Inpatient pharmacy drugs based on mobile information technology in a "carbon neutral" context Research in a closed-loop management system

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Research Article

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Abstract

Background

The objective is to build a green and low-carbon closed-loop pharmaceutical management system, to improve the quality of pharmacy services and enhance pharmaceutical management based on the Healthcare Information and Management Systems Society Standard (HIMSS), thereby reflecting the value of pharmacists, and improve the level of hospital management.

Methods

By using Mobile information technology and replaced the traditional paper dispensing model and constructing a multi-node information registration system to redesign and reform the hospital information system and inpatient pharmacy workflow.

Results

After the transformation, the entire process of drug data can be traced and closed-loop management, as well as real-time data verification and control, thereby improving the work efficiency, and reducing the drug dispensing time. The number of dispensing errors decreased from 5 cases/month to 1 case/month. The comprehensive dispensing process can achieve the whole process of paperless operation, and reduce the use of A4 paper by 180,000 pieces per year.

Conclusions

Mobile information technology is highly expandable and suitable for continuous innovation and improvement of pharmacy services, the levels of drug management and hospital quality management can be improved, the safety of medication for inpatients can be guaranteed, and the usage of A4 paper can be significantly reduced by continuous iterative improvement of technology.

Background

At the end of 2020, the Central Economic Work Conference set "carbon peak" and "carbon neutral" as important tasks for the first time. The goal is to peak carbon dioxide emissions by 2030 and to be "carbon neutral" by 2060 [1]. In recent years, with the continuous development of China's medical infrastructure, the comprehensive management level of hospitals has proposed higher requirements, and the development of a green hospital has received an increasing amount of attention. Advocating a strict economy, energy saving and emission reduction, and improving operation efficiency have become the top priorities of hospital development. By introducing a paperless office system and strictly controlling the

printing quantity of paper documents and newsletters, the requirements of a paperless office can be gradually realized [2].

Healthcare Information and Management Systems Society (HIMSS) creates a standardized evaluation model for hospital information construction and grades hospital information systems. HIMSS rating is a globally recognized rating tool for medical information systems and is the gold standard for hospitals to obtain international certification. HIMSS classifies medical electronic documents into Levels 0–7 according to the degree of informatization perfection. HIMSS goal is to ensure the safety of patient medication through informatization. It involves the overall informatization of clinical, nursing, pharmacy, laboratory, radiology and other disciplines [3]. Strict closed-loop management of drug use and a higher level of clinical decision support are key criteria for HIMSS Level 6 [4–5]. By 2020, more than 8,000 hospitals worldwide had received an HIMSS rating, and domestic medical institutions are actively promoting the construction of HIMSS. At present, there are 13 HIMSS Level 7 hospitals and 45 HIMSS Level 6 hospitals in China [6]. The First Affiliated Hospital of Guangxi Medical University (hereafter referred to as "our hospital") began to conduct an HIMSS evaluation in 2020, and the informatization of the hospital was constructed in accordance with the HIMSS Level 6 standard.

Under the background of national "carbon neutral" and HIMSS Level 6 standard construction, the pharmacy of our hospital began to use a paperless drug dispensing mode, combined with two-dimensional code technology, so that the information (e.g., time, personnel) could be recorded at each key node from pharmacy to ward logistics. Moreover, full play was given to the technical advantages of mobile informatization, which can provide enough information prompts to ensure that every correct drug can enter closed-loop logistics and realize "carbon neutral" closed-loop management of drugs in an inpatient pharmacy [7].

This paper introduces the closed-loop management mode of the inpatient pharmacy at our hospital, with the goal of providing experience and reference for the construction of a modern hospital drug safety system.

Methods

Current situation and analyses of drug placement before transformation

Before the transformation, the working mode was as follows. The drugs in each ward were summarized into a dispensing list and printed out on A4 paper (1-3 pieces of A4 paper were consumed according to the number of drugs in each ward, and printed out at least twice a day). The pharmacist placed the drugs according to the drug location code on the dispensing list and put the target drugs into the medicine basket. The pharmacist in charge of checking the medicine checked the medicine out of the medicine basket according to the paper list, and marked the correct medication on the list with a pen after ensuring that it was accurate. Finally, all of the drugs were handed to the logistics personnel in charge of receiving drugs in the ward.

