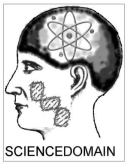
British Journal of Mathematics & Computer Science
15(5): 1-13, 2016, Article no.BJMCS.23954
ISSN: 2231-0851

SCIENCEDOMAIN *international*
www.sciencedomain.org



Design of an Integrated Computerized Pharmacy Inventory Monitoring System (ICPIMS): A Case of University of Calabar Teaching Hospital (UCTH)

I. Ele Sylvester[1*], W. A. Adesola[2], A. O. Ofem[1] and P. A. Ackley[3]

[1]Department of Computer Science, University of Calabar, Cross River State, Nigeria.
[2]Department of Computer Science, Cross River University of Technology, Calabar, Cross River State, Nigeria.
[3]Department of Nursing Science, University of Calabar, Cross River State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author IES designed the study, wrote the abstract, handle the methodology and database design, and supervised the work. Authors WAA and AOO carried out literature searches and edited the manuscript and the database integration. Author PAA provided and compiled the drug and pharmacy information. Author IES wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJMCS/2016/23954
Editor(s):
(1) Doina Bein, Applied Research Laboratory, The Pennsylvania State University, USA.
(2) Qiang Duan, Information Sciences & Technology Department, The Pennsylvania State University, USA.
(3) Tian-Xiao He, Department of Mathematics and Computer Science, Illinois Wesleyan University, USA.
Reviewers:
(1) Kexin Zhao, University of Florida, USA.
(2) Anand Nayyar, KCL Institute of Management and Technology, Jalandhar, Punjab, India.
(3) Anonymous, Rzeszow University of Technology, Poland.
Complete Peer review History: http://sciencedomain.org/review-history/14041

Original Research Article

Received: 30th December 2015
Accepted: 4th February 2016
Published: 6th April 2016

Abstract

The healthcare sector today are looking for opportunities to improve their daily operations efficiencies, increase pharmacist and pharmacy technician efficiency and improves patient care by promoting medication dispensing accuracy and allowing pharmacists to spend more time on patient care activities. The aim of this work is to design and model an Integrative computerized pharmacy inventory system that would have the capability to improve patient care by promoting medication dispensing accuracy and also allow pharmacists to spend more time on patient care activities, using University of Calabar Teaching Hospital (UCTH) pharmacy as a case study. The specific objective of the system is to provide better

**Corresponding author: E-mail: el_silver2@yahoo.com;*

security by more securely controlling access to medications in the pharmacy, Saves space – reduces pharmacy storage footprint, aids in Joint Commission compliance by providing complete audit trail of all transactions. In this paper we adopted the structured system analysis and design methodology (SSADM). UML (Unified Modeling Language) is used for the model design. The interface between the front-end and the back-end is through SQL (in WAMPSERVER) and through an application program interface (API) defined in PHP. PHP is used as back-end for managing access structures, query evaluation and optimization, concurrency control and recovery. NetBeans IDE was used as front-end to develop forms, report-trail, and graphical user interface.

Keywords: Pharmacy; inventory; drug; inventory.

1 Introduction

Records are subject to auditing from time to time or when there is information of appropriation indecorous record-keeping or there is case of theft, inferno or flood. Errors on report should be precisely cancelled out and signed for but not wiped out. Records should be completed in the dispensary each day, and not afterward. This will facilitate straightforward compilation of drug utilization and cash receipts. Inventory is a subject in business that is hope can minimize profit. In healthcare industry, inventory management system can handle their inventory particularly in pharmacy department. These consist of all activities such as transaction, order items, item movement tracking, financial management, report generation amongst others [1].

Drug inventory management can be a frustrating and onerous work. Each day, hospital pharmacist/pharmacists in general must procure and return orders to wholesale suppliers. Pharmacist verifies the drug supply in each pharmacy section in the hospital every now and there. Automation in inventory management as well as procurement control would help enthusiastically [2]. In hospital, pharmacists are inadequate staff principally due to hospital financial plan that is also under pressure to adapt to various changes in health care administration and delivery [3].

Examples of automation used in hospital pharmacy practice include computerization, automation of dispensing and bar coding (automation in drug distribution processes). Many hospitals continue to face the problem of ineffective and inefficient medication distribution systems. Automation in the drug distribution is useful in creating new medical services [4]. This study intend to design an integrated drug inventory monitoring system in academic pharmacy settings, that will help to improves patient care by promoting medication dispensing accuracy and allowing pharmacists to spend more time on patient care activities.

