Mobile PCIS: Point-of-Care Information Systems with Portable Terminals

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Abstract

We have developed a Point-of-Care Information System (PCIS) that uses portable terminals and supports the entire loop of daily nursing work for the first time. Nursing work includes a great deal of indirect nursing work, such as documenting patient information, conferring with other health-care providers, and so on, as well as direct patient care. The time needed for this indirect work often exceeds the time actually spent directly caring for patients and needs to be reduced. Our system was developed with the goal of doing this to make nursing work more efficient. The system consists of personal digital assistants (PDAs) that nurses carry in the hospital wards and a server computer located in the nursing station. The system has three main functions: 1) Data Browsing provides patient information such as a brief history, vital-sign charts, and handwritten notes; 2) Schedule Planning helps nurses organize doctors' instructions and make To-do lists for the day: and 3) Care Management reminds nurses when they should execute the doctors' orders and provides tools for data entry. These three functions cover the entire loop of daily nursing work. The PDAs and the server computer can share up-to-date information by data transmission through telephone lines (low-power cellular phones can be used), infrared devices, or RS-232C cables. Results from a preliminary hospital evaluation showed that use of the system can reduce the time needed for nursing documentation by 60% (a 10% saving of a nurse's total working time). and that more than 80% of the nurses who used the system felt it would make nursing work more efficient.

Keywords

Point-of-Care Information System; PDA; Nursing Documentation

Introduction

Our goal is to reduce the time spent on documentation in nursing work by introducing a Point-of-Care Information System (PCIS) based on the use of portable terminals and that includes several original functions.

Computers are now widely used in most sections of hospitals. However, point-of-care nursing has been less computerized than other types of work because the information used comes from several different sections of the hospital and there is a lack of a standard structure for processing this information. In addition, the workplace of nursing professionals is not limited to a nursing station but includes the patient rooms, bathrooms, and other places in the ward.

To solve these problems, the use of portable terminals in the PCIS has been proposed [1][2]. A system with portable terminals has the advantage of data-entry at the source; for example, once a nurse enters a patient's vital signs, the data is immediately sent to the nursing station and a chart can be printed.

Still, to develop a practical PCIS, we must carefully examine the nature of nursing work. Thus, we observed the details of the time spent on conventional paper-based nursing work during a four-day analysis in six wards at Hitachi General Hospital, a 500-bed hospital in Japan (Figure 1). Generally speaking, nursing work consists of direct patient care and indirect nursing work, and more time spent on direct patient care increases the quality of care provided. As shown in Figure 1, however, nursing work includes far more indirect work than direct patient care. In particular, documenting patient information is a significant proportion of the indirect nursing work, and is considered both a mental and a physical burden by many nurses.



Figure 1 - Details of the time spent on paper-based nursing work (Hitachi General Hospital)

To find ways to reduce the documentation in nursing work, we then investigated the data-flows and work flows in the paperbased nursing work during a five-day analysis of the normal operation at Hitachi General Hospital. As shown in Figure 2, the work of the nursing staff proved to be divided roughly into three phases; reviewing patient information, planning daily schedules, and executing the work. These phases form a loop. The work of doctors and head nurses is also a loop of data reviewing, giving orders to nurses, and confirming the status of orders previously given. At each phase, the health care professionals refer to and record information on many kinds of documents, and a large part of this information is simply copied from other documents manually. Manual copying of information is not only time-consuming, but also poses a potential danger of serious medical accidents due to miscopying, so this practice should be eliminated. Minimizing redundancy in record-keeping and other activities could thus dramatically reduce the documenting work.

However, many of the existing PCISs make use of portable terminals only as data-entry devices and/or as simple data browsers [3]. Therefore, a new system that covers the entire loop of nursing work is needed to eliminate the manual copying of information and increase the quality of care.

In this paper, we propose a new PCIS concept based on portable terminals and evaluate its effectiveness in reducing the time spent in documenting inpatient information.



