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Development of a Web-Based Software for Prescription Monitoring and Medicine Management in a University Healthcare Facility

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ABSTRACT

In a typical health care facility in Nigeria, pharmacy operations are laden with paper-based methods of documentation and routine tasks of medicine distribution. As a result, there are largely inadequate structures in place to monitor patients' prescription history and prevent impersonations and fraud. This study presents the development of a web-based system (PharmaPortal) to manage medicine inventory and prescriptions at the healthcare facility of the Obafemi Awolowo University (OAU), Ile – Ife. PharmaPortal was implemented with PHP, MySQL, JavaScript and CSS on Apache web server. The software is browser-based and was made accessible at various workstations within the Local Area Network (LAN) of the healthcare facility. Routine activities in five sections of the healthcare facility were digitized into six modules with each containing closely related tasks and activities within the sections. The use of PharmaPortal was shown to enhance the speed of patients' registration and information retrieval, as well as provide a simplified pharmacy inventory and prescription management. Most significantly, an evaluation of the system revealed an improved tracking of prescriptions through the use of patient identifiers which served to eliminate impersonation and reduce fraud.

Keywords:
Prescription monitoring, Pharmacy software application, Prescription electronic transmission, Pharmacy computerization

1.0. Introduction

Efficient management of prescription medicines in health institutions is central to the delivery of quality patient care services. Medicines have special importance in any healthcare system because they can save lives, improve health and promote trust and participation in healthcare services. Essentially, adequate management of medicines, prescription monitoring, and provision of relevant information could save money and improve performance of the healthcare system. However, provision of these services is hindered by lack of appropriate infrastructure and software to facilitate the required activities (Afolabi, *et al.*, 2009).

Meanwhile, Information Communications Technology (ICT) has great potentials to facilitate medicine supply and information management. Yet, the efficiency of institutional pharmacies in Nigeria is limited by the use of paper-based documentations (Afolabi and Oyebisi, 2007). For this reason, it becomes imperative to develop application software with embedded features to suit the required tasks and socio-cultural environment within which the technology will be used. Hence, there is the need to develop web-based software for medicine supplies and prescription management within healthcare facilities in Nigeria.

The healthcare services unit of Obafemi Awolowo University, Ile-Ife, Nigeria, was selected as the study site. This site was chosen because of the large and diverse population the unit serves. The complexity of managing diverse groups suggests difficulty in finding an off-the-shelf software application that is adequate and suitable. Currently, the student population is about 35,000 and most of them access healthcare at the university healthcare facility under the Tertiary Institution Student Health Insurance Policy (TISHIP). The staff strength in the university is equally large and a high percentage of these employees along with their dependants also access care at the health centre under the National Health Insurance Scheme (NHIS).

In the University's 2010 - 2015 Strategic Plan, it was shown that the University's management seeks to develop ICT to serve as the backbone of the University's development strategy in every service unit including teaching, research, innovation, administration, and health. As a result, the University is currently seeking partnership for investment in the development of ICT especially in the area of customized software. This makes this study more imperative.

2.0. Literature Review

Three categories of patients are recognised in the National Health Insurance Scheme (NHIS); patients with no health insurance coverage, patients on NHIS with a 90% discount and students on TISHIP with a full discount on medical bills. Abuse of the insurance scheme has been identified to be done mostly through indiscriminate prescriptions by doctors and impersonation by ineligible patients who take advantage of the provision for discounted medical bills under the insurance scheme. Other problems associated with the current medicine dispensing processes at the health centre include the following:

a. The scheme is prone to leakages as some individuals engage in fraudulent practices such as accessing the discounted medications more often than necessary for the purpose of resale.
b. Pharmacy staff are encumbered with routine tasks of paper-based inventory management and dispensing with little time for clinical tasks which require professional judgments.
c. Patient medical records and medicine inventory are poorly managed.
d. Difficulty in comprehending prescriptions due to illegible handwriting of some of the doctors

Presently, there is no suitable software being used for these tasks, most off-the-shelf software have either failed or produced inefficient results.