The focus of this study is rested on the design and modeling of drug inventory system. It is hope that this article will serve as a reference source for students, professionals' application developers, and scholars. As a reference material, it could generate other researchers' interests in the unfinished part of this research, especially in the full implementation and deployment of the system.

1.1 Drug characterization

A drug can be defined as a chemical substance that affects the processes of the body or mind; it is any chemical compound used on or administered to humans or animals as an aid in the diagnosis, treatment or prevention of disease, or other abnormal condition, for the relief of pain or suffering, or to control or improve any physiologic or pathologic state; moreover, a drug is a substance used recreationally for its effects on the central nervous system [5]. In pharmacology, a drug is "a chemical substance used in the treatment, cure, prevention, or diagnosis of disease or used to otherwise enhance physical or mental well-being [6].

Drug should be available and accessible at all times, in the appropriate dosage forms and at prices affordable to all. This does not in any way imply the diminution of the usefulness of any drug that may not be on any given essential drug list. It is a mindful attempt to make the most of available resources on the most essential drugs of importance to the majority of the hospital community and patience whilst identifying the competition in the public sector.

1.2 Pharmacy description

Pharmacy is the place where most pharmacists practice the profession of pharmacy. It is a community pharmacy where a dichotomy of profession exists- health professionals who are also retailers [7]. Pharmacists are professionals with specialized education and training who performed various roles to ensure optimal health outcomes for the patients through the quality use of medicines. Pharmacist may also be small-business proprietors, owning the pharmacy in which they practice. Pharmacists are represented internationally by International Pharmaceutical Federation (FIP), and represented internationally by various national professional organizations. Varieties of pharmacy occupational settings are academic pharmacy, Ambulatory Pharmacy, Community pharmacy, Consultant pharmacy, Federal pharmacy (armed services), and Federal pharmacy (public health) [8].

1.3 Pharmacy distribution

Drug distribution follows the orders below [9].

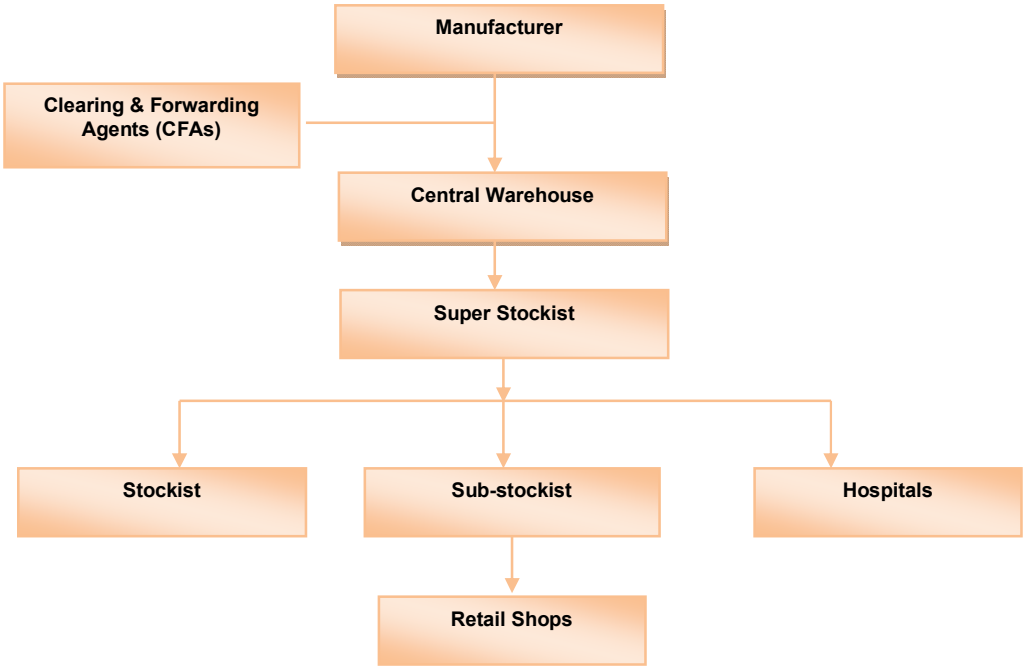


Fig. 1. Drug distribution order
(Source: www.biopharminternational.com, 2008)

CFAs (Clearing and Forwarding Agents) are organization primarily responsible for maintaining storage (stock) of company`s products and forwarding SKUs to the Stockist on request. Most companies keep up to 1 – 3 CFAs.

