—Regular Articles—

Automation in Drug Inventory Management Saves Personnel Time and Budget

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Automation in the drug distribution processes is helpful to pharmacists in creating new clinical services. We have ameliorated the drug inventory control system seamlessly connected with the physician order-entry system. This control system application, named Artima, allows inventory functions to be faster and more efficient in real time. The medicines used in our hospital are automatically fixed and arranged to sold-packages, and are ordered from each wholesaler by a fax-modem every day. Artima can search the lot number and expiration date of drug in the purchase and delivery records. These functions are powerful and useful in patient's safety and cost containment. We surveyed the inventory amount stored in the computer database, and evaluated time required for inventory management by tabulating working records of employees during past decades. Inventory decreased by 70% along with the continuous improvement of the system during the past decade. The workload in the inventory management in each section of the Pharmacy Department as well as in clinical units was dramatically reduced after the implementation of this system. The automation system in the drug inventory management allows creating new clinical positions for pharmacists. This system also could pay for itself in time.

Key words——inventory; automation; computerization; drug delivery; workload; cost containment

INTRODUCTION

As we entered the 21st century, there are many factors that influence the future practice of pharmacy and delivery of pharmaceutical care. The pharmaceutical care role takes substantial time for pharmacists; however, pharmacists have multiple responsibilities in the hospital. These include drug inventory management, dispensing, in-hospital preparation, aseptic mixture and adjustment of injections, drug information service, many clinical services including therapeutic drug monitoring, clinical research coordination, etc. Hospital pharmacists are limited in number, mainly due to the hospital budget that is also under pressure to adapt to various changes in health care administration and delivery. Shrinking of operation budgets forces many hospital pharmacy departments to search for ways to reduce drug inventory costs and maximize the cost-effective use of personnel.[1)] Efforts to reduce costs and restructure services have prompted increased use of automated technology by health care facilities.[1,2)] Examples of automation used in hospital pharmacy practice include computerization, automation of dispensing and bar coding; i.e., automation in drug distribution processes. Many hospitals continue to face the problem of ineffective and inefficient medication distribution systems. Albeit there are many varieties of drug distribution systems in use throughout the world, all have the same goal to ensure that each dose of medication administered to each patient is exactly that which has been intended by the prescriber.

Drug inventory management can be tedious work. On a daily basis, pharmacists must purchase and return orders to wholesale suppliers. Pharmacists check the drug stock in each pharmacy section every morning. Automation in inventory management including purchasing control would help ardently.[3)] Computer assisted inventory management for oral and topical medicines is comparatively easy, since the amount of drug used can be confirmed at the time of dispensing. However, automated inventory management for injections is very difficult, since the usage confirmation of injection drugs is generally complicated. During the past decade, we have employed several systems in the inventory control system and

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improved the system at each time. Now we have achieved a satisfactory computerized inventory control system, which is seamlessly connected with the physician order-entry system. This control system ameliorates the drug inventory management in our pharmacy department and allowed the creation of new clinical positions for pharmacists. The automation in the inventory control should be valuable in performing pharmaceutical practices as well as for the hospital revenue. However, there is no report evaluating and discussing the effect of automation in inventory management. The net value of automation has been difficult to evaluate because of the involvement of multiple health care units. Thus, we therefore evaluated our new inventory control system in terms of workload and inventory quantity.

METHODS

1. Outline of the System Our medical college hospital consists of 17 clinical departments and has 602 beds. The computer network in our hospital is based on the client server system (NEC, Japan, http://www.nec.com) and consists of mainframe servers, division servers and more than 400 user terminals. The physician order-entry system is integrated with many pharmacy software applications. In our pharmacy department we have 4 sub-servers, 15 data management computers and 23 terminal computers. Each sub-server controls preparations of oral and topically applied medicines, cocktail-dose-drug (different tablets and capsules for one dosing) packaging (LEADER 5001, Tosho, http://www.tosho.cc/en/), preparation of injections or inventory management.

