Design and Development of ICU Intelligent Medicine Management System Based on MVC

Jingxia Wang  
Xiangya Nursing College  
Central South University  
410013, Changsha, China  
Email: tangsyuan@126.com

Xiao Yu  
The Third Xiangya Hospital  
Central South University  
410013, Changsha, China

Lu Ren  
Xiangya Nursing College  
Central South University  
410013, Changsha, China

Siyuan Tang  
Xiangya Nursing College  
Central South University  
410013, Changsha, China

Abstract—With the popularity of Internet and management informationization, people’s understanding and demand of information technology has increased significantly, it is especially important for top hospitals where large amounts of information need to be processed. Medicine management is the core of hospital management, and it is the most promising link to cut down the expense and increase the income. Because there are many types of patients admitted to the Intensive Care Unit (ICU) and a wide variety of drugs stored there, especially many high risk medicines, the workload of medicine management for medical staff in ICU is really heavy. ICU intelligent medicine management system was designed in accordance with the requirements of the new financial system of the Ministry of Health, and the classification coding system was national standard. At the same time, it promote the realization of the integration of prescription, dispensing and inventory management. The ICU intelligent medicine management system was constituted of human-computer interaction modules (touch screen and fingerprint entry device), motherboard module, mechanical and electrical control module (I/O), communication module (printer, HIS), drawer storage module and narcotic drugs information system module. It used Java as a programming tool, applied user-friendly and powerful Dream Weaver as a development tool, and used JSP/JAVA, also Java, MySQL5 and Tomcat7 as the server-side, Client-side scripting tool, Database and Server respectively. Moreover, this system used Struts, session management, filters and database integration technology, built robust applications, whole prepared through the MVC mode, and had a very good scalability.

Keywords: ICU; MVC Model; Medicine Management System; Medical Information

I. INTRODUCTION

Medicine management is an important part of clinical medical activities. At present, there is not unified medicine management model in Chinese hospital wards. High-risk drugs refer to the drugs with significant and rapid pharmacological effects, which would cause serious injury or death if used improperly, including preparation with high concentration electrolyte, muscle relaxants and cytotoxic medicines and so on [1]. Types of diseases in ICU are complex, and many patients with critical illness need rescue with many kinds of medicines and high-risk drugs. Therefore, the task of ICU medical staff referring drug management is more arduous and medication safety management is more critical. Nowadays, sound drug management information system is a part of the construction of digital hospital. The usage of modern pharmacy equipment (such as smart pills machines, intelligent medicine cabinets, etc.), has reduced man-made dispensing errors, ensured the safety of patients with medication, reduced drug administration work intensity in ward, and returned nurses’ time to the patient at most. At the same time, the automatic operation of medication administration can reduce the contact between the medicine and the staff in the dispensing stage, so as to reduce the pollution of the medicine, which is quick and convenient. Furthermore, the modern medicine management system is good to facilitate the batch number, the effective period, the stock, and the traceability of the medicine information. In short, medicine administration automation is the trend of modern medicine management system development. Foreign pharmaceutical management system is perfect. For instance, the Singapore management of drug safety measures reflected in more advanced and perfect in staffing, operating procedures and management system, especially for nurses who play an important role in hospital drug safety management. The nurse engaged in medicine administration according to strict operational procedures and worked processes under the supervision of the pharmacists and assistant of electronic intelligent medicine cabinet in the whole process(from the doctors’ advice check to take medicine, then dispensing), which not only maintained the safety of patients, also played a protective role on the medical staff. The Affiliated Hospital of Yale University has been applying intelligent technology to ensure medicine safety. Most foreign hospitals have been widely applied in drug management information technology, to achieve the intelligent medication management in the ward [2]. Drug management system research in China starts relatively late. The traditional way of taking medicine is to take medicine directly artificially according to the doctor’s advice, then register of the situation manually, which may result in medication errors and false record risks. Nowadays, most of ICU in domestic hospitals classify place drugs in fixed point according to the need of clinical application, including emergency service vehicle, common medicine cabinets, vein medicine cabinets, oral medicine cabinets, narcotic drug cabinets, cabinet of high-risk drugs and special drugs. Because of the complex diseases in ICU, more kinds of drugs should be prepared than general wards, so that it takes nurses more time in medicines counting and supplement. Moreover, poison or narcotic drugs should...
be managed by special person and double lock and establish a strict registration system, which contents including the date, name of patient, admission number, drug names, dose, executor, checker, and prescriber [3-5]. So the pure manual management is time consuming, and there are many security risks. The smart drug monitoring and warning interactive system in the ICU has been put into trial operation, which has improved the working efficiency of the medical personnel, ensured the patient’s medication safety and increased the patients’ satisfaction of the medical service, enhanced the harmony of the doctor-patient relationship. However, the intelligent drug management system used in ICU in China is rarely found in literature, and the intelligent ICU medicine management system based on the theory of risk management should be carried out and implemented.