Stockist – Is the distributor, who can simultaneously handle more than one company usually 5 – 15 depending on the city area.

The Retailer Pharmacist – obtains products from the stockist or substockist through whom it finally reaches the consumers (Patients) [10].

2 Model Design

Pharmacy services, especially the academic pharmacy are more effectively provided via corporate services delivery model from a centralized location to more than one facility in the organization. The following are example of pharmacy corporate services; Ambulatory clinic, Billing, Chemotherapy management, financial management, investigational drug, pharmacy informatics, policy & compliance, procurement, and technician program. We shall adopt this service model in our proposed system.

2.1 High level diagram of the proposed pharmacy inventory system

The High-level diagram (HLD) of the system is presented in Fig. 2. The HLD explains the architecture of the **ICPIMS**. It presents the general idea of the **ICPIMS**, and also identifies the main components that make up the **ICPIMS** with its interfaces.

3 System Analysis and Methodology

The design model adopted in this work is the structured system analysis and design methodology (SSADM). UML (Unified Modeling Language) is used for the model design of this system. The UML is now the most widely used graphical representation scheme for modeling object systems. An attractive feature of the UML is its flexibility. UML modelers are free to use various processes in designing systems. The UML is a complex, feature-rich graphical language [11,12].

The UML specifies diagram for documenting the system behaviour. In this paper work, three UML diagrams (use case, class and activity diagrams) are used to explain the behaviour of the components of the database system. We employed MYSQL as the database engine because of its extreme power, security and scalability, speed, which makes it an ideal database solution for web sites, its ability used in both embedded system and large scale information system, available of its APIs in various programming language platforms including Java, C++ and PHP. The MySQL engine is available for both transactional and non-transactional operations.

3.1 System design

The system will be model using the Universal Modeling Language (UML) as a tool. The components identified in section (2.0) will constitute the classes since they are centralized for integrative interactions.

3.1.1 Use case diagram

The use case diagram of the ICPIMS is presented in Fig. 3. In the use case diagram, the hospital Chief Medical Director (CMD) access drugs procured, activities in the ambulatory and chemotherapy unit directory via the platform, view the state of accounts etc. pharmacists registers drugs access billing records etc.

3.1.2 Class diagram

The classes required to build the computerized Pharmacy Inventory System are identified and are implemented using java Netbeans as the front-end and PHP as the back-end. There are as those identified in the Use Case Diagram. For lack of time, this paper will capture the following subsystems (modules) as class; Chemotherapy, Pharmacy Informatics, billing, Ambulatory Clinic, Financial management, and Drug Registration Subsystem (classes) as shown in Fig. 4.

