Comparing the working time between Bar-Code Medication Administration system and traditional medication administration system: An observational study

Sing-ling Tsai [a,*], *Ying-Chou Sun* [b], *Fang-Meei Taur* [b]

[a] *Mackay Medical College, Taiwan*
[b] *Taipei Veterans General Hospital, Taiwan*

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ABSTRACT

Background: The medical institutions had paid attention to the medication error via Bar-Code Medication Administration system (BCMA) to improve the accuracy of the medication process for patient safety. Yet, the working time of drug delivery was under investigated.

Objectives: Comparing the working time of oral drugs between Bar-Code Medication Administration system and traditional medication administration system.

Methods: Purposive sampling, observational and questionnaire study design was used. Participants were invited from a medical center in North Taiwan, 51 nurses from three neurosurgical wards who were using the BCMA system; 51 nurses from three neurological wards who were using traditional medication administration record (MAR). The working time of oral medication administration including order transcribing, verifying, drug giving, and renew in BCMA and traditional group were observed and recorded.

Results: (1) Working time for oral medication administration reduced from 36.49 to18.42 s after BCMA implementation. (2) In the same period, working times for oral drug administration were 62.89 and 56.07 s before and after BCMA implementation in the traditional group. (3) Most nurses (66.7%) felt BCMA could save their oral drug administration time under 50%. (4) Frequent crash of the wireless network, which extended the oral drug administration time was the major threat in the process of BCMA implementation. (5) 93.5% nurses think that BCMA could enhance patient oral medication safety and promote quality of oral medication.

Conclusions: The results demonstrated that implementation of BCMA for oral medication could reduce half of the time for oral medication delivery. Nurses coordinated the hardware and software by accommodating the new facilities and operating BCMA system. The stability of wireless Internet was the main threat. However, 93.5% nurses think that BCMA could enhance patient oral medication safety in spite of making more effort in learning new technology.

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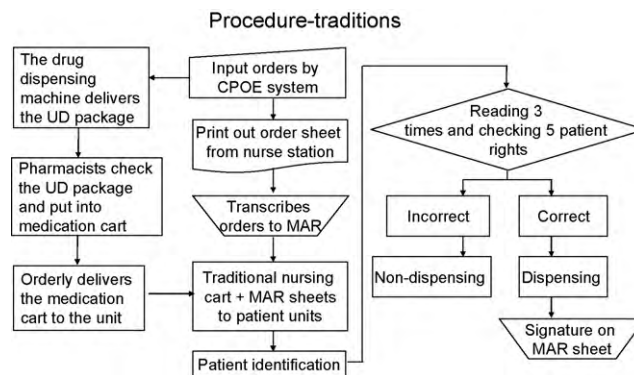
1.   Introduction

Patient safety is the major concern since Institute of Medicine published "To Err is Human". Medication errors raised health care profession awareness of this critical issue in patient safety. Giving medicine to patients is a frequently performed activity by nurses in the medical centers. Researchers found that nurses spent 16.9–26.9% of their time on medication-related activities [1,2]. In a complete procedure of medication administration, which involves physician's prescription, pharmacist's dispensing and nurse's administration, the right patients and right drugs were repeatedly checked. Errors happened in any process of the long medication administration manual procedures. Bar-Code Medication Administration system (BCMA) provides safety features for nurses and patients alike [3]. BCMA included machine-readable barcodes on patients and medications via informatics' system and verify right patient, dosage, form, time, and route. Thus, the repeatedly checked procedure could be replaced by BCMA, and time spend in repeatedly checked procedure might be shortened.

To monitor the medication error rates was used to evaluate the outcomes of BCMA [4]. One veterans hospital decreased medication errors by 23% in the first year using BCMA and by 66% after using BCMA for 5 years [3]. Researchers conducted a before-and after, observational study in a 386-bed academic teaching hospital and found that implementing BCMA technology decreased medication administration errors in medical-surgical units when time errors were excluded [5].

Yet, what is the influence on nursing activities by implementing this informatics technique of BCMA? When evaluating the effects of implementing new informatics techniques, most researchers measuring the acceptance of these new techniques [6]. Researchers found that perceived usefulness and perceived ease of use significantly affected healthcare professional behavioral intent to use mobile healthcare systems [7]. To improve the acceptance of BCMA, there were 15 recommendations for "best practices" of BCMA implementation, continuous improving, training, trouble shooting, maintenance of equipment and bar-code [8]. These suggestions offered clear directions for beginners of BCMA system.