II. THE KEY TECHNOLOGIES

A. The client/server structure

The client/server structure, is also known as the CS structure. The basic principle of CS is to split the task into multiple subtasks, that is, the application of the principle of “distribution function”, which need cooperation of multiple computers to complete. Interface functions for user, data representation and data processing are all completed through the client, whereas, the core function of DBMS (database management system) is completed by the server. The processing mode of the computer application is that the server is responsible for providing services, client for requesting services.

B. Development and operation environment

(1) Hardware environment: Client configuration (P4 above, more than 1G memory, hard disk: 80G above, operating system: XP Windows above); Server configuration (2*CPU quad core Intel R to strong R processor, the processor clocked at ≥ 3.06GHZ, 16G memory, 2+500G hard disk).

(2) Software environment: ICU intelligent medicine management system using Java as the programming tool, applying friendly interface and powerful DREAMWEAVER as a development tool, using JSP/JAVA script to write for Server script, using JAVA script to write for Client script; using MySQL5 in Database, and Tomcat7 in Server. Further more, The Struts, session management, filters and database integration technology used in this development, including the applications built robust, are all white through the MVC mode [6, 7, 8].

C. Java

Java is the general name of object-oriented programming Java language launched by Sun Microsystems company and Java platform [9]. It is developed by Gosling James and his colleagues, and officially launched in 1995. The characteristics of Java are stated as follows:

(1) Java language syntax is very close to C and C++ language, which makes it easier for programmers to learn and use;
(2) Java language is a pure object-oriented programming language;
(3) Java language supports the development of Internet application, and there is a network application programming interface in the basic Java application programming interface called Java Net, which provides a class library for network application programming, including the URL, URLConnection, Socket, ServerSocket and so on;
(4) Java security inspection mechanism makes Java more robust;
(5) Java provides a security mechanism to prevent malicious code;
(6) It can be implemented in any system of this Java platform;
(7) Java system itself also has a strong portability;
(8) One of the goals of Java language design is to adapt to the dynamic changes of the environment. And the excellent characteristics of Java language make Java application incomparable robustness and reliability, which also reduces the maintenance costs of the application system.

D. MVC

MVC is the abbreviation of "Model-View-Controller". Event causes Controller to change Model or View, or both. As long as the Controller changes the Model data or properties, all Views dependent on it will be automatically updated. Similarly, as long as the Controller changed the View, View will get the data from the potential of Model to refresh themselves [10]. View is on behalf of the user interface. For Web applications, it can be summarized as the HTML interface, but it is possible be XHTML, XML and Applet [11]. With the complexity and scalability of the application, the processing of the interface also becomes a challenge. An application may contain a lot of different views, the MVC design pattern for view processing is limited to data acquisition and processing on the view, as well as the user’s request, but don’t cover the business process on the view. Then, Business process will be handled by Model. Model is the process of business process/state and the development of business rules. The design of business model is something of the core of MVC. MVC design pattern tells us that if we want extract the application of the model according a certain rule, the level of extraction is very important, which can be design basis for judging whether the developer is excellent. The controller can be understood as receiving requests from the user, then match the model with the view, and complete the user’s request together.
III. REQUIREMENT ANALYSIS

A. System feasibility analysis

The study was conducted in a first-class general hospital, where medicine management in ICU must meet the requirements as follows: It should be convenient for the administrator to check out the storage of drugs and other situations, and time-saving, then more effective and accurate. In order to adapt to the development of the new situation, the hospital carried out ICU intelligent medicine management system based on MVC pattern, and it is hoped that the system can play an efficient and convenient role in the ICU medicine information management, then freed system administrator from the heavy work. So, design and development of ICU intelligent medicine management system is necessary.