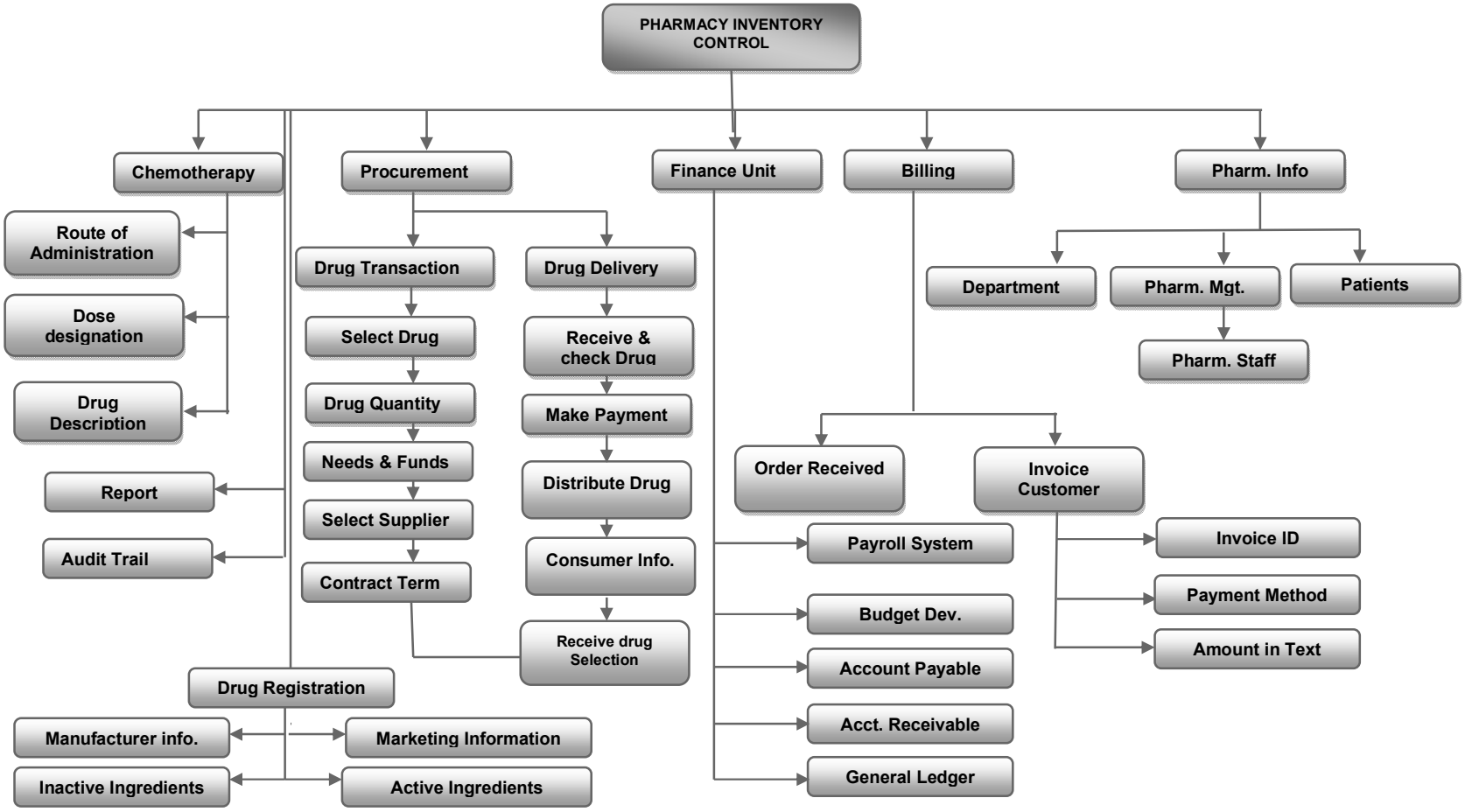


Fig. 2. High level diagram of the ICPIMS

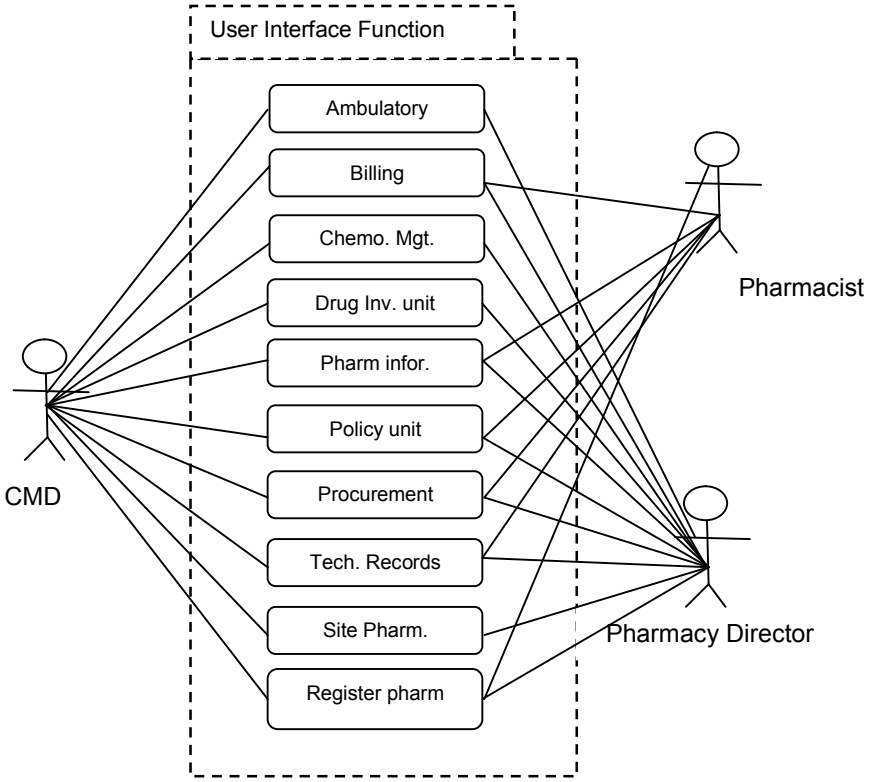


Fig. 3. Use case diagram of the proposed system

3.2 Database design

The database detail model of our work is presented. The logical model containing all the needed logical and physical design choices and the physical storage parameters for generating a design in DDL (Data Definition Language) are defined in this work. Most test parameter(s) used in this work to represent a particular object or entity in the database definition table is for illustration purpose and does not necessary represent the based on fact information of that object. All entity tables in this work are defined using MySQL standard data definition language (DDL) in WAMPSERVER. The numbers of tables defined are limited to the scope of the work. The database schema for our system is presented as follows.