A new inventory management system is named Artima, which is an application connected with the order-entry system to allow multiple management functions. We originally developed this system in conjunction with CSI Co. Ltd. (Sapporo, Japan; http://www.csiinc.co.jp) based on concepts as follows: (1) Drug inventory data management without effect on other hospital systems: (2) real time data can be taken into the sub-server settled in the pharmacy department through the physician order-entry system, and can work allowing analysis of drug inventory data in real time: (3) the management system can search the lot number and expiration of drugs in purchase and delivery records: (4) operation of the system should be easier and faster.

2. Data Fles for the Inventory Functions The inventory data flow and files used in the inventory control system connected with the main hospital system are illustrated in Fig. 1.

2-1. File for injections We set daily closing times to receive injection orders from different clinical units. The injection orders are classified into two categories, which are regular (orders before the closing time) and extra (after closing time) orders. When entering the regular order, prescribed injections are dispensed per each patient by automatic ampule dispenser robots (AAD144R-TR, Central Uni Co. Ltd., http://www.central-uni.co.jp/work/i_buturyu.html) and delivered to the clinical unit by the unit-dose-cart system. In the case of the extra order, injections are supplied for clinical units and assumed as ward stock on the data file. Certain amounts of often-used drugs are stocked in the wards. For the use of these injections, the appropriate and minimum stock levels for each injection drug are assigned according to the past consumption data in each ward. In this system, however, all injections are deemed to be stocked in the ward; appropriate and minimum stock levels for drugs, which are actually not in the ward stock, are treated as 0. When the ward stock is under the appropriate level in the normal business hours, the shortfall of the corresponding injection drug is supplied to the clinical unit by the box conveyor system, which connects to all clinical units in the hospital. During hours when the pharmacy is closed, if the ward stock reaches the minimum level, the pharmacist on duty supplies drugs to each floor through the box conveyor. A list of supplementation is automatically printed out in the Pharmacy Department.

The consumption data file of injections in the pharmacy sub-server is temporally updated when a physician orders injections from the terminal computer either by a regular or an extra order. At this time, however, dispensed drugs are regarded as the stock in the Pharmacy Department. If the physician doesn't cancel use of these drugs (cancellation entry) before midnight, these drugs are automatically contemplated to be used, and then the data file of used injections is renewed.

2-2. File for oral and topical medicines The data file for inventory management is automatically renewed in real time according to the physician order entry.