There were problems in the working mode before the transformation. First, in order to ensure the printing speed, the pendulum list was printed on A4 paper. At least one A4 paper was used for each printing. Even if one drug was temporarily used in the ward, one A4 paper was consumed, resulting in a great waste of resources. In addition, the limited area of A4 paper limited the drug information that could be provided. When dispensing the paper drug list, it was inevitable that there would be "similar drug" errors, and indeed, there were many errors, and hidden dangers of drug safety. Second, the dispensed drugs were placed into the medicine basket in a disorderly manner. Although it is convenient for pharmacists to arrange drugs, it is inconvenient for the checking pharmacists. For example, checking pharmacists spend a lot of time looking for drugs in order to find all of drugs to check in the basket. The more the variety and quantity of drugs on the list, the more time it takes to find them. Taking too long to check, leads to ward patients failing to use drugs in a timely manner. Therefore, the ward nurses were dissatisfied with the efficiency of the inpatient pharmacy. Third, Due to historical and scale reasons, there are 70 wards in our hospital, which are distributed in eight inpatient buildings at different distances from the inpatient pharmacy. The farthest ward takes at least fifteen minutes to and from the inpatient pharmacy. Because the treatment area is scattered, the drug recipients in the ward often cannot return the drugs to the ward on time, and the ward nurses usually think that the work progress of the pharmacy pharmacist is too slow. In addition, the work progress of the pharmacy is not clear to the ward, and drug delivery cannot be reasonably arranged. Information communication is not smooth, resulting in many unnecessary misunderstandings between the ward and pharmacy. Lastly, the inpatient pharmacy drug logistics are not monitored. Once the drug leaves the pharmacy, the pharmacist loses the ability to monitor the drug logistics, which is a great potential safety hazard.

Taking advantage of "carbon neutrality" and HIMSS rating, it is imperative to reform the working mode of inpatient pharmacy and realize green, low-carbon and whole-process closed-loop management of inpatient pharmacy drugs.

Drug closed-loop management reform practice based on the HIMSS standard

The main practices of the inpatient pharmacy in our hospital are comprehensive dispensing and single-dose oral dispensing. After the transformation based on the HIMSS standard, the drug information is associated with the medical orders information in all wards of the hospital to form a traceable closed-loop management mode in all links, such as doctors issuing medical orders, pharmacists pre reviewing doctor's orders, summarizing and placing drugs according to medical orders, checking drug varieties and quantities, packaging and sealing drugs, centralizing and unifying distribution of drugs; and nurses confirming drug receipt (see Fig. 1). After each link is completed, personnel and time information will be recorded in the system to make the entire process from inpatient pharmacy to ward traceable.

In addition, several high-definition surveillance cameras were installed where there might be medical and protective disputes, to carry out all-round monitoring of checking and packing, and have real-time video streaming back within the department. If nurses have doubts about whether the quantity of drugs is sufficient whether the drugs are damaged, and other drug quality issues in the process of dispensing

nuclear drugs, the staff of the pharmacy can immediately retrieve the monitoring video of the drug packing for verification and proof. The real-time call of monitoring video reduces the tendency to shift responsibility when drug quality problems occur due to dispensing drug errors, packaging process damage, and other links, greatly reducing the contradiction between pharmacists and nurses and masking the communication more harmonious.

Paperless comprehensive drug laying transformation

After analyzing the congestion points and combining the hardware advantages of our hospital's informatization, which has completed the full coverage of the hospital's wireless network, we completely abandoned the traditional paper-based drug dispensing mode and tablet computers are used as information media, and trolleys as drug carriers (Figure 1(a)). The specific working steps are as follows. First, the drugs in the ward are input to the tablet computer, which generates a list of drug orders. The drug dispensing sequence is automatically generated according to the pre-maintained dispensing route, and the drug dispensing pharmacists place the drugs in an orderly fashion on the drug-carrying trolley one by one according to the information on the tablet computer (including but not limited to cargo location information, picture information, and voice print information.) (Figure 1(b)). In the process of "not going back", the drugs on the list are dispensed at one time, and then, the drug-carrying trolley is pushed to a fixed position for checking under monitoring by high-definition cameras. Then, the pharmacist places the medicine into the logistics box for packing and sealing. Finally, a sealing label is generated and pasted on the outside of the box as a logo. The label contains information such as the name of department, the time of checking, the two-dimensional code of the drug list number and other information (Figure 1(c)).