Figure 2 - Data flow of paper-based nursing work: Nurses spend a large amount of time on just copying information from one document to another (Hitachi General Hospital)

System Design

Basic Concept

We designed our proposed Mobile PCIS by first considering the best ways to reduce the documenting work of nurses and eliminate manual copying.

To minimize information redundancy, all the data in the nurses' work-flow loop should be computerized.

Since nurses need to be able to access patient information anywhere in the ward at any time, we decided a portable terminal would be the best device for nurses to use. On the other hand, doctors and head nurses mainly handle information at a nursing station, so personal computers (PCs) should be used there to manage and integrate the data in the ward. To keep the information consistent, the portable terminals and the server PCs must continually synchronize data with each other by means of data communication.

Thus, we decided the work-flows and data-flows for the Mobile PCIS should be as shown in Figure 3, where communication between PCs and portable terminals replaces the manual copying of information.



Figure 3 - Work-flows and data-flows in the Mobile PCIS. The system is designed to eliminate manual copying and minimize redundancy.

System Architecture

Based on the basic concept, we developed a prototype of the Mobile PCIS. The system consists of a PC and portable terminals, where the PC is in a nursing station and mainly used by doctors and head nurses. Portable terminals are carried around the ward by nurses (Figure 4).

Though a pen-based tablet PC was used for the initial prototyping of the system [4], it was a little too heavy for use as a portable terminal. If a portable terminal is too small, on the other hand, it is difficult to simultaneously display enough information on its screen. Thus, we selected a PDA (personal digital assistant); weighing less than one pound and having a 5-inch touch screen, as a portable pen-based terminal in this prototype (Figure 5).

The system provides three modes for data communication between the PC and the PDAs: by a telephone line (including a low-power cellular phone), an infrared signal, or an RS-232C cable.



Figure 4 - System architecture of the Mobile PCIS



Figure 5 - A PDA (HITACHI POSSIBLE) for use with the Mobile PCIS; it weighs 420 grams, and has a pen, a touch screen, an infrared communication port, and an internal modem.

Software Design for Portable Terminals

As mentioned, the work of a nursing staff can be divided in three phases. To support the nursing work effectively, we designed the software for the portable terminal to have a primary function for each phase. The system provides a Data Browsing function on the portable terminal for reviewing patient information, a Schedule Planning function for planning a daily schedule, and a Care Management function for executing the work.

With this design, the Mobile PCIS is the first systems we know of that supports the entire loop of daily nursing work. The portable terminal not only allows data input and output, but can also be used for the general management of the daily nursing work loop.

Data Browsing

With the Data Browsing function, nurses can easily review patient information such as a brief history, handwritten memos, and vital-sign charts. Figure 6 shows an example of the information displayed.



Figure 6 - An example of the Data Browsing display

Schedule Planning

The Schedule Planning function shows a list of orders from doctors and head nurses on the right side of the screen (Figure 7), and allows nurses to make a To-do list for the day. This function is unique to this system.

	Schedule Input-box	Info	Information about Selected Order	
Planned o-do List	DATA BECHELING STIELUIE PERMENING HERMAL GENERAL ROOM, WAS SIDE of WASHINGTON, WAS STORED AND AND AND AND AND TADA STREAM AND AND AND AND TADA AND	CATE MAQUIDI C1-9(L-1) MAQUIDI C2 C3 C1-9(L-1) C1	2. John Shi TM DET John 1+ HEV(TILLIE 1g UTD STORM + HEV(TILLIE 1g UTD STORM + HEV(TILLIE 1g 23/07 12:00 HORL 23/07 12:00 HORL 23/07 01:00 HOR 23/07 H	Order List
	23/07 16:30 DIV N.L.E	ADEM C.PAT	23/07 #:# VITAL (P.000 ¥.000 ¥.000	с



Care Management

The Care Management function links the To-do list with the tools used for confirming input, handwriting memos, and recording vital signs. The program checks the planned time of the To-do list items, and reminds nurses with warning signals when the work is to be done (Figure 8). This function is also unique.

