Analysis on data captured by the barcode medication administration system with PDA for reducing medical error at point of care in Japanese Red Cross Kochi Hospital.

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Abstract. Our study aim to understand complete picture and issues on medical safety and investigate preventive measures for medical errors by analyzing data captured by bar code system and entered by Personal Digital Assistance. Barcode administration system named Point-of-Act-System was designed to capture every activity at the bed sides. Complete activity data including injection, treatment and other nurses' activity and warning data showing mistakes on injections were used for our analyses. We described the data and analyze statistically by accumulating data by hour to find potentially risky time and understand relationship between business and errors. The warning rate as a whole was 6.1% in average. The result showed there was a negative correlation between number of injections and injection warning rate (-0.48, $p<0.05$). Warning rate was relatively low in the hours that numbers of administrating injections are high. Bar code administration system is quite effective way not only to prevent medical error at point of care but also improve patient safety with analyses of data captured by them.

Keywords: Barcode administration system, Point-of-Act-System, Point of Care, Patient Safety, Warning data

1 Introduction

It is widely believed that patient safety is an important issue for health care systems. Many organizations and hospitals have been trying to gather information and evidences on patient safety for the purpose to improve patient safety based on the data collected. These data is accumulated to provide information on threats for patent safety including bottle neck of administration and high risk areas. Such data are quite useful in understanding the threats and actual situations related to medication errors in hospitals. However, most of evidence is basically information on medical accidents and incidents, compiled from voluntary reports submitted by medical workers and the workers need to write reports to inform the situation to them. This information is not detailed enough to enable the discovery of underlying general principles, because accidents and errors are part of the reality in a hospital setting. A complete picture of the situations in hospitals, including details of medical accidents and incidents, is essential to identifying general causes and frequency of medical errors. However, it is extremely costly to obtain by observational research sufficient data to enable an

understanding of all the activities conducted in a hospital, and furthermore, the accuracy of data collected by observation is sometimes defective.

Information technology such as electrical medical record and barcode administration system at point-of-care have the potential to provide new opportunities for us to understand the overall picture of medical activities by digital capturing data on patient care through daily medications in hospital settings. By using information systems for all patients in all wards, data captured by the systems become useful resources to understanding various phenomena in medical situations and investigating research questions. In terms of medication accidents, the point of care is potentially risky area in medical activities [1-3]. Barcode medication administration systems prevent medication errors by authenticating the "5 rights" of medication: right patient, right drug, right dose, right time, right route. Performed at the bedside, the system offers an excellent opportunity to gather data on medications. In addition to their contribution to the authentication of the 5 Rights, data captured by barcode administration systems have the potential to provide sources of research to improve patient safety in terms of actual injections and medication data.

Our study aims to use and analyze complete data on medical activities captured at the point of care by the system to understand complete picture and issues related to medical safety, and to investigate preventive measures for medication accidents. We focused on injections, which are one of the major causes of medical accidents and, investigated the relation between errors and the contexts of medication activities including how busy staffs were, and shift works.

2 Methods

2-1. Settings and items to be addressed

Japanese Red Cross Kochi Hospital located on southern part of Japan has 482 registered beds and approximately 290,000 out-patients and 9,355 in-patients per year. The hospital implemented a hospital information system called "Point of Act System" or POAS, in 2004. POAS is a real time bar-code capturing health information system designed to prevent medication errors by capturing the barcodes of patients, workers and drugs, and then authenticating the 5 Rights of each medical action with real time information [4-6]. At the same time, POAS captures complete data of each medical action including 6W1H information (When, Where What, Why, for what, to whom and How) and stores the data to access in an instance. The system was designed to use data secondly for improve quality and productivity of health care. The basic requirement for successful measurement and data capturing, they must be integrated with the routine provision of care and whenever possible should be done using IS and this system satisfied this requirement The principal characteristics of data captured by this system are (1) complete data including every action in real time and accurately and (2) process management that enables POAS to ensure right process of medication and assure capturing complete data. Complete data capture through routinely use of hospital information system including 6W1H information is an innovative source to understand real situations directly without estimations and investigate solutions to prevent errors.

2-2. Data

Data captured at the sites of injection process was used for our analyses of medication administration, especially nursing care. Data on injections means both injections and IVs. 6W1H information was captured at each point of the injection

process; Order to give injection, Drug picking, Drug audit, Drug mixing and Injection. Although the first objective of a bar code administration system is to ensure patient safety by verifying medication rightness including the 5 Rights of medication, another objective is to capture activities of nurses enforcing medications for patients. At the point of care or activity, nurses uses PDAs to scan the barcode of ambles or vials containing the medication to be injected or other activities including treatment, care, observation, counseling and emergency to enter information on their actions. This information is primary used for the documentation of nursing activities. However, this information can also be used not only for hospital management through understanding the workloads of nurses and the actual costs of administering medications but also for patient safety by understanding the prevailing situations when warnings are made. In addition to these data entered by nurses, we also used warning data demonstrating mistakes that can be made in scanning the barcodes on bottles of drugs. Warning data do not directly mean data on errors. However, warning data is useful sources to analyze causes of medical errors, because warned activities have potential possibility of medical errors without barcode administration system. Therefore, high warning rates in some specific times, places, situations and workers mean risky times, places, situations and workers for patient safety. Types of warning are basically wrong bottle, wrong patient and mixing error meaning incorrect mixing of drugs. All data from January 2005 to June 2008 was used for the analyses. Total numbers of activities are 14,824,046 and number of injections are 604,847. That covered almost 100 % injections and 99% of activities by nurses.