B. Feasibility analysis of system technology

Database technology has formed a complete set of language system with structural integrity and a large number of system modules to create a good technical platform for developers. At present, there are more and more software project teams who master the management information system development technology, which provides technical feasibility for the development of ICU intelligent medicine management system. At the same time, the Internet provides a cheap platform for the hospital to establish a local area network. So the ICU intelligent drug management system as the HIS subsystem is completely feasible in terms of technology and platform.

C. Economic feasibility analysis of the system

The ICU intelligent medicine management system is easy to operate fast, can reduce management weakness of medicine information, reduce errors due to redundant work, and reduce many unnecessary personnel. In view of the above reasons, this system has saved money and increased wealth for the hospital. The needs of the development of intelligent medicine management system in ICU are more readable, coupled with the mature software and hardware environment, so the cost on software and hardware is relatively low. Moreover, the technical architecture of ICU intelligent drug management system is not very complex, and it can greatly enhance medicine management quality after the system development finished and actual operation, and create the conditions for the further promotion of the system as well as bring convenience for users. So the economic return will be far more than cost, and the development of drug management system is feasible from an economic point of view.

D. System functional requirements analysis

ICU intelligent medicine management system are mainly divided into the following six modules in terms of functional requirements

1) Man-machine interaction module (Touch screen and fingerprint input apparatus);
2) Main board module;
3) Mechanical and electrical control module (I/O module);
4) Communication module (printer, HIS);
5) Drawer storage module (placing medicine);
6) Anesthesia drug information system module.

E. System performance requirements analysis

On the basis of meeting the functional requirements of the system, the system also need to meet certain performance requirements. Firstly, it should meet the needs of accuracy and timeliness of the system processing, that is to say, the system can make accurate and fast response to the user's related operations. Secondly, it should meet the needs of security of the system, the system is only open to the internal users of the system, and the operation of the information is based on the role of internal users in the system configuration. Thirdly, scalability of the system can not be ignored. In view of the system uses an open development tool architecture, and it is in line with the workflow management system reference model, thus the system scalability is guaranteed. Fourthly, maintainability of the system should be meet. The system provides a good user interface, as well as easy-to-use human-computer interaction interface. Moreover, the system can provide enough online help when any problem comes up. Finally, the performance index of the system must be guaranteed. The performance index mainly includes the reaction time of system event, the concurrence environment, and the response time for query and so on.

IV. THE PROCESS DESIGN

A. Medicine taking process

1) Doctor orders a medicine in HIS (doctor workstation);
2) Nurse checks the orders in HIS (nurse workstation);
3) Nurse sends orders to the medicine cabinet;
4) Nurse login smart medicine cabinet (fingerprint recognition or login user name), and chooses patient information. Next, nurse selects the prescriptions, and then opens the door according to the indicator light in order to get the medicine. Finally, nurse confirms the quantity of drug and closes the door to complete medicine taking.

B. Withdrawal process

1) Nurse sets withdrawal conditions in the HIS(nurse workstation);
2) The drug is returned to the pharmacy.

C. Putaway process

1) The ward area decides which medicine should be added;
2) The medicine cabinet management selects the medicine about to add to the medicine list of this ward;
3) The medicine cabinet management sets medicines on the cabinet.