Decreasing medication errors by BCMA and ways of coping difficulties in the process of implementing BCMA were studied in the above literatures. However, time spend in Medication Administration by BCMA was seldom studied and the observation of BCMA drug delivery time was under investigated.

In a 2-h period observational study of nursing activities at the initial stage of BCMA, the medication-related activities were divided into management of physician orders, information retrieval, obtaining and verifying medications, verifying patient identity, medication delivery, documentation of medication administration, inefficient waiting, and other [2]. The task that occupied most of the nurse time was obtaining and verifying the medications (7.44%), next was medication delivery (6.7%). Two parts were observed during medication delivery step. Part 1 included programming pump, connecting IV tubing, and injecting medications. Part 2 were obtaining fluids for PO medicine and observing patients taking medications. This study delineated all the steps of medication

Fig. 1 – Traditional medication administration procedure.

administration including intravenous and oral routes of delivery medications. However, it did not describe times spending in medication delivery after BCMA system was implemented. Therefore, our study focused on comparing oral medication delivery time before and after BCMA system was implemented.

2.   The setting

2.1.   Paper-based system of medication administration of the medical center

The medical center has 2909 beds and 2347 nurses in northern Taiwan. The unit dose delivery system (UDD) and computerized physician order entry (CPOE) were carried out since 1986. Physician prescribes orders, CPOE connects to pharmacy via network, and the drug dispensing machine delivers the UD packages for all the medication daily to the unit. After physicians prescribed an order, nurses have to transcribe the computer generated order onto the medication administration record (MAR) in the nursing record (Fig. 1).

2.2.   Establishing the project team

The bar-code UDD and BCMA were started to establish since Sep, 2005. BCMA is a novel infrastructure of computer software development, not just a digitalized paper-based operation. In consideration of meeting the demand of a system for more than 2900 beds, the system uses three neurosurgical units as the trial units, forming a multiple disciplinary team from informatics personnel, physicians, pharmacists and nurses, together to plan out the progress and discuss at regular meetings. Initially a meeting for system demand consensus discussion and journal reading was held biweekly, and after 3 months changed to a monthly discussion, in the hope to create an information system that conforms to the clinic practice operation. Prior to the program that went on-line, 30-min on-line training was given to the nurses in the trial units. The training included introduction and operating procedures for the software, the concept of network infrastructure and an initial strategy for operational problem trouble shooting. During the initial period when the system went on-line there were engineers at the trial units each day, to determine whether

the problems were caused by improper operation, or system design, and to timely trouble shoot or modify the program. Upon completion of the development of the system, the paper-based and on-line system were run in parallel for a week, to verify the correctness of the BCMA drug connection and the operation smoothness of the system, and BCMA was officially on-line on Oct, 2007.

2.3. Structure of BCMA system

The functional structure of *BCMA* is primarily divided into five parts including system setup, sign in operation section, sign records search, print sign in record forms, and system crash re-entering section. The system setup has authorization control, the head nurse has the authority to modify according to the characteristics of each unit, and also it can check the status of nurses administering medication and sign in at correct times from back stage. Signing operations includes the selection of patient list; after scanning the wristband bar code of patients enters the case signing function, including the routines of this time, and intravenous (IV), STAT, PRN drugs; all the patients' medication can be found by searching the signing records. Yet, since there was no bar code in each vial, ample and intravenous solution, the IV route could not be scanned and required keying in to the computer. Only the oral drugs were packed and bar coded for each medication delivery time by the pharmacy department. Thus, BCMA system was used only for oral drug administration. System has also added a problem responding function, which enables a fast communication channel for nurses and informatics personnel to quickly solve problems with the system when the system is unstable and no informatics personnel are on site.

2.4. Facilities

Good tools are prerequisite to the successful execution of a job. Other than the software, the hardware includes the wireless hotspots and BCMA action station (Fig. 2).

2.4.1. Installation of wireless local area network (LAN)
With the computer hardware and software equipped, a no dead-end wireless communication installation allows the mobile nursing cart to carry out its full functions. The stability of the wireless environment is important to prevent nurses from missing receiving real-time information of medication administration, or when the system crashes during use and needed to re-login the system constantly, resulting in additional work loads for nurses, and thus increasing the working times.