2-3. Data Analysis

We accumulated the data by each hour (24 hours) to find high risk times to understand big picture of medical activities and medical error in hospital wards. Warning rates were computed by each hour. These rates were treated as indicators to show risky times and situations.

We described these data and analyzed statistically to investigate correlations between situations and warning rates. Total number of injections per hour, total number of activities, total number of injection per PDA by hour and total number of activities per PDA by hour were used as indicators for workload at the time. Fraction of injections among total activities and fraction of treatments among total activities were used as indicators for variation of hours. We employed Pearson Correlation Analysis to investigate relationships and significant level was 5%.

3 Results

3-1. Description

Total number of activities data was 14,824,046 including 69,276 injections (0.4%), 535,571 IV starts (3.6%), 483,770 IV finishes (3.3%), 1,979,804 cares (13.3%), 10,437,250 observations (70.4%), 14,713 counseling (0.1%), 824,743 treatments (5.6%) and 478,919 emergency (3.2%). Total injections combining injections and IV drops were 604,847 and total warning on injections is 37,046 (6.1%). Figure 1 shows trend of injection warning rate at point of care. After a half year of implantation, the warning rates were relatively higher. The injection warning rate has been gradually decreasing.

Figure 1. Trend of Injection warning rate from March 2003 to June 2008

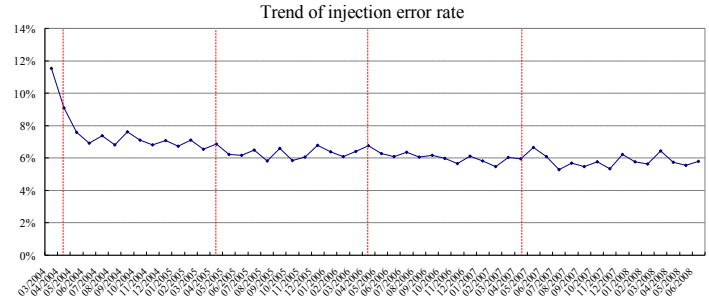


Figure 2 shows number of total entered data by nurse hour by hour. This data imply the workload at the time, though every activities were treated as same workload and actually the workloads are depend on the activities. Number of activities are higher on around 6AM and 10 AM.

Figure 2. Number of Total Entered Data by hour

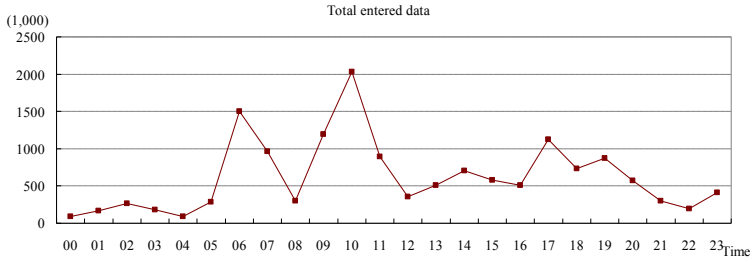
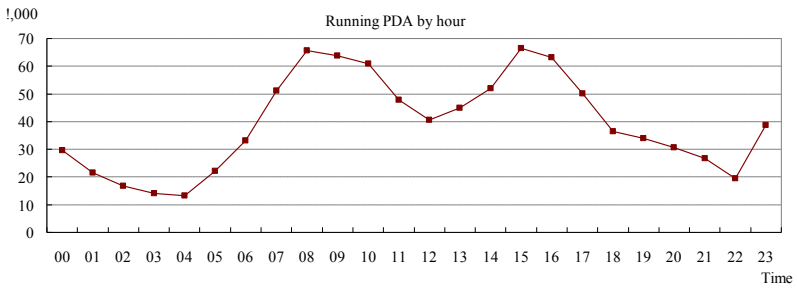


Figure 3 shows number of running PDA by hour. In Japanese Red Cross Hospital, Patients to nurse ratio during day time twice as high as during night time. The data implys actual working people at the time.

