

Original Research Article**DESIGN OF AN INTEGRATED COMPUTERIZED PHARMACY INVENTORY
MONITORING SYSTEM (ICPIMS): A CASE OF UNIVERSITY OF
CALABAR TEACHING HOSPITAL (UCTH)****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 focus of this work is to design and model an Integrative computerized pharmacy inventory system, using University of Calabar as a case study. The system would provides better 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 WAMPSEVER) 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.

1.0 Introduction

Records are subject to auditing from time to time or when there is information of improper record-keeping or there has been a burglary, fire or flood. Mistakes on records should be neatly crossed out and signed for but not obliterated. Records should be completed in the dispensary on a daily basis, and not later than a week after the event. This will enable easier compilation of drug consumption 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 especially in pharmacy department. This includes all activities such as transaction, order items, item

movement tracking, financial management, report generation amongst others [1].

Drug inventory management can be wearisome and onerous work. On a daily basis, hospital pharmacist/pharmacists in general must purchase and return orders to wholesale suppliers. Pharmacist checks the drug stock in each pharmacy section in the hospital every now and there. Automation in inventory management including purchasing control would help enthusiastically [2]. Hospital pharmacists are limited in number mainly due to hospital budget 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 helpful in creating new clinical 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.

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.



Figure 1: Drug Distribution Order

109 **CFAs** (Clearing and Forwarding Agents) are organization primarily
 110 responsible for maintaining storage (stock) of company`s products and
 111 forwarding SKUs to the Stockist on request. Most companies keep up to 1 –
 112 3 CFAs.

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

115 The Retailer Pharmacist – obtains products from the stockist or substockist
 116 through whom it finally reaches the consumers (Patients)[9].

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118 **2.0 Model Design**

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

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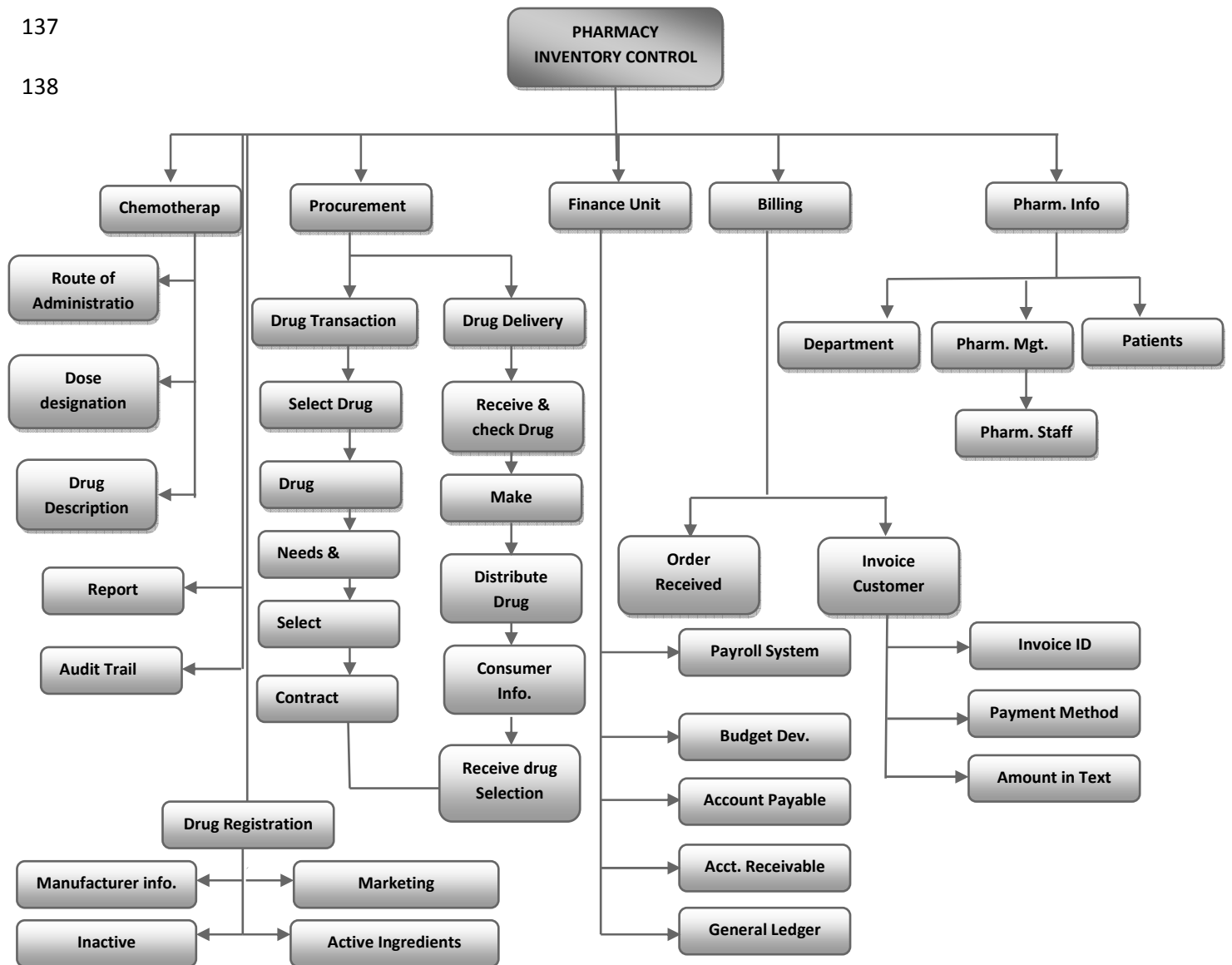
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136 **2.1 High Level Diagram of the Proposed Pharmacy Inventory System**