2.4.2. Mobile nursing cart
In addition to carry drugs, medicine cups, syringes etc. in the original nursing cart, it also needs to have a computer, keyboard and bar-code reader, etc installed. As BCMA has to use the bar code reader to scan wristband on patients at the same time, the mobile nursing cart not only needs to be able to enter patient units, it must also be adjusted at the ergonomic height to ease the push-pull of the car by nurses to avoid occupational injury. The size and weight of the mobile nursing cart are also the key factors in design considerations.
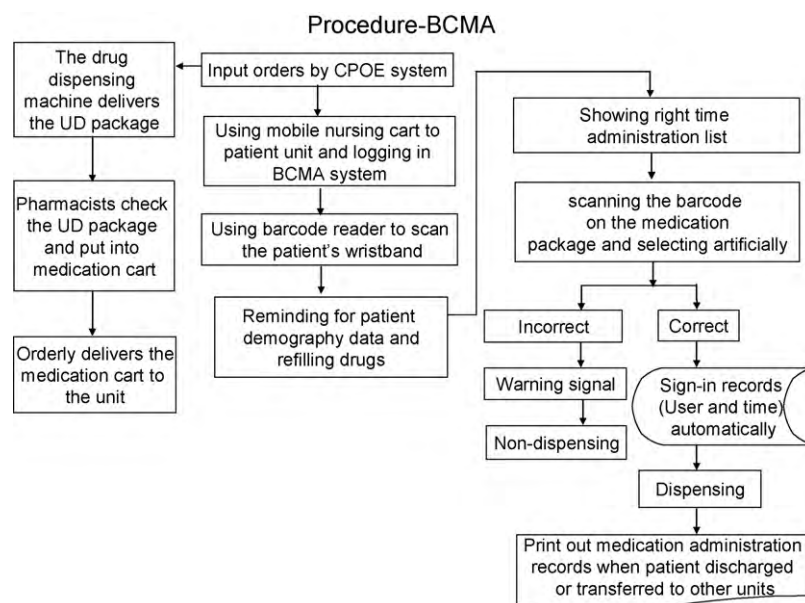

Fig. 2 – BCMA system computer cart.

2.4.3. Bar-code reader
As the BCMA system consists of handheld devices for scanning machine-readable bar codes on patients and medications, there is a greater likelihood of infection from contacting due repeated scanning (medication packages and patients' wristbands) with the barcode reader, hence to reduce the risk of infection, it should have a high sensitivity in reading and identification, and the clarity of the bar codes on wristband and medication packages would effect the time of operation for nurses.

Faster scanning helps to eliminate the possibility of nurses by passing some of the scanning steps due to long scanning time. It has shown that one in five nurses would enter the patient's social security number by keyboard instead of scanning the bar code wristband, which caused near misses could not be intercepted accurately [9].

2.5. Procedure of BCMA system

In addition to the different equipment and instruments, the new medication administration process is also largely different (Fig. 3). In the BCMA system, after the physician prescribes an oral order, the order is immediately sent to the BCMA system, nurse sign in the system with identification (ID) and password at the time of medication administration, and after selecting the function screen, scans the wristband on patient, allowing the system to display all the medication information of the patient of that time, and then scans the bar code on the oral medication package for the 5 rights check. The system will send out warnings when errors have been found while checking; if all is correct, the screen will automatically select all the oral medications for the administration time, and after assisting the patient taking the medication, press the confirm button to complete the correct oral administration process. If some drugs in the oral medication package are not to be given

Fig. 3 – The procedure of BCMA system.

at the time, a reason must be recorded in the system to explain why the drugs were not administered, otherwise this will be noted as medication not administered at the right time.

3. Methods

In this study, the working times were measured at Sep 2005 before the system being developed and at Dec 2007 after the BCMA system started. Medication used to be administered manually by verifying the medication package with the MAR by reading three times and checking the 5 rights. Therefore, the four processes to be transformed including order transcription, order verification before administration, oral medication delivery procedure and order re-transcription were chosen as a result for determining the working times. Working time of order transcription, order verification before medication giving procedure and order re-transcription were self-recorded by the staff nurses. Working time of giving oral medication to patient was observed and recorded by a project assistant.

