULL	Patient last name
4	Patient _middle name	Varchar(30)	Not NULL	Patient middle name
5	Gender	Varchar(10)	Not NULL	Gender
6	Age	Int	Not NULL	Student/Staff
7	Passport	Varchar(30)	Not NULL	Patient passport
8	Phone_no	Int	Not NULL	Patients phone number
9	Patient _type	Varchar(10)	Not NULL	Student/Staff

Table 2:	Input	design	for	patient	data	entry

Several tables were created to make up the database namely: login, diagnosis, prescriptions, medical history, medication information, patients' complaint, disease classes, symptoms etc. Figure 8 gives a snapshot of the database

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Figure 8: The snapshot of the database

3.2.4 Creation of the home page

The homepage was designed as the first page displayed to the user which consists of the following links: about, contact, scan-login and login link.



Figure 9: Home page

3.2.5 Login page

The login link was designed in two ways; via the smart card or the user password and user name. All users including patients and the clinic staff which includes; the doctors, pharmacists, laboratory attendances, accountants and the administrative staff can log in on this page. However, the only role a patient can play is to view reports. All other users can carry out duties according to the roles assigned to them.

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Figure 10: Login page

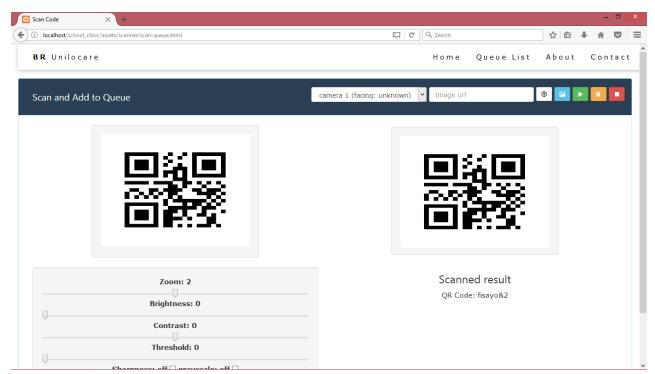


Figure 11: Scanning interface

3.3 SYSTEM TESTING

The system was tested in the department of Biomedical Engineering and the system assures its aim and objectives by solving problems associated with the conventional way the patient's records are stored and transferred as well as enabled fast data access within the university clinic. Primarily the system was set up on five (5) different systems on the same network and concurrent usage of different modules was carried out. Only the system set up as the server requires the XAMPP software while the other systems serving as the clients require only the web browsers. No untraceable bug was observed during this phase. The modules were worked on in parallel and periodic testing was done to ensure the performance of the system is accurately monitored.

3.4 SECURITY

The system is well secured in such a way that the user can access their section with their card or with their user name and password, preventing access by unauthorized users. The patient records are also secured because unauthorized users cannot access the patient's record without the consents of the patient. The administrative officer is the only person that has access to all the sections and can define roles for all other users.

4. CONCLUSION

The development of electronic health record undertaken by this research presents six sections which are; record, patient, doctors, account, laboratory and pharmacy but can seamlessly be expanded based on requirements. A database containing 37 tables was created for the University of Ilorin Health Service. Its interface allows smooth interactions between the various sections in the Health Service Center. Patient records were digitalized and tested with the developed system. Smart cards were produced for the patient, doctor, laboratory attendant, record attendant, pharmacist, and accountant to access their various sections. The electronic healthcare record management system reduces paperwork, enable fast and secured access to patients' data for authorized users and the problem of patient's records getting destroyed has been solved. The incorporation of the smart card ensures confidentiality and security of patient data, ensuring that only authorized personnel could access the system. This project can be scaled and implemented on a national level to ensure every Nigerian's health care data is secured and would ensure that health records are easily identified and data loss due to disasters or otherwise is mitigated.

Some future works are recommended to improve this system

- The security of the system can be increased by making sure some information such as the patient's medical history is encrypted.
- The hosting of the database on a web server, rather than a local host of intra connected systems
- Incorporation of report interface for data analysis

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