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140 **3.0 System Analysis and Methodology**

141 The design model adopted in this work is the structured system
142 analysis and design methodology (SSADM). UML (Unified Modeling
143 Language) is used for the model design of this system. The UML is now
144 the most widely used graphical representation scheme for modeling
145 object systems. An attractive feature of the UML is its flexibility. UML
146 modelers are free to use various processes in designing systems. The
147 UML is a complex, feature-rich graphical language (Deitel and Deitel,
148 2004; Ele & Adesola, 2013)[10],[11].

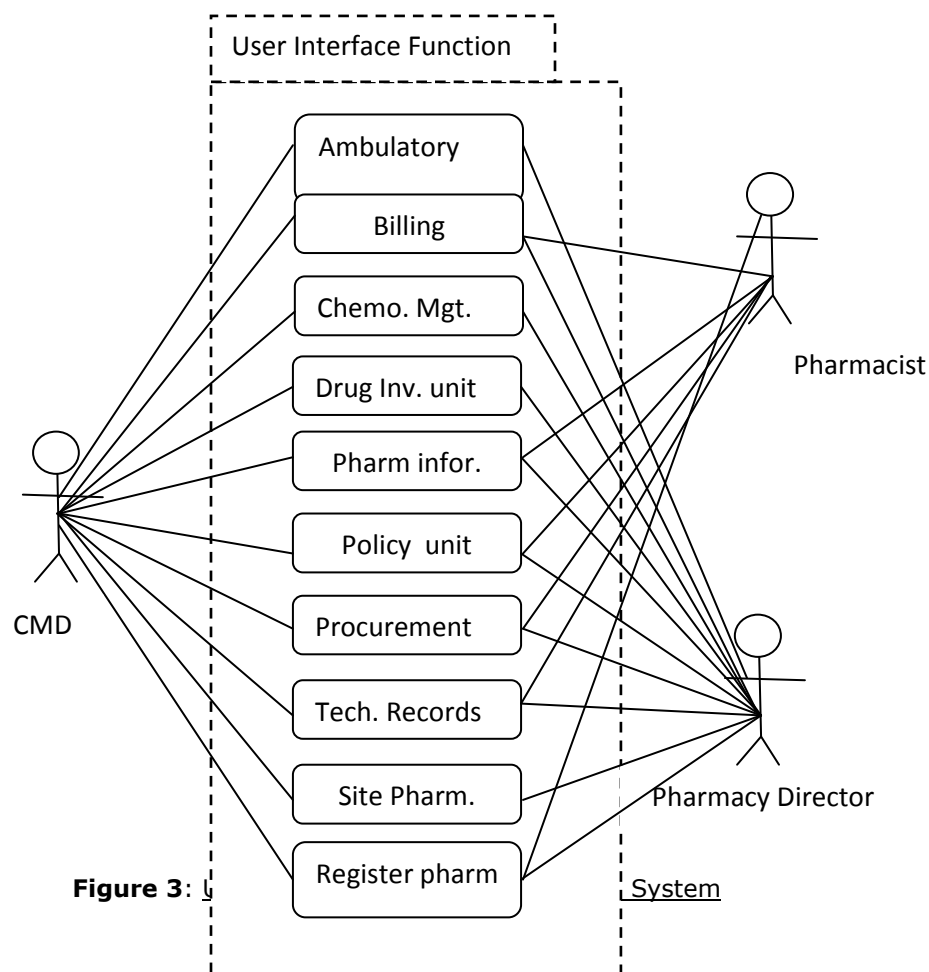
149 The UML specifies diagram for documenting the system behaviour. In
150 this paper work, three UML diagrams (use case, class and activity
151 diagrams) are used to explain the behaviour of the components of the
152 database system. We employed MYSQL as the database engine
153 because of its extreme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