The data file, in which there are drug names cor-

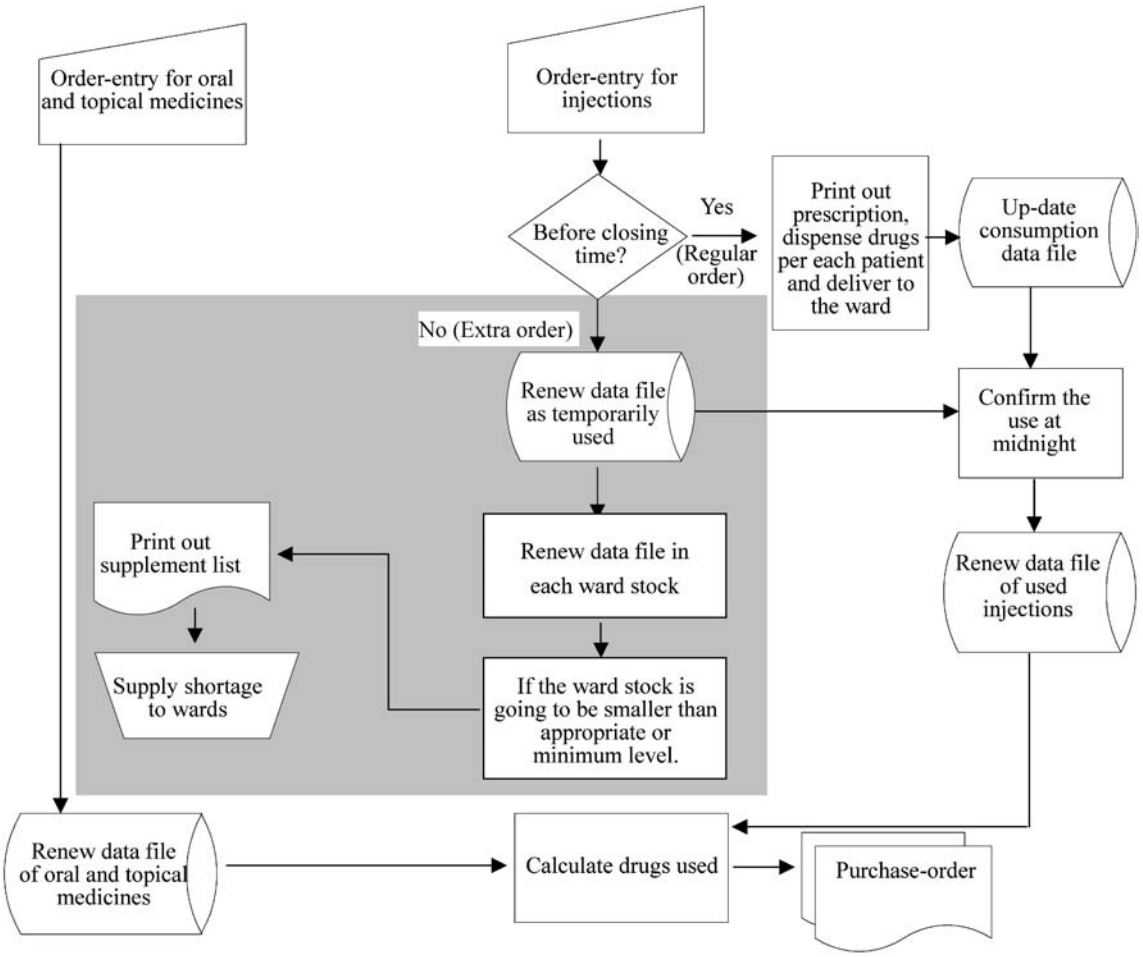

Fig. 1. Data Flow and Files Used in the Inventory Control System

Shaded area expresses data flow in the extra order. In this system, all injections are deemed to be stocked in the ward; appropriate and minimum stock levels for drugs, which are actually not in the ward stock, are treated as 0.

responding to wholesale suppliers, is set in the Artima program. The fixed amounts of medicines used are automatically sorted, arranged to sold-packages and ordered from each wholesaler through a fax modem every morning.

3. Functions of Artima Artima is an application connected with the physician order-entry system to allow multiple management functions. For example, (1) daily functions such as purchase- and return-orders to the wholesaler, drug supplies to each pharmacy section and maintenance of stock, (2) monthly and yearly aggregates by requests of the hospital administration, (3) search functions on the lot number and expiration of drug in purchase and delivery records, (4) aggregate and sorting analyses on various factors, such as demand-forecasting for specific drugs. As shown in Table 1, this system is powerful in daily purchasing compared with the former system used in our department.

Table 1. Time Required in Daily Inventory and Purchasing Control Using DMS and Artima

Business	Time required (min) *	
	DMS, 1995	Artima, 2004
1. Making a supply list for each pharmacy section	15	3
2. Making a purchase-order list	20	0
3. Purchase-order processing	25	5
4. Making a turnover list in the drug storage room	5	2
5. Printing out a purchase-order list to each wholesale store (by fax)	5	0
6. Data management of drugs purchased and delivered	20	4
Total time	90	14

DMS: Drug Management System (*see* Table 2), Artima: Article Manager. * Data are expressed as an average time required operating each task.

4. Effects of the System on Workload and Quantities in Drug Inventory Management Time required operating each daily task in inventory management was compared from 1995 to 2004. We also calculated time spent on inventory management by surveying working records of pharmacy employees at each time when the system had been improved. The inventory quantities were surveyed form the record stored in the main computer database during a past decade.