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2.1. Application software in pharmacy operations

Automated systems have been developed for various aspects of hospital pharmacy operations such as dispensing prescriptions, inventory control, management of patient queues and maintenance of prescription records and medical information (Burleson, 1982; Murray *et al.*, 1998; Slee *et al.*, 2002). Other relevant applications were developed for the provision of medicine information and

clinical services such as medicine use review, pharmacokinetics, medicine interactions and surveillance of therapeutic incompatibilities. Similarly, interest in automation for pharmacy practice has stimulated the development of commercial hardware and software packages designed for pharmacy systems. Slee *et al.*, (2002) described an automated dispensing system and its positive impact on staffing requirements, prescription turn-around time, error rates and procurement of medicines. There are other software applications designed to support various pharmacy operations in the health facilities. For instance, the US Naval hospital pharmacy introduced a software application to manage patient waiting time. Similarly, the Q-Matic system is a patient queuing system which was found to improve pharmacy efficiency thus resulting in decreased waiting time and increased medication counselling opportunities. A computer programme, the Waiting Time Manager (WTM, version 1.0), was installed on a dedicated personal computer in a dispensary in the UK (nCare Software Systems Ltd., 2000). The WTM logs a prescription on arrival in the dispensary and the dispensing time is used to calculate the average waiting time. Results of the study showed that the computerised prescription log was associated with a reduction in patient waiting time and was also found to attend to prescription related enquiries. These application programmes served as tools to assist in monitoring prescriptions, enhancing pharmacy workflow and reducing patient waiting time.

In Nigeria, a similar study was carried out in Jos University Teaching Hospital to assess the effects of a computerised hospital pharmacy and patient medical records system on the delivery of pharmaceutical care (Dikwal *et al.*, 2005). In the study, a computer programme was designed to link the patient medical records, the pharmacy unit, and medical diagnostic laboratory with consulting units. The pharmacy segment consisted of an inventory programme, which allowed the pharmacist to have access to the central store's stock level, medicine indication, possible side effects, precautions and adverse consequences of the medicine. Prescriptions could be sent on-line to the pharmacy unit and the doctor could also make laboratory requests on-line and obtain the results by the same medium. The findings of the study demonstrated a reduction in patient waiting time for registration and retrieval of medical records. The tasks of medicine inventory management were simplified with enhanced speed of stock ordering. Furthermore, the application software improved communication among members of the health care team, thus allowing proper coordination of patient care.

Medikip (Digxi, 2011) is a commercial software designed in Nigeria, to make a drug store run efficiently and profitably with ease. These features include the tasks of inventory management and pricing. The software recognises the unique tasks involved in managing inventory in community pharmacies. Another commercial pharmacy software was developed by Mayjorad, a multinational company with a corporate head office in Lagos, Nigeria. The software automates key activities including inventory management, regulatory compliance, and dispensing of prescriptions. Another comprehensive pharmacy management software solution, RxLink was developed by Netsmart Technologies. This software supports key pharmacy functions and processes for inpatient facilities that operate their own pharmacies (RxLink, 2011). RxLink can be operated as a stand-alone pharmacy management system for hospitals, or can be integrated with Netsmart's Computerised Doctor Order Entry (CPOE) or with the electronic Medication Administration Records (eMAR) to achieve a Closed Loop Medication Management.

All these software do not take into cognisance the issues relating to the NHIS and are therefore unsuitable for medicine management at the site of this study.

2.2. Software implementation tools

Certain tools are essential in the implementation of software and some of these are discussed as follows:

(i). **PHP:** PHP is a server-side scripting language, which means that the scripts are executed on the application Server (Valade, 2004). It was used to execute series of instructions pertaining to the operation of the requirements gathered. It also contains a series of instructions that can accomplish tasks from designing Web pages to navigating

file systems and making a database connection. The PHP software works in conjunction with HTML and CSS. Unlike JavaScript that is a client side programming language whose operation is transparent to users, PHP runs on the server side which makes it more secure.

(ii). **Apache Web Server:** Apache is the Web server used in this project. Its main job is to interpret any file requested by a browser and display the correct results according to the code within that file. Apache is quite powerful and can accomplish virtually any task that a Webmaster requires (Michael *et al.*, 2004). Several Web servers are available out of which Apache and Microsoft IIS (Internet Information Server) are the most prominent. However the Apache was chosen for this project since it is available for all the major operating systems such as Linux, Microsoft Windows and Apple OS unlike IIS that only runs on windows. MySQL runs with the Apache and this is discussed in the next section.