Figure 1 Situation after transformation. (a) Take a trolley as the work carrier. (b) The tablet computer can provide all kinds of drug information, including location, package picture, voiceprint of name. (c) After the verification is completed, the pharmacist is undergoing logistics registration.

Single-dose tablet packing

Oral medical orders are subcontracted by the automatic tablet dispenser for single doses. Details including patient information, drug name, specification, quantity, usage and dosage, medication frequency, and medication time, are printed on each medicine bag. The medical orders and medicine bags have two-dimensional containing the above information, which are used for the pharmacist dispensing review. After the drug is delivered to the ward, the nurse scans the code to receive it, records the delivery time and the information of the drug giver and the recipient, and simultaneously connects the data with the mobile nursing system. Before drug delivery, the nurse needs to scan the two-dimensional of the patient’s wrist band to confirm his identity, and scan the barcode of the drug bag to check the medical order information. If the information matches, the operation can be carried out. At the same time, the mobile nursing system will send all data back to the closed-loop drug management system, to realize the traceability of the closed-loop management information of inpatient drug use, in order to prevent the occurrence of drug dispensing and drug administration errors.

Transformation of drug distribution logistics

The original mode of sending people from the ward to receive medicines was transformed into medicines being delivered to the ward, changing from "receiving here" to "delivering to ". Moreover, the open distribution basket was changed into a closed drug distribution box, supplemented by a cold chain incubator for the transportation of refrigerated drugs at low temperature [8]. The process after logistics transformation is as follows: After drug packaging is completed, logistics personnel scan personal information and the two-dimensional code affixed to the sealing box and confirm the distribution order number information on the computer. In order to improve the efficiency of the scattered wards of our hospital, the logistics personnel divide the areas according to the distribution of wards to deliver medicines. After the logistics box arrives in the ward, the nurse scans the two-dimensional code on the logistics box to confirm and receive the medicine. The nurse does not need to open the box and check it in person. If there is any doubt about the drug quality later, the pharmacy can query the surveillance video for proof.

Reform of pre-prescription review of medical orders

A pre-prescription review team was formed for the inpatient pharmacy. It had a full-time pre-prescription pharmacist, and accomplished the pre-prescription medical orders through a rational drug use decision support system combined with manual review mode. Pre-prescription review is an important part of closed-loop drug management mode based on the HIMSS standard. After the doctor issues a medical order, the system automatically audits; the audit can generate a normal medical order. If the order does not pass the examination, the doctor will take the initiative to modify the problematic medical advice according to the system prompts. If the doctor refuses to modify the problematic medical advice, the system will automatically send the medical advice to the online auditing pharmacist, who will manually audit the medical advice, and the auditing and modification suggestions will be sent to the prescribing doctor through the system. The whole real-time review process of medical advice is completed within 40 seconds. Doctors can adopt the advice of pharmacists to modify medication problems, or they can sign for confirmation again and enforce it. Pre-review helps doctors correct medication problems when issuing medical advice (Figure 2).

Figure 2 Closed-loop management mode of outpatient medication

Data

The records of drug dispensing time from November 2020 to March 2021 in five wards of our hospital and the error information from wards to inpatient pharmacy were selected as the research data by using the Excel table random formula.

Statistical analyses

SPSS 22.0 was used for the statistical analyses. The t- test was used to compare the data of the two groups before and after transformation, and $P < 0.05$ was considered statistically significant.

Results

Improvement effect and analysis of drug closed-loop management mode based on HIMSS

After the transformation, five wards were randomly selected (Excel random formula method) for comparison of drug placement time (Table 1 and Figure 3). As can be seen from Table 1, after process optimization, the average time of dispensing drugs in the five wards significantly decreased, suggesting that the work efficiency had significantly improved.