Table 1. Billing table

#	Name	Type	Collation	Attributes	Null
1	INVOICEID	int(10)			No
2	ORDER MADE	varchar(255)	latin1_swedish_ci		Yes
3	ORDER RECEIVED	varchar(255)	latin1_swedish_ci		Yes
4	DESCRIPTION OF DRUG	varchar(255)	latin1_swedish_ci		Yes
5	PAYMENT METHOD	varchar(100)	latin1_swedish_ci		Yes
6	INVOICE CUSTMER	varchar(255)	latin1_swedish_ci		Yes
7	AMOUNT IN TEXT	text	latin1_swedish_ci		Yes
8	AMOUNT IN FIGURE	bigint(19)			Yes
9	PAYMENT DATE	date			Yes

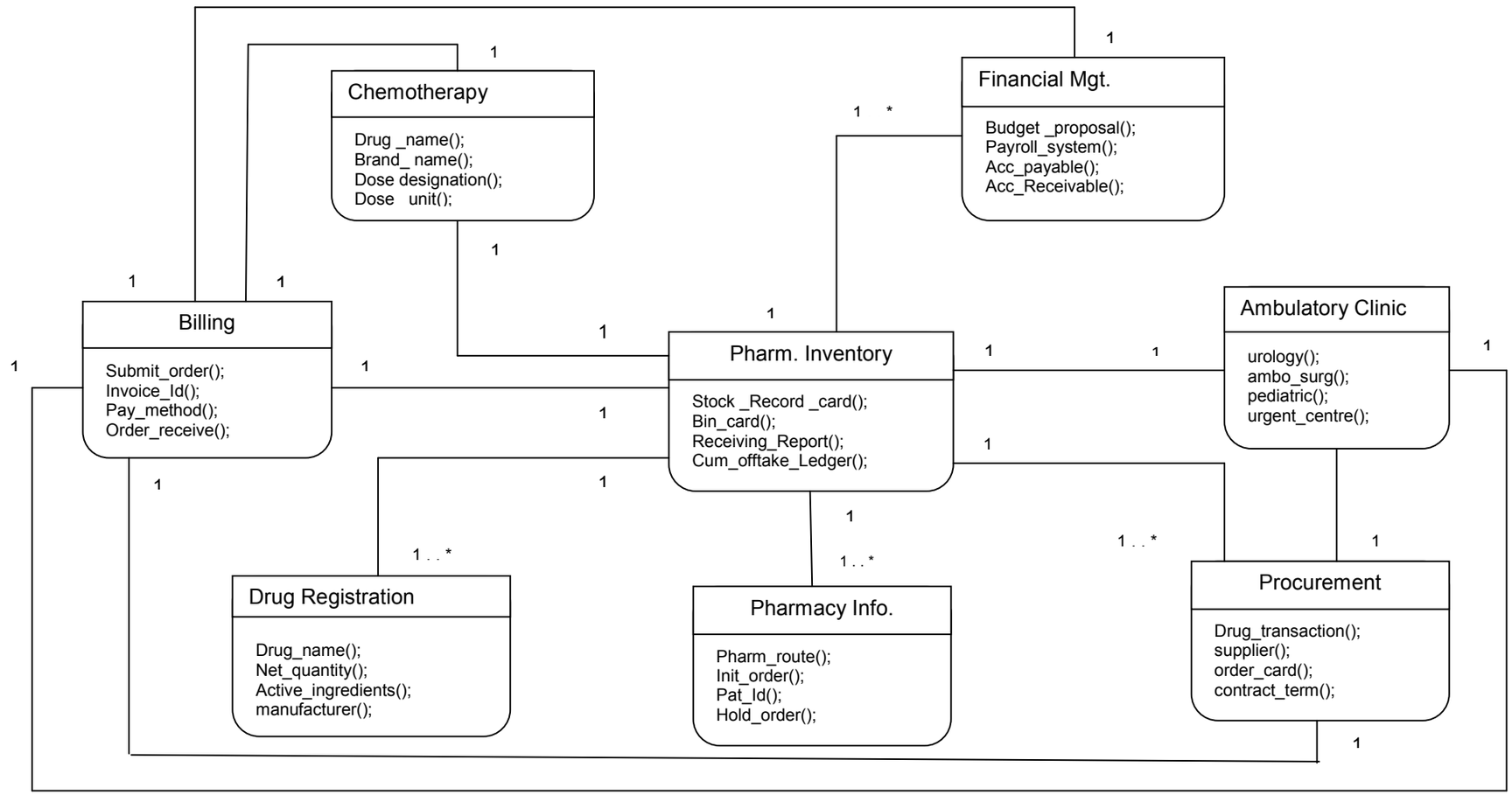


Fig. 4. Class diagram of the proposed system

Table 2. Pharmacy informatics table

#	Name	Type	Collation	Attributes	Null
1	PATIENT ID	int(10)			No
2	PATIENT NAME	varchar(255)	latin1_swedish_ci		Yes
3	PHARMACY PRESCRIPTION	varchar(255)	latin1_swedish_ci		Yes
4	PHARMACY ROUTE	varchar(255)	latin1_swedish_ci		Yes
5	OBSERVATION	varchar(255)	latin1_swedish_ci		Yes
6	PATIENT ALLERGY INFORMATION	varchar(255)	latin1_swedish_ci		Yes
7	COMMON ORDER INFORMATION	varchar(255)	latin1_swedish_ci		Yes
8	VISIT DATE	date			Yes
9	PHARMACIST COMMENT	text	latin1_swedish_ci		Yes

Swedish, case-insensitive

Table 3. Financial management table

#	Name	Type	Collation	Attributes	Null
1	HEADER ID	int(10)			No
2	BUDGET PROPOSAL	varchar(255)	latin1_swedish_ci		No
3	BANK STATEMENT	varchar(100)	latin1_swedish_ci		No