Whereas the BCMA system checked patient and medication by scanning the bar codes on wristband and medication package, and the BCMA system did not require transcribing orders. After the BCMA system went on-line, the nursing stations stopped printing orders, and the nurses were no longer transcribing orders. Thus, only the oral medication giving procedure left among the four processes of order transcription, order verification before administration, oral medication giving procedure and order re-transcription.

3.1. Definition of terms

3.1.1. Working time of medication order transcription
Included both the time taken for transcribing new and modified orders. It was from taking new or updated orders

(including medication record and patient administration sheet), and transcribing orders one by one onto MAR, ticking and signing medication record, and then filing the medication record sheet in the medical chart, and the patient administration sheet in the MAR chart, until returning the medical chart and MAR charts back to storage. This was recorded by nurses themselves including day shift and night shift.

3.1.2. Working time of verifying medication order prior to administration
The time required for verifying each patient's MAR with the medical orders on the patient's medical chart. It was recorded by the nurses themselves at 9 am and 5 pm.

3.1.3. Working time of renew medication orders
After an inpatient is admitted for 7 days, the medication order needed to be renewed and transcribed onto MAR. This was recorded by the nurses themselves during night shifts.

3.1.4. Working time of oral medication giving
A project assistant observed and recorded the working time of drug giving procedure at 9 am and 5 pm. During the process of recording, the followings were excluded: drug milling, drugs administered by feeding tubes, patient condition discussion, scheduling check, etc. The traditional paper-based process used medication package to verify patient's name on MAR, after completing the 3 readings and 5 rights, entered the room to assist patients taking medication, and signed after completion of administration. The working time of drug giving in BCMA started at bar-code reader checking the patient's wristband and the bar code on oral medication package, giving the medication package to patient, after observing patient taking all the drugs, pressing the confirm button of medications administration and was recorded by

the system automatically. Each observation period averaged 1 h.

3.2. Data collection

A nurse data recording list was developed by the authors with the description of the steps mentioned in Sections 3.1.1–3.1.3. Oral medication giving observation record list including Section 3.1.4 was designed for the project assistant to use. Thus, the nurses filled the nurse data recording list and the project assistant used the oral medication giving observation record list to collect data.

3.3. Participants

Using purposive sampling, we invited nurses of 3 neurosurgical units from each of the BCMA and the neurological traditional group, and nurses who have worked for at least 3 months. The research team members met with the staff nurses and explained the study objective. The definitions of each self-record time were instructed to the nurses along with the nurse data recording list. Nurses were offered the opportunity to voluntarily participate in this study. Information gathered in this study was de-identified and confidential. Thus, the data would not being used as part of employee's performance evaluation. The project assistant did not interact with the patient or nurse. Before collecting data, consent of the nurses was obtained. A single system was implemented prior to the trial of BCMA and after the stability of the system has been tested. Self-reporting and observational data of the working time in the process of oral drug administration delivery by nurses were performed for 2 weeks before and after BCMA being implemented at each of the units, and a form of working experience was completed before performing. The nurses of the BCMA group also assessed the effectiveness of BCMA by a self-assessment, which included the overall reaction to BCMA, recommendations, and the effects on the quality of work after BCMA was implemented.

3.4. Data analysis

Statistical analysis software, SPSS for Windows version 14.0, was used. The analysis included descriptive statistics, inference statistical analyses on Mann–Whitney U-test to evaluate the data collected.

4. Result

4.1. Nurse's working experience

It took 2 years for the BCMA of oral administration to go online; some nurses changed in the units, but no differences between two groups in work experience. Before BCMA was implemented, the BCMA group had a total of 51 staff nurses, they had the working years range between 0.30 and 22.77, and a median of 2.81 years; there were 51 staff nurses in the traditional group, the working years in this group ranged between 0.42 and 14.32, and a median of 3.20 years. After BCMA was implemented, the BCMA group had working years between

Table 1 – The frequencies of observation in each step of oral medication administration.