159 **3.1 System Design**

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

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Use Case Diagram



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 below.

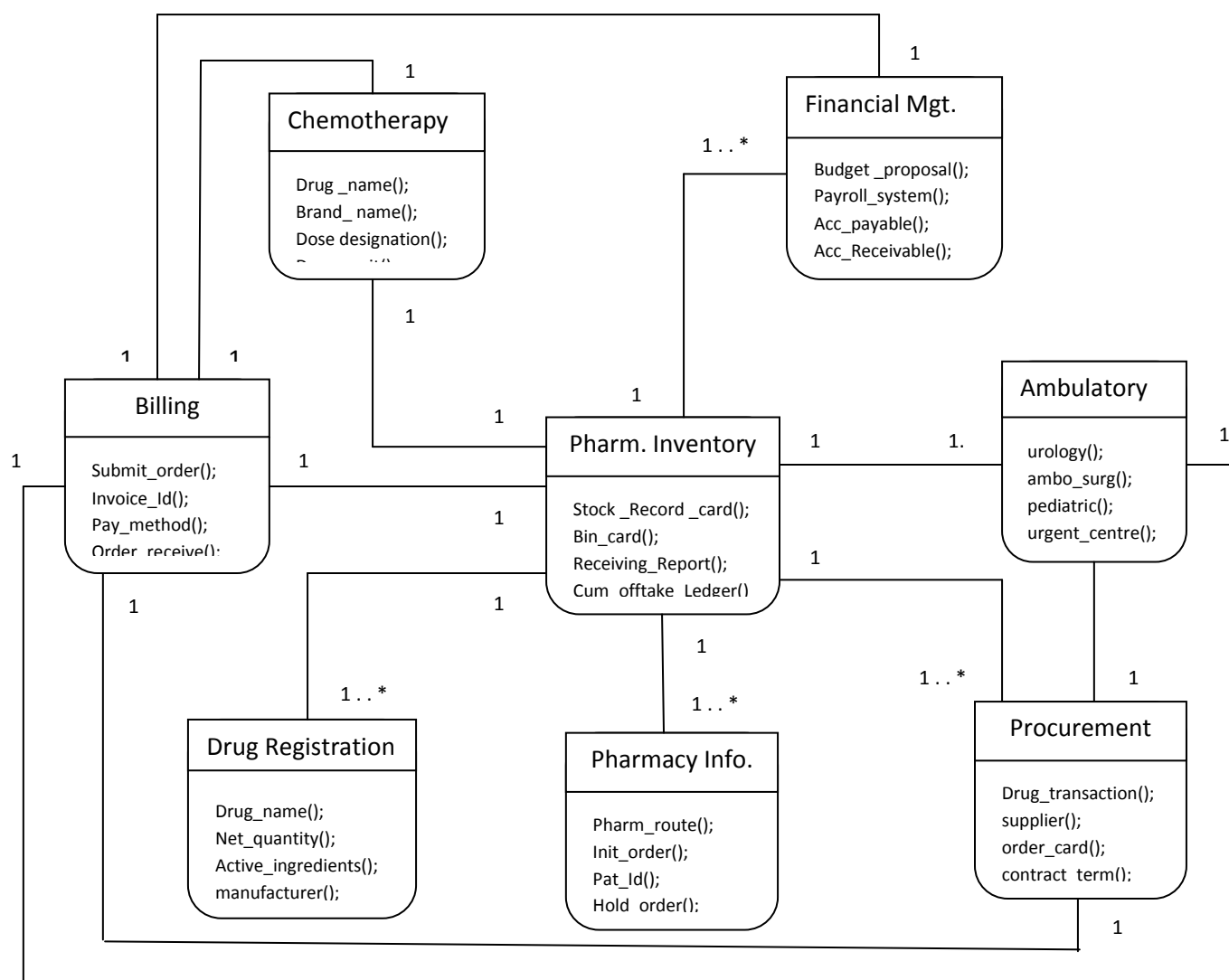


Figure 4: Class Diagram of the Proposed System

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 WAMPSEVER. 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	<u>INVOICEID</u>	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

Table 2: **Pharmacy Informatics Table**

#	Name	Type	Collation	Attributes	Null
1	<u>PATIENT ID</u>	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