Table 1 Comparison of the time before and after transformation

Department	Average time in March 2021（min）	Average time in November 2020 (min)	p value	95%CI	
				Lower	Upper
ward1	10.69±5.89	20.00±7.48	≤0.01	-14.17	-4.45
ward2	14.34±6.93	21.45±9.48	0.03	-13.56	-0.66
ward3	10.41±5.98	19.12±6.38	≤0.01	-14.52	-2.90
ward4	18.97±3.64	27.68±6.75	≤0.01	-11.96	-5.46
ward5	22.22±13.50	61.52±7.50	≤0.01	-46.00	-32.60

Figure 3 Comparison of the time before and after the transformation

Effect and analyses of closed-loop drug management mode based on HIMSS drug placement error control

After the transformation, dispensing errors decreased from 5 cases per month to 1 case per month (Figure 4). According to the subsequent summary and analyses, the reason errors occurred after the transformation was that similar drugs were placed without the mobile dispensing mode, which led to the error.

Figure 4 Comparison of errors before and after transformation

Discussion

After using a mobile tablet at work to complete the closed-loop management of the inpatient pharmacy, the author found that this mode has the following advantages:

First of all, it can greatly reduce the use of A4 paper in inpatient pharmacy and make "low-carbon pharmacy" possible. Before the transformation, a large number of A4 papers were needed for the comprehensive drug laying process. According to the calculation of the 70 wards of the hospital, each ward receives drugs at least twice a day, each time consuming at least two pieces of A4 paper on average. The inpatient pharmacy of our hospital consumes more than 500 pieces of A4 paper daily. Thus, a large amount of paper is consumed each year. Based on the reduction of carbon dioxide emissions by

0.002 kg per piece of paper, paperless drug dispensing in the inpatient pharmacy of our hospital can reduce carbon dioxide emission by more than 0.365 tons per year.

Furthermore, it can improve the safety of comprehensive dispensing in inpatient pharmacy and reduce dispensing errors of "similar drugs." The size of A4 paper does not provide enough information to distinguish between "similar drugs." Therefore, drug error is inevitable with the original work mode. When similar drug dispensing errors occur, if the nurse finds them on time, it is necessary to send someone to the inpatient pharmacy for dressing change, which delays the patient's medication time. If the nurse fails to detect it on time, the wrong medicine will be given to the patient, resulting in medical errors. The tablet computer, which is similar in size to A4 paper, not only provides drug text information but also provides picture information, voice print information, and so on. Furthermore, it can scan drug electronic supervision code for drug verification, greatly increasing the ability to correctly check drug information [9–11].

Thirdly, a trolley with a mobile tablet as the carrier can provide at least two layers of space for placing drugs. The display area is at least two times larger than before, and the drugs can be neatly listed, providing great convenience to the checking pharmacists. The medicines are placed according to the order of the list, and the verification of the reverse order of generation and placement is performed, which greatly shortens the medicine verification time.

After logistics transformation based on the HIMSS rating standard, the ability of inpatient pharmacy to supervise drug flow was improved. After the transformation, precise logistics traceability to individuals can be realized, the consumption time of logistics distribution to the ward can be monitored, the receiving ward can be monitored, and the full closed-loop monitoring of drug logistics can be realized. By analyzing the time data and logistics workload, fine management such as adjusting personnel ratio can be realized to improve the efficiency of drug logistics and distribution and improve the satisfaction of the ward's inpatient pharmacy.

As a multimedia mobile carrier, compared with traditional mobile tools such as a personal digital assistant (PDA), the tablet computer has many advantages such as large visual area, strong hardware performance and more expansibility. It can provide continuous hardware and software technical support for pharmacy management and meet the requirements of modern hospital information management.