	BCMA group	Traditional group
Before BCMA		
Transcribe order	196	1101
Verify order	1302	2634
Give oral medication	390	395
Renew order patient no.	28	32
After BCMA		
Transcribe order	–	2067
Verify order	–	4274
Give oral medication	633	641
Renew order patient no.	–	75

0.38 and 15.46, a median of 4.11, the traditional group had working years from 0.36 to 15.55 years, a median of 3.66 years. The working years were no difference by Mann–Whitney U-test between BCMA and traditional group before ($Z = -.602$, $p = .547$) and after ($Z = -.635$, $p = .526$) BCMA was implementation.

4.2. Observations of oral medication administration in BCMA and traditional group

Before and after implementation of BCMA, the frequency of observations of transcription, verification, giving oral medication, and the number of patients renew the order are listed in Table 1. The two groups had the same steps before BCMA implementation. There was one step left in the BCMA group after BCMA being implemented. Hence, the observation of BCMA group remained in one step. The transcribing, verifying and renew steps were replaced by scanning bar code on the wristband and oral medication package. The action of scanning bar codes was included in giving oral medication procedure.

4.3. Working time

In the BCMA system and traditional paper-based operation, entering of the medication order into CPOE was all done by physicians. However, in the traditional paper-based operation, in addition to the oral medication administration process, it also needs to transcribe medication orders, verify order and paper copy of MAR, and the time to renew orders (every 7 days). Before BCMA implementation, the total working time of the BCMA group to transcribe order, verify order and the giving oral medication required an average of 36.49 s, and renew the order of each patient took an average of 259.72 s. After BCMA implementation, the time to perform the oral medication administration only required an average of 18.42 s. The nurses in the BCMA group, although not required to perform order transcription and signing on papers, but have the new process of scanning the bar codes on wristband and medication package, so the process of giving oral medication increased from 6.24 to 18.42 s.

Whereas for the traditional group, prior to BCMA went online, the time to transcribe order, verify order, and giving oral medication required an average of 62.89 s and renew the order of each patient took an average of 291.97 s per week. While the BCMA went on-line, the traditional group that did not use

Table 2 – Comparison of the average time for oral medication order transcribing, verifying, administrating and renew (s).			
	BCMA group before BCMA after BCMA mean (SD)		Traditional group before BCMA after BCMA mean (SD)	
Order transcription time	24.83 (21.93)	–	50.09 (30.61)	26.75 (17.12)
Order verification time	5.42 (2.02)	–	3.72 (1.52)	7.92 (10.46)
Giving oral medication time	6.24 (1.87)	18.42(6.54)	9.08 (2.35)	21.40 (6.41)
Subtotal	36.49	18.42	62.89	56.07
Order renew time for each patient	259.72 (93.85)	–	291.97 (114.48)	284.54 (168.06)

Table 3 – The effects of BCMA to the quality of patient care, medication safety and work quality of nurses N = 46.				
	Greatly increased n (%)	Slightly increased n (%)	Approx. same n (%)	Slightly decreased n (%)
Quality of patient care	12 (26.1)	24 (52.2)	10 (21.7)	–
Patient medication safety	22 (47.8)	21 (45.7)	1 (2.2)	2 (4.3)
Work quality of nurses	15 (32.6)	23 (50.0)	7 (15.2)	1 (2.2)

Table 4 – Comments and recommendations for the BCMA system from the nurses N = 21.	
Items	No. of person
Advantages of the system	
Greatly reduces the working time of manual transcription	3
Reduces the chance for medication errors	2
Helps to increase the quality of care of nurses	1
Medication verification is more convenient	1
Suggestions for system modification	
Warning for temporary orders and new orders	5
Integrate the processes of oral, IV and self-prepared medication using by physicians	5
The design of monitor screen format	4
Allergic medication and contraindication should be connected to BCMA from CPOE	2
Medication information in Chinese and update	2
Overall recommendations	
Frequent crash of the wireless network, which extended the administration time	10
Hoping for a more complete hardware equipment to allow more convenient handling, and also to reduce more time.	1
Display the questions in lists for processing, otherwise many were ignored or are repeated	1
Unit for night shift system emergency contact	1
Forgot to sign, and was unable to know if orders have been executed	1

BCMA, the average administration time was 56.07 s, and order renew time of each patient's order on average was 284.54 s, the time spent for transcribing order to complete the administration, and the time of order renew for each patient every week did not change much (Table 2).