(iii). **MySQL Database:** The MySQL database system uses a client-server architecture that centers on the server. The server is the programme that actually manipulates databases. Client programmes do not manipulate databases directly but rather they communicate an intent or request to the server by means of queries written in Structured Query Language (SQL). The client programme is installed locally on the machine from which MySQL may be accessed (Paul, 2002). The typical client programme suitable for the application access is the Google Chrome. The choice of MySQL database is made in this application because of its flexibility, power and performance. It could be recompiled for specific purposes (e.g., security or performance), and it offers different storage engines, out of which InnoDb is used for this project because of its suitability for transactional applications.

(iv). **JavaScript and JSON:** JavaScript is a client side programming language. It is employed in the project because of its quick response in validating user's input and its seamless interoperation with PHP in fetching data from the server. Thus it enhances the usability of the system by providing quick response and interaction. JavaScript Object Notation (JSON) is a lightweight data interchange format (Douglass, 2008). JSON is based on JavaScript's object literal notation. However it is language independent. Thus, its use in the project facilitates data transmission as patient records (fetched from the records department) and prescription details are usually in JSON form.

3.0. Methodology

An in-depth requirement analysis and software requirement was conducted using a focus group discussion. This led to the design and implementation of the software. The focus group consisted of five doctors, four pharmacists, the NHIS desk officer and the head of medical records unit. Purposive sampling method was used to select doctors and pharmacists within the ranks of senior and principal officers. The healthcare facility had a total of fifteen doctors and six pharmacists at the time of study. Secondary data were obtained from the pharmacy store, using the stock control records.

3.1 Requirement analysis

The doctors described the requirements for writing prescriptions for patients in the health facility. Patient information was obtained from the medical records and the NHIS office. An extensive study was conducted on inventory management of medicines in the pharmacy. This includes the method of ordering stock, arrangement of stock on the shelves and system of monitoring expiry dates of medicines.

Obtaining the basic requirements for the implementation of the system involved detailed documentation and categorisation of the activities of each user while taking note of exceptional cases. The identified users of the system were doctors, pharmacists, cashiers, insurance desk officers and the medical records officers. The use-case diagram in Figure 1 below illustrates the major roles of each user. For example, the medical doctor performs two tasks. This includes sending prescriptions and checking drug information. The tasks performed by other users are identified by the lines linking the tasks and the users. A set of tasks performed by the system are placed in a rectangle without any line linking them.

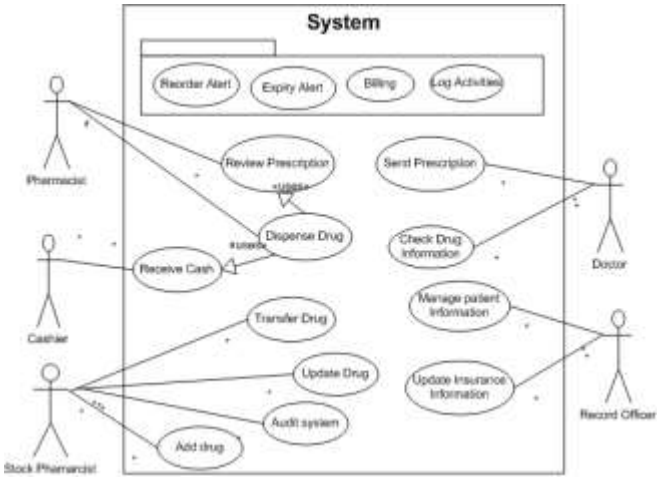

Figure 1: System Use-Case

3.2. Software requirements

After gathering all the requirements and information, it became clear that the software would have to be accessed from different units within the health care facility. This informed the decision to make the software browser - based in order to enhance reachability from multiple users.

The Central Computer (server) to which all other computers (clients) are connected runs Linux Operating System on which LAMP is installed. LAMP is an acronym of a software bundle. It refers to the first letters of Linux (operating System), Apache Server, MySQL (database software), and PHP (Perl or Python).