RESULTS

1. Effects of the Computerized System on Workload in Drug Inventory Management During the past decade, we employed several systems in inventory management and improved the system each time. We surveyed the workload of pharmacists and technicians for performing daily drug inventory management. The initial inventory management system application, which was a data management system (DMS) application, was established in 1994. At that time, DMS was not connected with the hospital network system (Table 2). In 1995, DMS was connected with the main hospital system. The major distinction between DMS and Artima is the operation speed. In the present system, data from the hospital order-entry system are renewed in real time and stocked in the Artima sub-server. DMS had to read the data stocked in the mainframe computer, which was allowed just once a day due to interactions with other hospital system software. By placing a data management server in the Pharmacy Department, total human hours in drug inventory management were significantly reduced. In 2004 the data management computer was connected directly with a facsimile machine through a fax modem. Designating total workload without use of any computer in 1990 as 100%, those with the Artima system in 2004 were estimated as 25% (Table 2). This result represented that pharmacists and technicians spent less time on drug inventory-related activities. This allowed us to create new clinical positions for pharmacists in the patient care units.

2. Effect of the Automation on Inventory Quantity Cost containment was also surveyed during the past decade. Although many factors were involved, inventory decreased by 70% along with the continuous improvement of the control system during the past decade (Table 3), indicating the system is cost-effective. Especially, the inventory quantities in clinical units were dramatically reduced.

DISCUSSION

There is growing evidence that points to medical errors as a leading cause of death and injury.[4] Since the medication use process is so complex, error reduction requires to change many systems in medication deliv-

Table 2. The History of Inventory Control System and Workload of Pharmacists and Technicians in Weekly Inventory Functions

Year	System	Section	Human hours	%**
1990	Without computer	Inventory section	45	100
		Other sections*	66	100
		Total	105	100
1994	DMS (manual data input)	Inventory section	22.5	50.0
		Other sections	66	100
		Total	88.5	84.3
1995	DMS (connected with the order-entry system thorough the mainframe server)	Inventory section	22.5	50.0
		Other sections	22.5	34.1
		Total	44.5	42.4
1998	Artima (data from the order-entry system through the sub-server in the department)	Inventory section	4.5	10.0
		Other sections	22.5	34.1
		Total	26.5	25.2
2004	Artima (the use of a fax modem)	Inventory section	4.0	8.9
		Other sections	22.5	34.1
		Total	26.0	24.8

DMS: Drug Management System, Artima: Article Manager. Human hours were total workload of employees who engaged in the inventory management. * Other sections were dispensing, injection and in-hose preparation sections. ** The total human hour in 1990 is expressed as 100%.

Table 3. The Transition of Drug Inventory Quantity in the Past Decade in Asahikawa Medical College Hospital

Year	In clinical units	In pharmacy department	Total
February, 1990	22,000,000	249,700,000	271,700,000
February, 2004	5,500,000	70,400,000	75,900,000
Balance	16,500,000	179,300,000	195,800,000

The data are expressed as mean daily inventory amounts (yen) in 1990 and 2004.

ery, including prescribing, transcribing, dispensing, administering and monitoring. Many studies report that computerized physician order-entry has reduced prescription errors by 80%.[5,6] Computerized physician order-entry system requires seamless connection with other hospital systems, data security issues, and patient confidentiality.[7] Also, the role of pharmacist, who is integrated and utilized in the health care system, is important to achieve medication safety. The number of hospital pharmacists, however, is limited, mainly due to the hospital budget. Automation in drug distribution can help us, although the system is primarily for patient safety.[8] Many types of software that can help pharmaceutical practices are currently available.[9,10] There are still some problems with current computer applications sold by vendors, however, when they are incorporated into the hospital system. Computer assisted inventory management for oral and topical medicines is comparatively easy, since the amount of drug used can be confirmed at the time of dispensing. Thus, the computer assisted ordering system for these drugs comes into practical uses. However, automated inventory management for injections is very difficult, since the usage confirmation of injection drugs is generally complicated. For the establishment of total drug inventory management, we designated the system composed of 2 parts; one is a data processing part directly connected with the order-entering for injections and the other is an inventory control part in the Pharmacy Department. A notable feature of the former part, all injections are deemed to be stocked in the ward; appropriate and minimum stock levels for drugs, which are actually not in the ward stock, are treated as 0. Then, this part allows real time grasp of used and stocked amounts in each clinical unit. The data from the former part are transferred and putted together into the file, ''Renew data file of used injections'', and then integrated with ''Renew data file of oral and topical medicines'' illustrated in Fig. 1. The design of the system is dependent on each hospital's need. It is important that pharmacists and system engineers should develop the system jointly.[11]