4.4. Self-assessment of the effectiveness of BCMA's

From the self-assessment of the overall feel of the BCMA's by the nurses, only 1 (2.0%) of the nurses felt the use of BCMA system would increase the working time by 30%. 88.2% (45/51) of the nurses all thought BCMA system would reduce the working times. 66.7% (34/51) of the nurses thought that less than 50% would be saved in the working times, 21.6% (11/51) of the nurses thought that 60–100% of working times can be reduced; 9.8% (5/51) of the nurses felt that the working times spent before and after BCMA system implementation were approximately the same.

In the quality of care, only 46 nurses answer the questions, 78.3% of the nurses were positive about BCMA system, the quality of patient care did not decrease due to learning the new system, and thought that BCMA system could improve the quality of patient care. 93.5% of the nurses thought this system could increase the patients' medication safety; 82.6% of the nurses thought it could increase the quality of work of the nurses (Table 3).

Twenty-one nurses responded to the open-ended questions in the "comments and recommendations for the BCMA system", a total of 39 comments were made by 21 nurses (Table 4).

5. Discussion

It required various kinds of capabilities to work on the project including the preparation of facilities, design of the software, communication among informatics personnel, physicians, nurses, pharmaceutical personnel, administrators, and the interconnection of soft and hard wares. The interdisciplinary team including the technical, clinical, and medication personnel were detrimental as it stressed in the literature [10]. Although researchers did not suggest double-documentation system for BCMA [8], the double line systems were used

to ensure the accuracy of medication administration in the beginning week of BCMA implementation. Nurses were the main coordinators in developing BCMA in the study site because they were keen on keeping a safe medication administration. The journal reading encouraged them to take this adventure in spite of putting in extra workloads. Clinicians in veterans general hospitals also emphasized the crucial role of early nursing involvement when BCMA system was introduced in a patient care setting [10].

The working time of oral medication administration between BCMA and traditional group were different before BCMA implementation. It might be due to the BCMA group belonged to the neurosurgical units, whereas the traditional group belonged to the neurological units. This study only observed the oral medication administration. The number of oral medication for medical patient was more than surgical patients as showed in Table 1. Also, the nurses' work pattern of the medical units may differ from the surgical units. In medical units, there were many laboratory tests, different kinds of examinations and interventions. In neurosurgical units, interventions were more focused on pre- and post-operation care.

However, the working time of oral medication administration before and after BCMA in the traditional group did not change much. The steps of oral medication administration ideally should be done at the same time sequentially. While there were time lags in each step. The total times for all three steps did not change much. Yet, each step varied before and after the BCMA implementation. One possible reason was the longer time spent in transcribing made writing more clear. This time spent for clear writing may save time in order verification and administration. Thus, the total times including transcribing, verification, and administration did not change much before and after the BCMA implementation for the traditional group. The automation of medication checking and recording by bar code screening improved this variation of writing in transcription after BCMA implementation. Hence, the potential cause of medication error due to writing could be resolved in advance.

The working time of oral medication administration of BCMA group was twice before than after implementation. In addition, 259.72 s of re-transcription of medical orders for each inpatient after 7 days were saved. Before BCMA implementation, the time of giving oral medication only took 6 s, and it was 1/6 of total oral medication time (36.49 s). After BCMA, the step of giving oral medication was 18.42 s. Though it was increased tripled comparing to this step before BCMA, it was the only step left for giving oral medication. Thus, the working time of oral medication reduced from 36.49 to 18.42 s due to shortening the repeated check manually among transcribing, verifying and renew steps.

In a time study of medication administration, obtaining and verifying medications, medication delivery, and documentation of medication administration took 16.97% out of 26.9% medication-related activities [2]. The new informatics technology of BCMA could reduce the transcribing and verifying and renew parts of patients and medication orders. Yet, it was only part of the medication-related activities. Discussion of medication with another health professional or patients or their relatives was an important part of the medication

process [1]. It is suggested the obtaining and discussion of medication in medication administration process should be considered in addition to the working time of BCMA.

Time of oral medication administration after BCMA was half of the time before BCMA implementation. Yet, nurses' self-rating of the time saving was not proportional to the working time observed. Most of them (66.7%) believed time saved by BCMA was under 50%.