The configuration of the server is as follows: 4 GB RAM and 4.4GHz processor speed to facilitate quick response to user requests. The software was deployed on a Local Area Network (LAN) such that all computer systems on the LAN can access the software within the Health Centre. The system was implemented with PHP, MySQL database, Apache Web server, JavaScript and CSS. The implementation tools were discussed under the literature review.

4. Implementation and Discussion

The implementation details of the software, its architecture, database design and data flow are discussed. Processes which run behind the scene are also examined in the following sections.

4.1. Database design

The database is the most important part of any transactional system, thus *PharmaPortal* design and implementation started from the database. After a thorough analysis of the requirements, it was realised that eleven (11) tables would be required for the system implementation. A table is a structure containing fields across it in one dimension defining the structure of records repeatedly added to it. For instance, each of the drugs in a drug table is a record with fields consisting of drug name and dosage form. Figure 2 shows the relationship between the tables. For instance, the table 'central_stock 'has relationship with tables 'drugklass', 'central_stock_tally', 'drug', and 'medication'. The relationship between 'central_stock' and 'drugklass' is such that several drugs in the 'central_stock' can belong to a single 'drugklass'. A drug record is made up of its fields (ID, drug name and generic_name) as shown in the database table 'central_stock'.

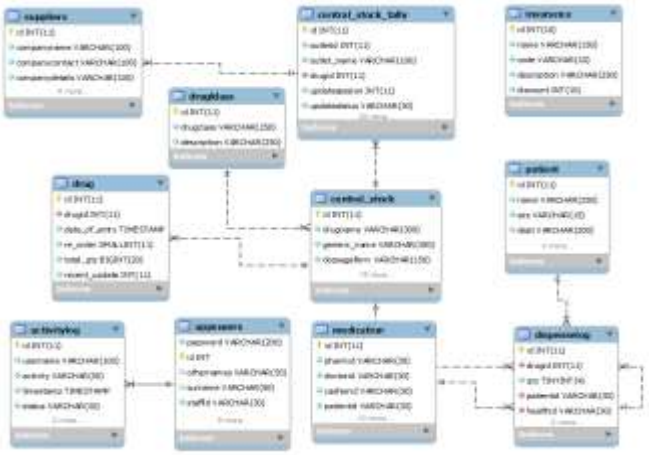

Figure 2: PharmaPortal Database Model Diagram

4.2 Software system architecture

The architecture of the *PharmaPortal* is shown in Figure 3 and comprises of the Server, Client (user access point), and the Database.

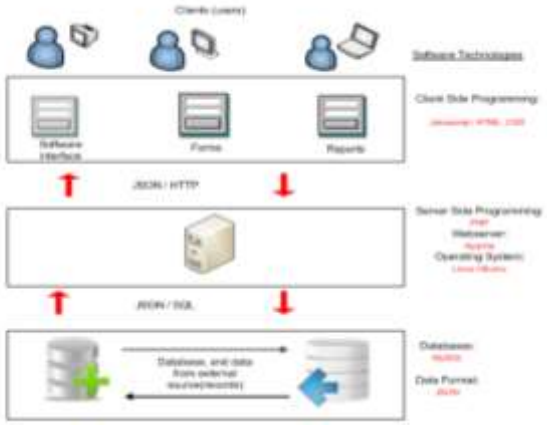

Figure 3: PharmaPortal Physical Architecture

The Client refers to the browsers on computers through which the user accesses the software. The client is the presentation layer where the user requests are fed into the system and gets feedback. The implementation technology at this level is JavaScript, HTML and CSS. Almost all the processing is done on the server and it contains Apache (web server) which is responsible for communications between the client and the database, which stores all the data.

4.3 Software modules

Logically, *PharmaPortal* is made up of 6 modules namely: Administrative, Inventory, Dispense, Prescription, Records and Payment modules. Table 1 shows the tasks captured in each module. To access any of the modules, the user is presented with a login page which is shown in Appendix 1. The login page has hyperlinks to the general software help manual, and display slides showing information related to drug usage. The interface to each of the modules is presented in Appendices II to VII. Appendix VIII depicts pop-ups available in all the modules to display the patient's information and passport photograph to prevent impersonation.