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 CUSTOMER	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	RECEIVED 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	

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250 4.0 Implementation & Results

251 4.1 Development Tools

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

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

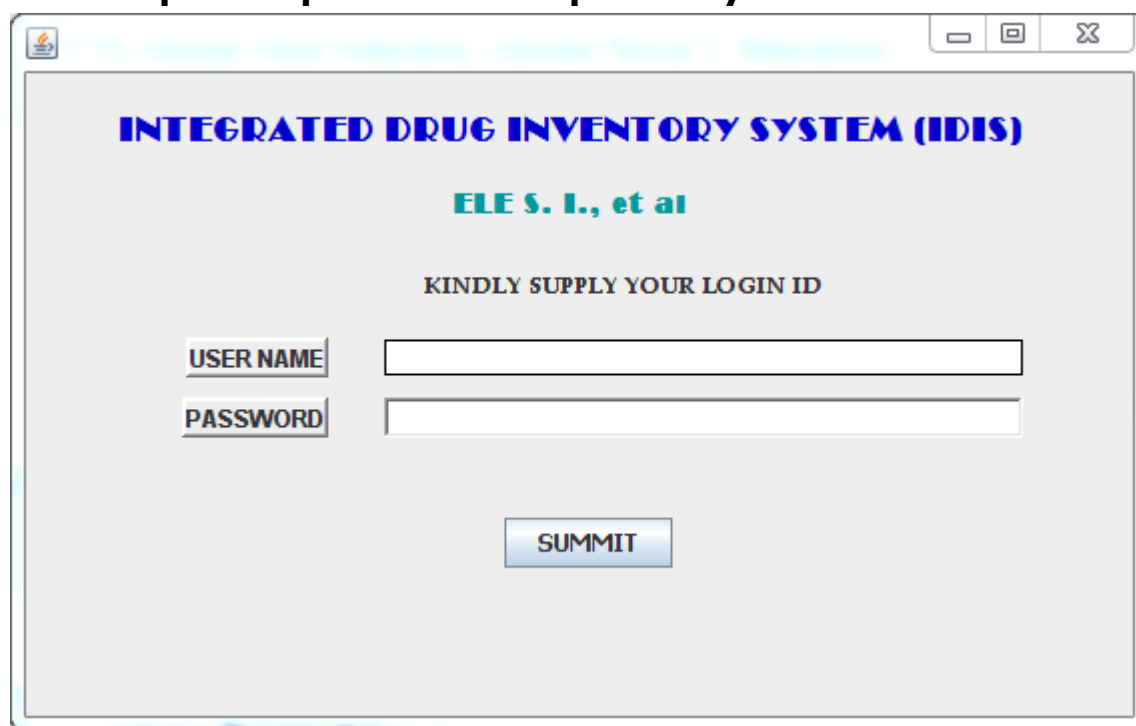
256 **MySQL, API, and WAMPSEVER** - The interface between the front-
257 end and the back-end is through SQL (in WAMPSEVER) and through
258 an application program interface (API) defined in PHP.