There were several reasons. First, the familiarity of this BCMA procedure might influence nurses' perception of time saving from BCMA. Though there were orientation training programs for nurses in the beginning of BCMA. This training program may not fulfil nurses' continuous interaction with BCMA system. Researcher suggested developing a process for informing personnel about complex BCMA software [10]. The training program may be periodical to discuss new problems encountered.

Second, new instruments like wireless Internet, bar-code sticker, bar-code reader, and computer cart took time to handle in the process of BCMA. Nurses spent times in checking and maintaining proper functions of these new instruments. Third, the stability of wireless network was criticized by the nurses throughout the BCMA implementation process as commented in Table 4. They spent extra time for data re-entry due to the interruption of wireless Internet. Fourth, the definition of medication administration times excluded some important actions like tube feeding of drugs might have resulted in underestimation of the working time of BCMA.

There were no integration between oral and IV medication administration. The medication administration might through IV or oral at the same time. We only measured oral medication administration because the bar code was only printed on the oral medication package and there was no bar code on ample or vial yet. The nurses scanned the bar code for the oral medication, keying the medication for IV route. The time spend in oral medication administration was only a part of oral and IV medication-related activities. Researchers also found that only 64.5% of the medication administration had bar-code verification in a Dutch hospital [11]. The other drugs did not have bar code to verify. Therefore, it was difficult for the nurses to judge working time saved by BCMA between the un-integrated medication situation and extra time dealing with computer delays by re-entering or mastering the new system. However, time nurses spent in checking and maintaining the function of facilities was not recorded in this study. This is the limitation of this study.

Although the team of BCMA met frequently with the nurses in the developing process, there were still some design issues related to the information retrieval, monitor screen format and questions for emergency contact as demonstrated in Table 4. The dissatisfaction with informatics design was also found in the literature [12]. The informatics technology in medical system took multiple disciplinary approaches. Yet, the nurse experience, computer knowledge, skills, and technology usability all had impacts on using the informatics system [13]. It was suggested that the knowledge of nursing informatics empowered nurses to be influential in a transformed all-electronic work environment [14]. Other than the nurse's factor, the informatics design teams' knowledge about the medical system, nurse's workflow, and fluent communi-

cation among the design team also influenced the usage and time spends in BCMA. These influencing factors did not measured in this study and needed attention in considering the time spend in BCMA.

Ideally, the working time saved by BCMA could be changed to direct patient care. From the interaction of the research team and nurses in the study site, nurses seemed to have changed their working style. After each shift report, the nurse checked their computer cart, and then signed in to the patient list, made sure the wireless network was functioning well. They wanted to be sure that their bed side work with the nursing cart would not be interrupted by problems of facilities or wireless network.

The workflow of BCMA was shorter than traditional group as shown in Table 2. This straight workflow gave the advantage of less interruption which often provided chances of making error. Most nurses (47.8%) in BCMA group felt it greatly increased patient medication safety. Comparing the satisfaction of improving medication error, only one quarter (26.1%) nurses felt BCMA greatly increased quality of patient care and 32.6% felt it greatly increased work quality of nurses as demonstrated in Table 3.

BCMA provides safety features for nurses and patients alike [3]. The implementation of BCMA was viewed as a way of continuous improvement of patient safety. This is the natural experiment of health service research. It is suggested that the safety and risk/benefit ratios should keep appropriate for this type of research [15]. The results of this study were observed in three trial units of BCMA and three waiting units. Nurses were in high morale of attempting to test the new informatics technology. They were enthusiastic when the research team invited them to join this study and explained the data would be kept de-identified and confidential. Nurses in both groups were informed the progress of BCMA, they felt it provided them new knowledge and direction for professional development. Thus the benefit of gaining knowledge balanced the potential risk of odd feeling by being observed. Besides, hospital administration did not have access to any individual data to prevent any data from being used as part of any employee's performance evaluation. This study followed the suggestion of ethical consideration from health service research as reported in the literature [15]. However, we would like to suggest that the expert of patient safety and members of Institute Review Board (IRB) organize a panel to offer an objective opinion of safety and risk/benefit ratios for this type of study. This paper was granted approval by IRB of Taipei Veterans General Hospital.