D. Remove off process

1) The medicine cabinet management does the inventory reduction from medicine stores;
2) Remove the medicine from the medicine cabinet;
3) Reduce inventory in HIS.
E. Replenishment process

1) The pharmacy agrees on replenishment cycle time;
2) The pharmacy sets automatic replenishment plan in the server (including the time for replenishment, upper limit of the inventory, replenishment baseline and alarm baseline);
3) The system automatically generates replenishment document for pharmacy (can print automatically);
4) The pharmacy prepares for the medicine by convention and confirm the replenishment document in the HIS (pharmacy management system);
5) The medicines are delivered to the ward;
6) The nurse in the ward checks the medicine according to the replenishment document;
7) The replenishment personnel selects the replenishment document in the medicine cabinet and place the medicine according to the indicator light.

F. Inventory process

1) The medicine cabinet management carries out the inventory check on the medicine cabinet;
2) The medicine cabinet management opens the cabinet and count the number of drugs according to the indicator light;
3) The medicine cabinet manager confirms the number of drugs in the medicine cabinet;
4) Check all drugs and close the door;
5) Print inventory differences.

V. PRELIMINARY APPLICATION

A. Participants

In September 2015, ICU intelligent medicine management system was officially put into use in the ICU of the Third Xiangya Hospital of Central South University. At the end of February 2016, the professionals who meet the inclusion criteria in ICU of the Third Xiangya Hospital of Central South University were investigated and got to know the staff satisfaction of ICU intelligent medicine management system after it was put into use. Participants inclusion criteria: Engaged in clinical work in our department for more than one year; The using time of ICU intelligent drug management system was more than 2 months; Voluntary participated in the study. Finally, 75 professionals were meet the inclusion criteria and choose as the participants.

B. The survey on staff satisfaction

The survey on staff satisfaction was conducted after 6 months when intelligent cabinet system was put into use. Then, the satisfaction evaluation on convenience, practicability, handleability, stability, veracity and security of this system was carried out. Our results show that, no one was dissatisfied or very dissatisfied in the above 6 aspects on this system and 93.3% of the staff were satisfied or very satisfied with the use of this system in the above 6 aspects (TABLE 1).

<table>
<thead>
<tr>
<th>Date</th>
<th>Coincidence rate</th>
<th>Inventory difference rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2015</td>
<td>98.0</td>
<td>0.00039</td>
</tr>
<tr>
<td>Oct. 2015</td>
<td>98.3</td>
<td>0.00034</td>
</tr>
<tr>
<td>Nov. 2015</td>
<td>98.1</td>
<td>0.00037</td>
</tr>
<tr>
<td>Dec. 2015</td>
<td>98.4</td>
<td>0.00032</td>
</tr>
<tr>
<td>Jan. 2016</td>
<td>99.2</td>
<td>0.0009</td>
</tr>
<tr>
<td>Feb. 2016</td>
<td>98.5</td>
<td>0.00018</td>
</tr>
</tbody>
</table>

C. The inventory difference rate and coincidence rate of account and goods after intelligent cabinet use

Between September 2015 and February 2016, the pharmacy checks inventories once at the end of every month, and make inventory difference rate and coincidence rate of account and goods as an evaluation index. Inventory difference rate = profit and loss amount/stock amount (TABLE 2).

D. Conclusion

As one of the important means of clinical treatment, drug therapy on safety, effectiveness, timeliness is an important embodiment of the overall management level of hospitals. Ensuring the patient’s safety with medication requires the joint exploration and collaboration of multi discipline and multi departments. With the wide application of information technology in the field of medicine, intelligent medicine cabinet system is becoming more and more widespread. Since the intelligent medicine cabinet put into use, the coincidence rate of account and goods has kept above 98%, and the inventory difference rate has remained at a low level. Intelligent medicine cabinet system has electronic records on each taking medicine, and it can be tracked according to the record if wrong medication number occurs, so as to improve the safety management of medication. Intelligent cabinet belongs to the computer intelligent system, the system needs to constantly improve in terms of stability and further humanity on details of the function. Although there are still insufficient of intelligent medicine cabinet system at the beginning, it will be further optimized along with the improvement of the computer technology. Furthermore, it also can further improve the work efficiency of medical staff, and provide security and quality service for patients.
REFERENCES


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