4	CONSOLIDATION STATE OF ACCOUNT	varchar(100)	latin1_swedish_ci		No
5	PAYROLL SYSTEM	varchar(100)	latin1_swedish_ci		No
6	BUDGET DEV	varchar(100)	latin1_swedish_ci		No
7	ACCOUNT RECEIVABLE	varchar(100)	latin1_swedish_ci		No
8	ACCOUNT PAYABLE	varchar(100)	latin1_swedish_ci		No
9	LEDGER NUMBER	int(10)			No
10	ACCOUNT REMARKS	text	latin1_swedish_ci		No

Table 4. Drug registration table

#	Name	Type	Collation	Attributes	Null
1	DRUG ID	int(10)			No
2	DRUG NAME	varchar(100)	latin1_swedish_ci		No
3	MANUFACTURER	varchar(100)	latin1_swedish_ci		No
4	BRAND NAME	varchar(100)	latin1_swedish_ci		No
5	MANUFACTURE DATE	date			No
6	EXPIRE DATE	date			No
7	INACTIVE INGREDIENTS	varchar(255)	latin1_swedish_ci		No
8	ACTIVE INGREDIENTS	varchar(255)	latin1_swedish_ci		No
9	PACKAGE SIZE	int(10)			No
10	PACKAGE TYPE	varchar(100)	latin1_swedish_ci		No
11	NET QUANTITY	varchar(50)	latin1_swedish_ci		No
12	CATEGORY	varchar(100)	latin1_swedish_ci		No
13	ROUTE OF ADMINISTRATION	varchar(100)	latin1_swedish_ci		No
14	START DATE	date			No
15	STOP DATE	date			No
16	NAFDAC	varchar(50)	latin1_swedish_ci		No
17	RECEIVED BY	varchar(100)	latin1_swedish_ci		No
18	CHECK BY	varchar(100)	latin1_swedish_ci		No
19	RECEIVED DATE	date			No
20	REMARKS	text	latin1_swedish_ci		No