	Confirmation Input-box	ailed Information about Selected Order
To-do List	DATA STRUTUR CORE CORE CORE ENGERING FARMENTS ENGERING FARMENTS ENGERING FARMENTS ENGERING FARMENTS ENGERING	0-2402/UTRAS 2010 04 8422 97 10:12:3666 87 (111.18 1.9 30: - 347848 9:86 5:10



Software Design for Server PC

Since patient data is sent from portable terminals and managed collectively, and orders are given based on this data, there should be three main functions on the server computer at a nursing station: ordering, communication management, and data management.

Figure 9 shows an example of a chart drawn by a charting tool that is part of the data-management function. With this tool, the trends in a patient's vital signs can be reviewed and printed out.



Figure 9 - Vital-sign charting tool



Figure 10 - Comparison of input time



Figure 11 - Results from the questionnaire

Experiments and Results

Evaluation of Time-saving Effect

To confirm the effectiveness of the Mobile PCIS, we conducted an experiment in a plastic-surgery ward of Hitachi General Hospital. We compared two input times: one with the portable terminal prototype and the other with conventional written forms. As shown in Figure 12, while a nurse went through her daily nursing procedures with paper, one of the authors accompanied her and input the same data with a PDA. The time spent on documenting by hand and by inputting was measured. The information on inpatients and the care instructions were inputted in advance and all information concerning the privacy of the patients was deleted after the experiment.

The result is shown in Figure 10. The recording time of the nurse writing on paper forms was 94 minutes during a single day-shift, but only 38 minutes was needed to record the same data with a portable terminal -- a 60% reduction.



Figure 12 - Evaluation of time-saving effect at Hitachi General Hospital

Evaluation by nurses

To collect the opinions of the nursing staff, we performed an arranged operations experiment in the same ward of Hitachi General Hospital. An arranged operations scenario was prepared that included reviewing patient' information, making a daily schedule, and inputting vital signs. After a brief explanation of how to operate the portable terminal, nurses were shown the scenario and performed the operations as the scenario indicated. The opinions of the nurses concerning the usefulness of the Mobile PCIS were collected through questionnaires. Eight nurses whose nursing experience ranged from 1 year to 20 years took part in the evaluation.

Figure 11 shows the answers the nurses gave on the questionnaire. Though the ratings of the user-friendliness were widely dispersed, half of the nurses considered it good or relatively good. Seven of the eight nurses thought the system would improve the efficiency of nursing work.

Discussion

If the 60% timesaving effect of the Mobile PCIS for recording work is applied to the results of the nursing work analysis shown in Figure 1, we can expect the time spent on documentation to be reduced from 17% of a nurse's total working time to about 7%. With this system, therefore, about 10% of a nurse's workload could be spent on other work: direct patient care, for example. This would be a significant advantage when using the Mobile PCIS.

Even with the system, however, 40% of the recording work remained. As well as the time needed to copy information, this 40% includes time for documenting patient records, which requires careful thought. In our opinion, this part of the documentation process should not be fully automated, because nurses need some time to reflect upon and understand the status of patients when documenting their condition. It is possible, though, to further support nurses when they are completing patient records, and that will be our next goal. Though we focused on the time needed to record information in this experiment, the Mobile PCIS should also make other work more efficient. We will investigate this further.

We felt the results of our arranged operation experiment demonstrated the practicality of the system. Only one nurse had previous experience using computers, but half of the nurses thought the user-friendliness was good or relatively good. We attribute this to the advantage of the pen-based interface and the user-friendly design of the graphic user interface.

The answers to the second question on the questionnaire show that the basic concept of the system was appreciated by the nurses. Of course, we plan to collect more opinions based on clinical experiments prior to making the system available for practical use.

Conclusion

To minimize the time nurses spend on recording information, we have developed the Mobile PCIS (a Point-of-Care Information System with portable terminals) that covers the entire loop of daily nursing work. The proposed system consists of portable terminals carried by nurses around the hospital ward, and a server computer located at the nursing station. Our experimental results show that the system can reduce the time needed for recording work by 60%. Also, the system is user-friendly with its pen-based interface and was evaluated positively by more than 80% of the nurses who used it.

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