4.4 System activities (operation)

The activities of the system can be broadly classified into inventory management and electronic prescription. Figures 4 and 5, describe the system's activities.

The oval shape represents the action or state of the system, while the rhombus shape represents the decision state of the system. A typical prescription follows the sequence of activities as shown in Figure 4, which makes up the electronic transmission of prescriptions. The process starts when the patient enters the clinic and ends after he/she has received the prescribed medication.

Figure 5 shows the electronic inventory management processes and the roles a stock pharmacist and medicine product suppliers (company) play in the system. As the stock pharmacist logs into the system, the system checks the reorder level of each product and displays an appropriate message to the stock pharmacist who then decides whether to place an order to the supplier or not.

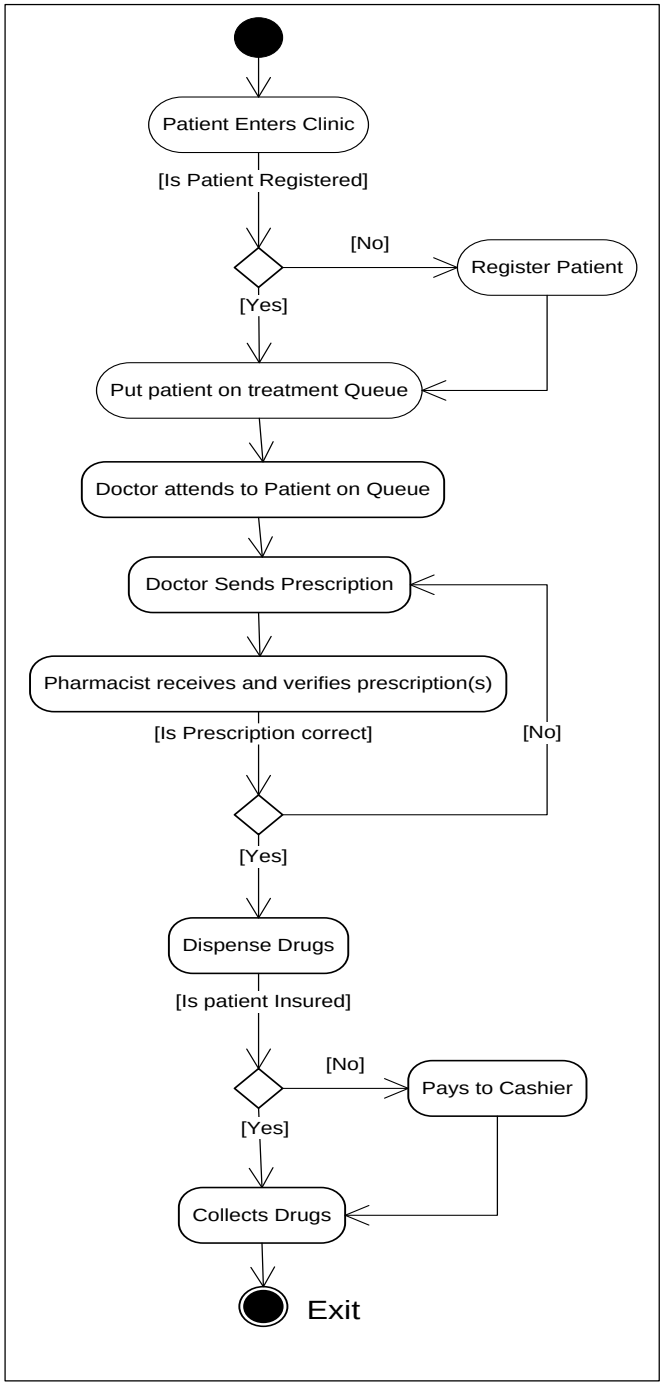

Figure 4: Electronic Prescription Activities

4.5.1 System security

Apart from the network firewall and other network security features on the LAN of the healthcare facility, a unique username and password system was also implemented for each user who can only access it within the clinic (specified IP range). Each client system (computer) would be pre-registered, such that only registered systems would be able to access the application to prevent intruders and/or imposters on the network.