Table 5. Chemotherapy table

#	Name	Type	Collation	Attributes	Null
1	DRUG ID	int(10)			No
2	DRUG NAME	varchar(255)	latin1_swedish_ci		No
3	GENERIC NAME	varchar(255)	latin1_swedish_ci		No
4	BRAND NAME	varchar(255)	latin1_swedish_ci		No
5	DOSE DESIGNATION	varchar(200)	latin1_swedish_ci		No
6	DOSAGE UNIT	varchar(200)	latin1_swedish_ci		No
7	ROUTE OF ADMINISTRATION	varchar(200)	latin1_swedish_ci		No
8	RATE OF ADMINISTRATION	varchar(200)	latin1_swedish_ci		No
9	MANUFACTURER	varchar(255)	latin1_swedish_ci		No
10	MANUFACTURE DATE	date			No
11	EXPIRE DATE	date			No
12	NAFDAC	int(9)			No
13	PHARMACIST REMARKS	text	latin1_swedish_ci		No

Table 6. Billing data table

INVOICEID	ORDER MADE	ORDER RECEIVED	DESCRIPTION OF DRUG	PAYMENT METHOD	INVOICE CUSTMER	AMOUNT IN TEXT	AMOUNT IN FIGURE	PAYMENT DATE
233	TETRACYCLINE INJECTION	TETRACYCLINE INJECTION	TETRACYCLINE INJECTION	CHEQUE	LAYA MATTHEW LAYA	SEVENTY EIGHT MILLION FIVE HUNDRED THOUSAND ONLY	78	2017-05-15
234							0	0000-00-00
345							0	0000-00-00
675							0	0000-00-00
7586							0	0000-00-00

Table 7. Pharmacy informatics data table

PATIENT ID	PATIENT NAME	PHARMACY PRESCRIPTION	PHARMACY ROUTE	OBSERVATION	PATIENT ALLERGY INFORMATION	COMMON ORDER INFORMATION	VISIT DATE	PHARMACIST COMMENT
9878							0000-00-00	
23435							0000-00-00	
45526							0000-00-00	
67579							0000-00-00	
908657							0000-00-00	

Table 8. Financial management data table

HEADER ID	BUDGET PROPOSAL	BANK STATEMENT	CONSOLIDATION STATE OF ACCOUNT	PAYROLL SYSTEM	BUDGET DEV	ACCOUNT RECEIVABLE	ACCOUNT PAYABLE	LEDGER NUMBER	ACCOUNT REMARKS
4563								0	
2435								0	
3452								0	
9875								0	
7856								0	
9807								0	
3452								0	

Table 9. Drug registration data table

DRUG ID	DRUG NAME	MANUFACTURER	BRAND NAME	MANUFACTURE DATE	EXPIRE DATE	INACTIVE INGREDIENTS	ACTIVE INGREDIENTS	PACKAGE SIZE	PACKAGE TYPE	NET QUANTITY	CATEGORY	ROUTE OF ADMINISTRATION	START DATE	STOP DATE	NAFDAC	RECEI BY
7				0000-00-00	0000-00-00			0					0000-00-00	0000-00-00		
6				0000-00-00	0000-00-00			0					0000-00-00	0000-00-00		
5				0000-00-00	0000-00-00			0					0000-00-00	0000-00-00		
2				0000-00-00	0000-00-00			0					0000-00-00	0000-00-00		
1				0000-00-00	0000-00-00			0					2015-12-28	0000-00-00		

Table 10. Chemotherapy data table

DRUG ID	DRUG NAME	GENERIC NAME	BRAND NAME	DOSE DESIGNATION	DOSAGE UNIT	ROUTE OF ADMINISTRATION	RATE OF ADMINISTRATION	MANUFACTURER	MANUFACTURE DATE	EXPIRE DATE	NAFDAC	PHARMACIST REMARKS
45625									0000-00-00	0000-00-00	0	
997595									0000-00-00	0000-00-00	0	
645346									0000-00-00	0000-00-00	0	
544356									0000-00-00	0000-00-00	0	
67634535									0000-00-00	0000-00-00	0	
4662562									0000-00-00	0000-00-00	0	
4726253									0000-00-00	0000-00-00	0	

4 Implementation and Results

4.1 Development tools

PHP: – used as back-end for the managing access structures, query evaluation and optimization, concurrency control and recovery.

NetBeans IDE - used as front-end to develop forms, report-trail, and graphical user interface.

MySQL, **API, and WAMPSERVER** - The interface between the front-end and the back-end is through SQL (in WAMPSERVER) and through an application program interface (API) defined in PHP.

Windows 7 – The system is developed in Windows 7 platform.