6. Conclusion

The results demonstrated that implementation of BCMA for oral medication could reduce half of the time for giving oral medication. Yet, most nurses felt it saved less than 50% of the time. Nurses coordinated the hardware and software by accommodating the new facilities and operating BCMA system. The stability of the wireless network was the main threat. Also, the definition of medication administration times excluded some important actions like tube feeding of drugs which might have resulted in underestimation of the working

Summary points

What is already known about the topic?

- BCMA system is a method of reducing medication error.
- Working time is a way of measuring time nurses spend in nursing activities.

What this paper adds

- The implementation of BCMA for oral medication could reduce half of the time for oral medication delivery.
- Most nurses felt it saved under 50% of the time. They think BCMA could enhance patient oral medication delivery safety and promote quality of oral medication in spite of making more effort to learn new technology.

time of BCMA. However, 93.5% nurses thought BCMA could enhance patient oral medication safety in spite of making more effort in learning new technology.

REFERENCES

[1] A. Ampt, J.I. Westbrook, Measuring nurses' time in medication related tasks prior to the implementation of an electronic medication management system, Information Technology in Health Care 130 (2007) 157–166.
[2] C.A. Keohane, A.D. Bane, E. Featherstone, J. Hayes, S. Woolf, A. Hurley, D.W. Bates, T.K. Gandhi, E.G. Poon, Qualifying nursing workflow in medication administration, The Journal of nursing Administration 38 (1) (2008) 19–26.
[3] G.A. Coyle, M. Heinen, Evolution of BCMA within the department of Veterans Affairs, Nursing Administration Quarterly 29 (1) (2005) 32–38.
[4] R.D. Paoletti, T.M. Suess, M.G. Lesko, A.A. Feroli, J.A. Kennel, J.M. Mahler, T. Sauders, Using bar-code technology and medication observation methodology for safer medication administration, American Journal of Health-System Pharmacy 64 (5) (2007) 536–543.
[5] P.J. Helmons, L.N. Wargel, C.E. Daniels, Effect of bar-code-assisted medication administration on medication administration errors and accuracy in multiple patient care areas, American Journal of Health-System Pharmacy 66 (July (1)) (2009) 1202–1210.
[6] F.C. Chen, S.J. Hsiao, C.Y. Chen, S.J. Dou, The factors affecting hospital mobile nursing station acceptance: a case study of teaching hospital, Journal of Information Management 12 (2005) 67–89.
[7] j.H. Wu, H.C. Wang, L.M. Lin, Mobile computing acceptance factors in the healthcare industry: a structural equation model, International Journal of Medical Informatics 7 (2007) 666–677.

[8] E.S. Patternson, M.L. Rogers, M.L. Render, Fifteen best practice recommendations for Bar-Code Medication Administration in the Veterans Health Administration, Joint Commission Journal on Quality and Safety 30 (7) (2004) 355–365.

[9] E.S. Patterson, M.L. Rogers, R.J. Chapman, M.L. Render, Compliance with intended use of Bar Code Medication Administration in acute and long-term care: an observational study, Human Factors 48 (1) (2006) 15–22.

[10] H. Weckman, S. Janzen, The critical nature of early nursing involvement for introducing new technologies, The Online Journal of Issues in Nursing 14 (May (2)) (2009) 1–11.

[11] H.A. Van Onzenoort, A. Van De plas, A.G. Kessels, N.M. Veldhorst-Janssen, P.M. Van Der Kuy, C. Neef, Factors influencing bar-code verification by nurses during medication administration in a Dutch hospital, American Journal of Health-System Pharmacology 65 (2) (2008) 644–648.

[12] T.T. Lee, Nurses' experiences using a nursing information system, Computer, Informatics, Nursing (September/October) (2007) 294–300.

[13] T.T. Lee, T.Y. Lee, K.C. Lin, P.C. Chang, Factors affecting the use of nursing information systems in Taiwan, Journal of Advanced Nursing 50 (2) (2005) 170–178.

[14] M.J. Ball, C. Weaver, P.A. Abbott, Enabling technologies promise to revitalize the role of nursing in an era of patient safety, International Journal of Medical Informatics 69 (1) (2003) 29–38.

[15] A.B. Flood, Health service research, in: E.A. Bankert, R. Amdur (Eds.), Institutional Review Board: Management and Function, 2nd edition, Jones and Bartlett Publishers, Sudbury, 2006, pp. 410–413.