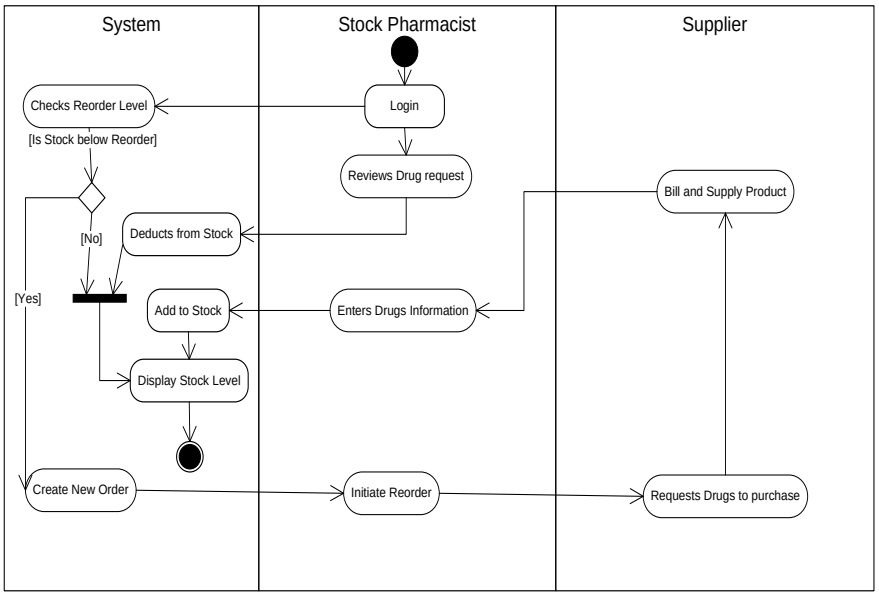

Figure 5: Electronic Inventory Management Processes

4.5.2 The Pharmaportal

The software was implemented, tested and evaluated. The process was performed repeatedly until satisfactory results were obtained in line with defined objectives.

The resulting software, *PharmaPortal*, is a computerized hospital pharmacy system that facilitates electronic transmission of prescriptions from the doctors' consulting rooms to the pharmacy unit of the health facility. It may also be useful in medicine inventory management and prescription monitoring through authentication of the patient's insurance status before the prescription is filled. The system consists of receiving by an electronic prescribing application, a request for information by the prescriber on the medicines in stock by therapeutic category and possibly its generic equivalents. Similarly, the price of a prescription can be retrieved with the necessary details on display.

Patient information can also be obtained from the medical records and National Health Insurance Scheme (NHIS), with two unique identifiers, consisting of the hospital ID number and the NHIS number of the patient. Categories of patients are created by the system administrator and the system calculates the patient's bill based on applicable insurance status of the patient. This can eliminate fraud, impersonation and mistakes in billing

All prescriptions transmitted to the pharmacy are served on first-in-first-out basis except in emergencies as specified by the prescriber, in which case emergency prescriptions take precedence. Patient identity is verified by displaying the identification number including the photograph of the patient. Uninsured patients are billed the full cost of items on the prescription. This can reduce patient waiting time and prioritise emergency cases.

5. Conclusion

The software was designed to track dispensing of medicines and prescription details, patient prescription history, inventory management of medicines in the pharmacy, online chatting to facilitate effective communication among the users, automatic billing, patient registration and identification, and management of cash receipts.

The software is scalable and flexible such that it could meet any surge in service. This flexibility allows redefinition of users' roles and permission at any point of usage, reclassification of medicines into classes and sub classes, setting of reorder level, addition or reclassification of the medicines and the capability to facilitate offline prescription and dispensing of medications to accommodate emergency cases and power outage. It is also modularly designed such that it could be expanded easily and interoperates with other emerging systems.

Apart from security features on the LAN of the health facility, the system required unique

username and password for each user, only registered systems on the LAN and those within a specific IP address could use the software, the system automatically log all action performed by a login user and the system administrator may disable any user with suspicious activity at any point in time.

6. Future Research Directions

Areas of further study include online telephoning to facilitate improved feedback system, self-check-in by patients, referrals from other hospitals, labeling and possible use of barcode reader for improved security and to facilitate automated drug information update.