4.2 Sample output of the proposed system

Fig. 5. Welcome page of the ICPMS

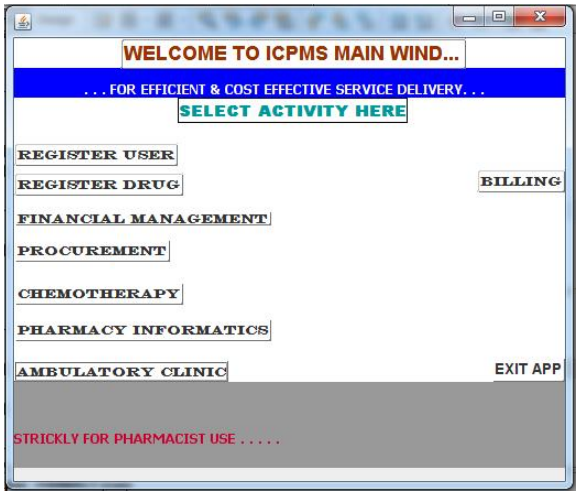


Fig. 6. Main window of the ICPMA

5 Algorithm

The algorithm below is to add drug record to Drug Registration table in the database.

```
add.php
<? php
    if (! empty ($POST))
 {
  name = $_POST[`drug name`]
  generic =  $_POST[`Generic Name`];
  .
  .
  .
  saveToDB(name, generic, - - - - -);
 }
  {"Drugs"[
   "Drug"
    {"name": "",
     "generic": "",
     "expireDate": "1995-09-04"
       .
       .
       .
     "DrugId: "1234321"
     "manufacturerId" :BT23405uc"
     },
  "Drug": {
   .
   .
   .
 }
```

6 Conclusion

Inventory control is essential in any commercial environment, however, even more so when it comes to maintaining inventory in a pharmaceutical setting because public health is concerned. Any person with pharmacy technician training can understand the significance of having enough medical stock in both retail and hospital pharmacies at all times in order to be able to successfully fill the prescriptions that customers may need instantly. Successfully dispensing prescriptions may seem like a simple task; however, if one has ever observed the process of a hospital or community pharmacy, he will understand the need for an efficient inventory control structure. Computer assist inventory management for oral and topical medicines is comparatively easy, since the amount of drug used can be confirmed at the time of dispensing. It is our believe that the system model in this work, when fully implemented will improve UCTH pharmacy daily operations efficiencies, increase pharmacists and pharmacy technicians efficiency, and also improves patient care by promoting medication dispensing accuracy and allowing pharmacists to spend more time on patient care activities.

Competing Interests

Authors have declared that no competing interests exist.

References

[1] Mustafa NB. Pharmacy inventory tracking system. A B.Sc project report, Universiti Teknikal Kebangsaan, Malaysia; 2006.

[2] Klibanov OM, Eckel SF. Am, J. Health System Pharmacy. 2003;60:569-572.

[3] Awaya T, Ohtaki K, Yamada T, Yamamoto T, Hayase N, Matsubara. Automation in drug management saves personnel time and budget. In the Pharmaceutical Society of Japan. 2005;125: 427-432.

[4] Kaushal R, Bates DW, Qual Saf. Health Care. 2002;11:261-265.

[5] World Health Organization. World Health Statistics 2011 - Table 6: Health workforce, infrastructure and essential medicines. Geneva; 2011.

[6] Tupper KW. Psychoactive substances and the English language: "Drugs", discourses, and public policy. Contemporary Drug Problems. 2012;39(3):461-492.

[7] Knapp KK, Okamoto MP, Black BL. ASHP survey of ambulatory care pharmacy practice in health systems--2004. American Journal of Health-system Pharmacy: AJHP: Journal of the American Society of Health-System Pharmacists. 2005;62(3):274–8.

[8] Available: www.aacp.org
(Retrieved 25 – 12 – 20015)

[9] BioPharm International; 2008.
Available: www.biopharminternational.com
(Retrieved 26 – 12 – 2005)

[10] Available: www.dolcera.com
(Retrieved 26 – 12 – 2005)

[11] Deitel HM, Deitel PJ. Java™ How to Program 6/ed. Prentice Hall; 2004.

[12] Ele SI, Adesola WA. Design of Computer Fault Diagnosis and Troubleshooting System (CFDTS). In West African Journal of Industrial and Academic Research (WAJIAR). 2013;9(1):45-55.

Peer-review history:
The peer review history for this paper can be accessed here (Please copy paste the total link in your browser address bar)
http://sciencedomain.org/review-history/14041