Conclusion

With the development of mobile informatization, many doctors, nurses, and pharmacists have applied mobile informatization to clinical treatment, but it is relatively rare for hospital pharmacy business in China [12–14]. At present, China is gradually building and improving the medicine traceability system. The closed-loop drug traceability system will facilitate hospitals implement HIMSS standardization. After reforming the inpatient pharmacy according to the HIMSS rating standard, the whole process of medicine traceability and quality control can be realized, and the closed-loop management of all in-hospital medicine can be realized [15].

The implementation of the mobile mode has improved work efficiency, reduces errors in inpatient pharmacies, and guarantees patient safety. At the same time, it is also the exploration and innovation of the green working mode. From how to expand the functions of mobile information technology, to how to optimize working mode and method, we need to constantly explore in practice and continue to accumulate experience. It is believed that with the continuous implementation of 5G applications, more and more green and low-carbon working methods will be applied to the hospital practice.

Abbreviations

HIMSS
Healthcare Information and Management Systems Society Standard.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

KW, LJ and XX designed the closed-loop management system and the study. KW, and LJ developed the app. TH, and YC collected data. KW, and LJ analyzed the evaluation data and drafted the manuscript. HZ, and TL made critical revisions to the paper for important intellectual content. All authors read and approved the final manuscript.

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Availability of data and materials

The data of work errors used in the current study are not publicly available due to privacy and security concerns. Consume time data can be found in the supplemental material.

Ethics approval and consent to participate

All participants signed informed consent forms for this research. The research was approved by the Ethics Committee of The Medical Ethics Committee of First Affiliated Hospital of Guangxi Medical University with the Ethical ID NO.2022-KY-E-(052).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Situation after transformation. (a) Take a trolley as the work carrier. (b) The tablet computer can provide all kinds of drug information, including location, package picture, voiceprint of name. (c) After the verification is completed, the pharmacist is undergoing logistics registration.

Figure 2

Closed-loop management mode of outpatient medication

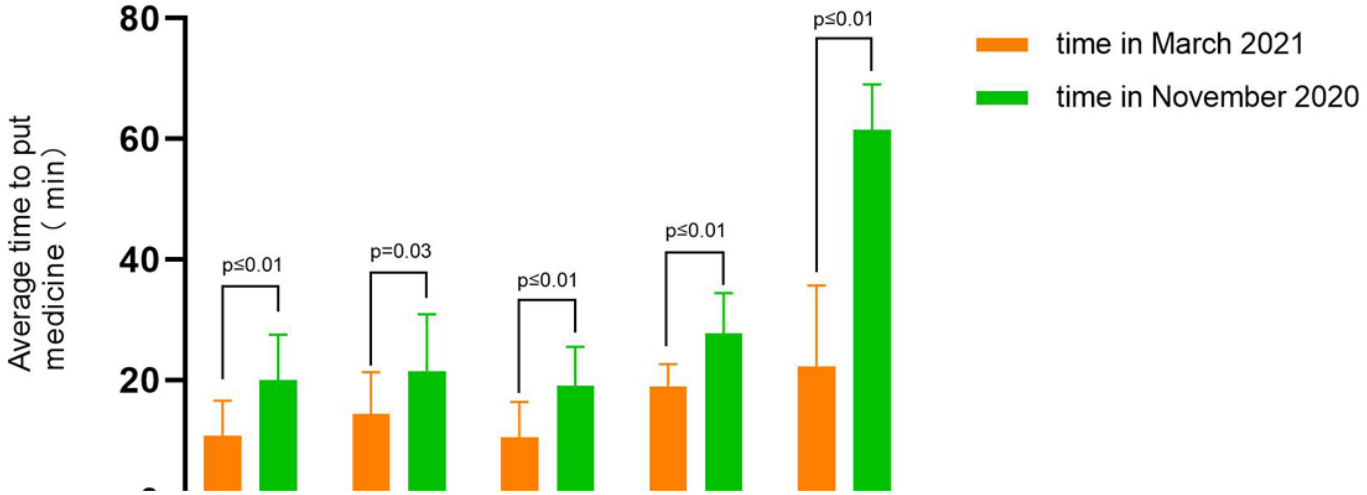

Figure 3

Comparison of the time before and after the transformation

Figure 4

Comparison of errors before and after transformation

Supplementary Files

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- dataoftime.xlsx