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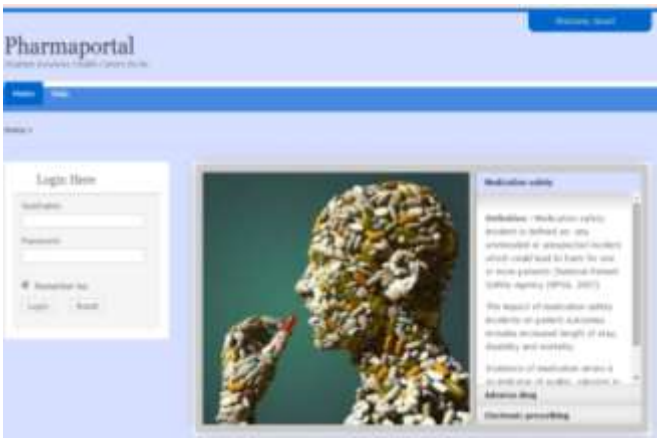
Table 1: Description of Tasks in each Module of the Software

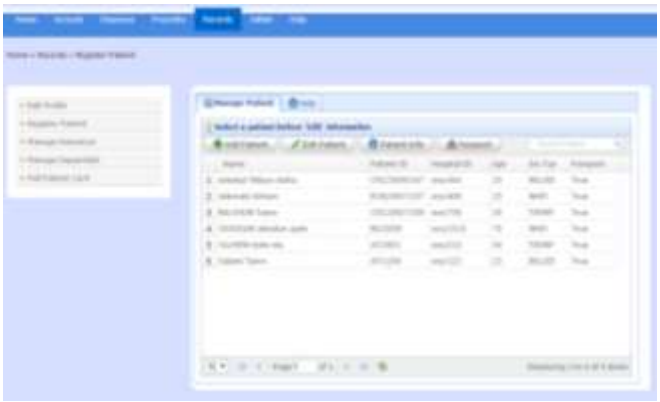
Module	Task /Task Description
Administrative	➢ Edit Profile - user changes password and update other personal information ➢ Stock Movement – authenticate drug movement from the central stock to dispensing and other units. ➢ Manage Users - register new user, and set roles and privilege ➢ Set Routine - add or remove drugs as a routinely used drug ➢ Stock Tally - Print stock tally of respective drugs within a specified date ➢ System Audit - dispense drugs, prescriptions and other users activities. ➢ Account preview – check daily payment history
Dispense	➢ Dispense drugs - dispense prescribed drugs ➢ Reject Prescription - Print stock tally of respective drugs within a specified date ➢ Check Medication History – view the history of drug received by the patient in the recent times ➢ Confirm Identity – view patient information including its passport photograph to confirm patients identity ➢ Offline Dispense – dispense drugs that might not be prescribe electronically

Table 1 Continued: Description of Tasks in each Module of the Software

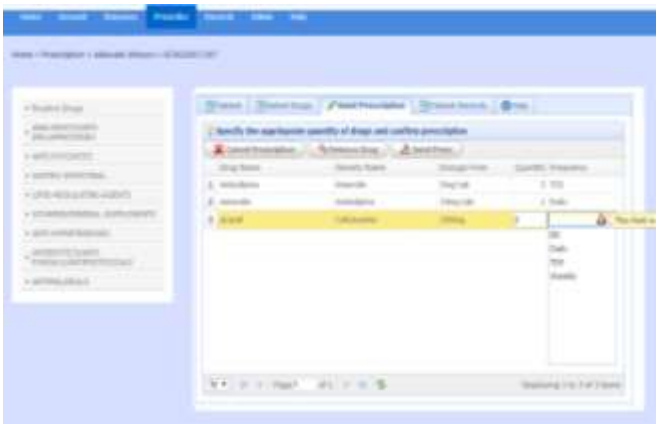
Module	Task /Task Description
Prescription	➢ Prescribe Drugs – electronic transmission of prescription
Inventory	➢ Add drug – add new drugs that might not be present in stock before ➢ Update drugs – add more quantity to existing drugs electronically ➢ Update History – view update history ➢ Reorder Level – set drug reorder level
Payment	➢ Receive Payment – enable prescriptions to be dispensed after payment ➢ Update drugs – add more quantity to existing drugs electronically ➢ Discount – automatically calculate the discount for patients based on their insurance policy.
Records/ NHIS	➢ Register Patient – add new patients ➢ Update Patient data – update information ➢ Register Insurance – add insurance information of each patients