Drug inventory management can be tedious. Having the automation system has been shown to save human resources and money as well.[12] The establishment of the computerized system in each hospital requires considerable time funds. Automation in the inventory management could pay for itself in time, however, as we have shown in this report. The workload and quantities in inventory management have been depended on classes and amounts of drugs used in the hospital, which has been considerably changing during past decades. However, the amounts of drugs, in terms of money, are usually increasing each year. On the other hand, from 1993, our hospital started to deliver outside prescriptions, of which ratio to total prescriptions was less than 50% during a past decade. Although this event was the big change in the drug delivery system in our hospital, the daily stock volume of drugs for out-patients (ca. 2,000,000 yen/day) was not largely affected by this event compared to that for in-patients. Overall, implementation of automated inventory control system is expected to increase hospital revenue by reducing expense. The automation system created new clinical positions for pharmacists. In other words, the computerized system would also save money when reduction in adverse drug events is achieved by pharmaceutical care. Also, it was expected that nursing personnel spent less time on medication-related activities, charting and documenting, and more time interacting with patients after installation of this system.

The automation system must integrate with pharmacy instruments, possess a self-regulating system and ensure quality and safety of drug distribution by the pharmacist. The system should be equipped with various inventory analysis features for managing inventory, containing drug costs, performing replacement and elimination analyses, and monitoring the health system's operations.[13] In addition to these functions, when an inferior or contaminant report in drugs is released, we have to survey the lot number in the purchase and delivery records to recall corresponding products and identify patients who received them. For the hospital budget, the quality management of drugs, in terms of checking expirations of drugs in stock, is essential. The lack of

professional and technological resources means that pharmacists are expected to do things ''better, faster, and cheaper'', as well as ''smarter.'' Technology would help and enable a pharmacist to be a health care provider under limited professional personnel size.

CONCLUSION

The improved inventory management system, which has been developed by pharmacists, makes inventory functions faster and easier in real time. This system can search lot numbers and expirations of drugs in purchase and delivery records. These functions are powerful and useful in patient safety and cost containment. The workload in inventory management in each section of the Pharmacy Department as well as in clinical units was reduced. The automation system in inventory management allows creating new positions for pharmacists providing clinical services.

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REFERENCES

1) Novek J., *Soc. Sci. Med.*, **51**, 491–503 (2000).
2) Schwarz H. O., Brodowy B. A., *Am. J. Health-Syst. Pharm.*, **52**, 823–828 (1995).
3) Wilson S., *Hosp. Pharm.*, **30**, 759–761, 765–766 (1995).
4) Kohn L. T., Corrigan J. M., Donaldson M. S., ''To Err is Human-Building a Safer Health System,'' National Academy Press, Washington, DC, 2000, pp. 1–287.
5) Kaushal R., Bates D. W., *Qual. Saf. Health Care*, **11**, 261–265 (2002).
6) Meadows G., Chaiken B. P., *Nurs. Econ.*, **20**, 76–77 (2002).
7) American Hospital Association, American Society of Health-System Pharmacists, Hospitals, Health Networks, Hosp. Health Netw., 75, 33–34 (2001).
8) Barker K. N., Allan E. L., *Am. J. Health-Syst. Pharm.*, **52**, 400–403 (1995).
9) Klibanov O. M., Eckel S. F., *Am. J. Health-Syst. Pharm.*, **60**, 569–572 (2003).
10) Sutter T. L., Wellman G. S., Mott D. A., Schommer J. C., Sherrin T. P., *Am. J. Health-Syst. Pharm.*, **55**, 1924–1926 (1998).
11) Barker K. N., *Am. J. Health-Syst. Pharm.*, **52**, 2445–2447 (1995).
12) Lee L. W., Wellman G. S., Birdwell S. W., Sherrin T. P., *Am. J. Hosp. Pharm.*, **49**, 851–855 (1992).
13) Salamie D., *Am. J. Health-Syst. Pharm.*, **57**, 351–367 (2000).