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

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262 4.3 Sample Output of the Proposed System



The screenshot shows a web browser window with the title "INTEGRATED DRUG INVENTORY SYSTEM (IDIS)". The page content includes the text "ELE S. I., et al" in green, followed by "KINDLY SUPPLY YOUR LOGIN ID" in black. Below this, there are two input fields: "USER NAME" and "PASSWORD". A "SUMMIT" button is positioned at the bottom center of the form area.

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264 Figure 5: Welcome page of the ICPMS

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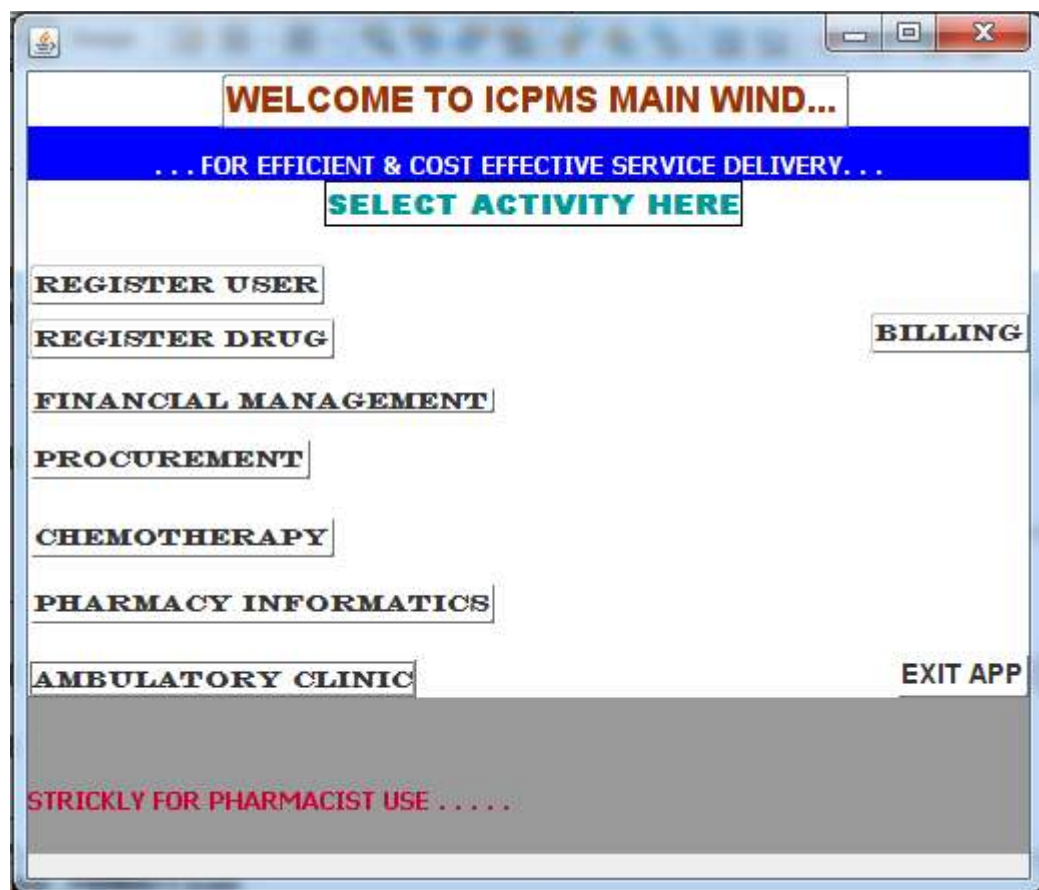


Figure 6: Main Window of the ICPMA

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, - - - - -);
    }

```

```
284     {"Drugs"[  
285         "Drug"  
286         {"name": "",  
287          "generic": "",  
288          "expireDate": "1995-09-04"  
289         .  
290         .  
291         .  
292         "DrugId: "1234321"  
293         "manufacturerId" :BT23405uc"  
294         },  
295         "Drug": {  
296         .  
297         .  
298         .  
299     }  
300
```

301 **Conclusion**

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

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342 Troubleshooting System (CFDTS). In West African Journal of Industrial
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