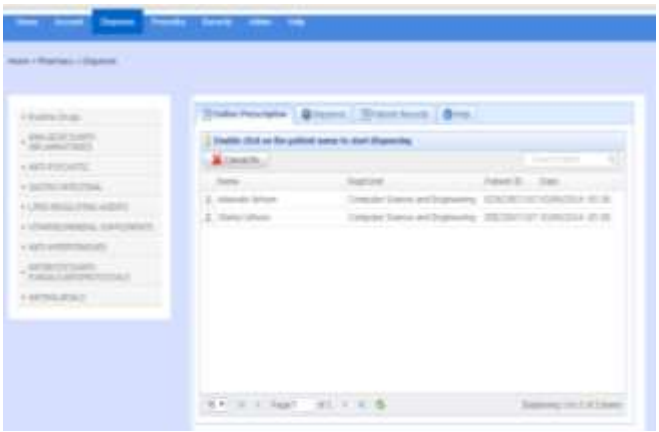
Appendix I: Application Home Page.



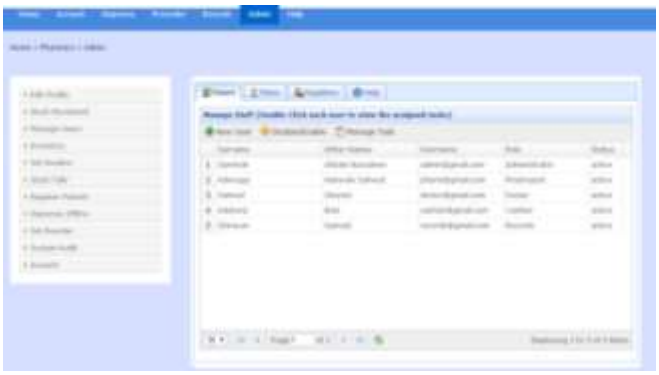
Appendix II: Interface to the Records Module.



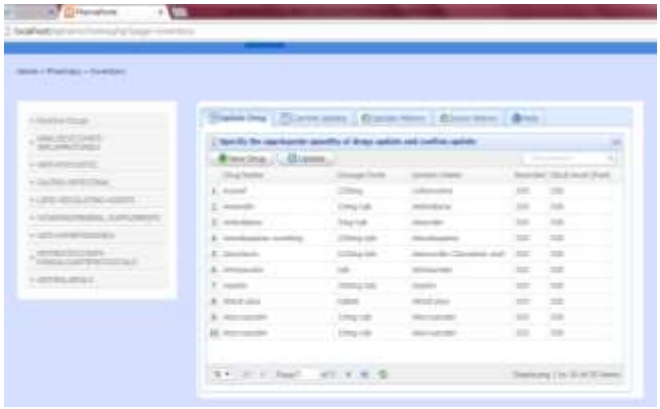
Appendix III: Prescription Module



Appendix IV: Dispense Module

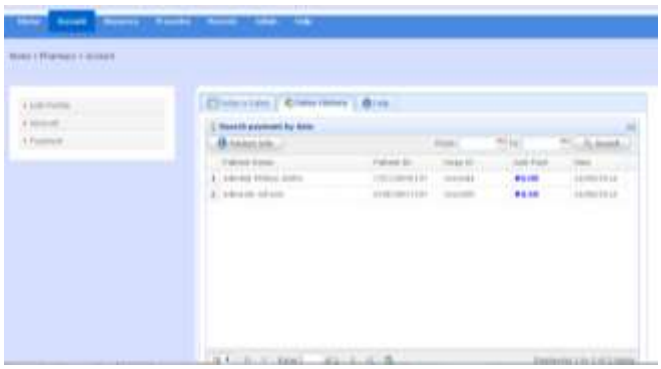


Appendix V: Administrative Module



Appendix VI: Inventory Module

Appendix VIII: Patient Information Pop-up.



Appendix VII: interface to the Payment Module