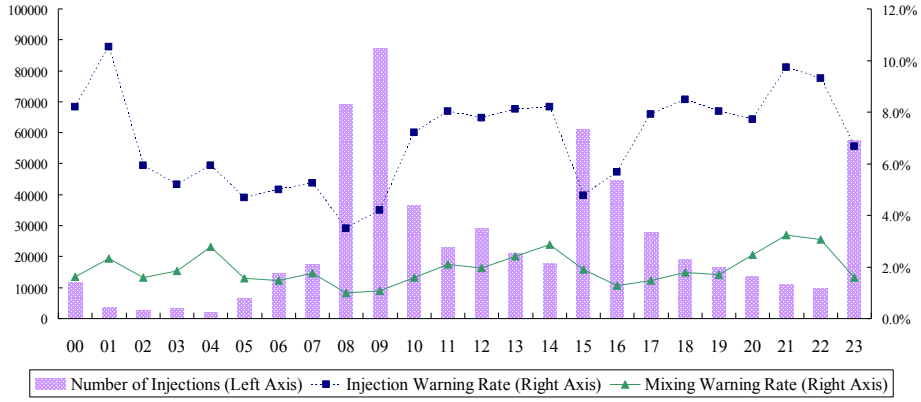
Figure 3. Number of running PDA by hour



3-2. Data Analysis

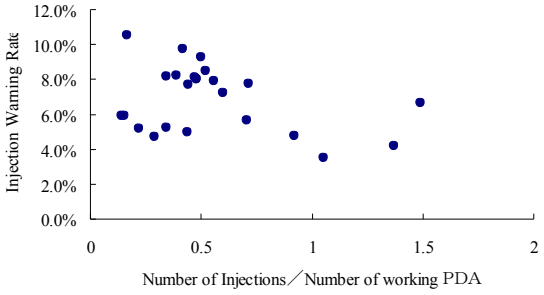
Figure 4 shows trend of warning rate and activities by hour. Bar graph shows number of injection by hour. There was variability in number of injections by hour. There are three points that nurses administrate injections in volume. Those were 9AM, 3PM and 11PM. Two line graphs show injection warning rates and mixing warning rates by hour. Mixing warning means drugs for injection are not mixed correctly. Minimum and maximum of the injection warning rates were 4.2% and 10.5%. Minimum and maximum of mixing warning rates were 1.0% and 3.2%. This graph shows the warning rate was relatively lower when nurses administrated many injections. In this hospital, there are three working shifts for nurses. These are Day shift (8:00-16:40), Evening Shift (16:00-0:40) and Night shift (0:00-8:40). The warning rates for each shift were 5.5% (Day shift), 7.3% (Evening shift) and 6.0% (Night shift). The tendency of injection warnings and mixing warnings have somewhere same tendency. Especially during day shift, this tendency was demonstrated quite clearly.

Figure 4. Number of Injections and Warning rate by hour



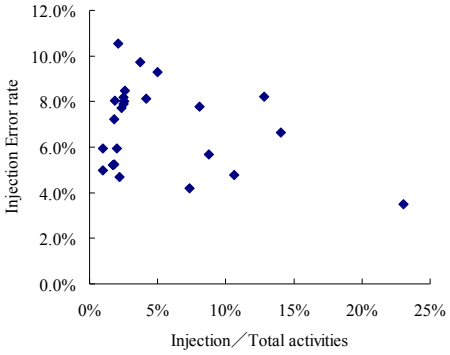
According to the results of correlation analysis, there was a negative correlation between number of injections and injection warning rates. The correlation coefficients between number of injections and injection warning rates was -0.48 ($p<0.05$) and between number of injections per PDA and injection warning rates was -0.34 ($p<0.05$) (Figure. 5). Both results are significant and implied negative relationships between error rate and business.

Figure 5. Scatter plot on Number of Injections and Warning rate by hour



Variation of activities had negative effects to warning rate. Figure 6 is scatter plot to show relationship between fraction of injections among total activities and injection warning rates. We chose proportion of injections among total number of activates at the time as an indicator for variation activities. In our assumption, nurse concentrating on administering injections tend to operate more safely. This figure implies negative correlation between the two indicators. The correlation coefficient between fraction of treatments among total activities and injection warning rates was 0.35 ($p<0.05$). High fraction of treatment means nurses should administrate injections with other kinds of treatments for patients and discourage nurses against concentrating on injections.

Figure 6. Scatter plot on proportion of injections among total number of activities adn Injection error rate



4 Discussion

In the literatures on patient safety, many studies had mentioned workloads and busyness are the principal cause of medical errors [7.8]. It was acceptable for workers that rushing and fatigue would cause lack of attentions to medications. However, this study demonstrated opposite tendency of medical errors. This study implied that people would make mistakes because of not doing too many things but too many kinds of things. Literatures on human factor engineering indicated same kinds of conclusions to ensure quality of activities [9.10].

Warning rates in this study was relatively high compare to other literatures on administration errors of injections [1-3, 7, 8]. This difference came from accuracy of data and detections of mixing errors. In this study, data was collected through routinely work by hospital information system. People tend to be careful when they are observed by other. Therefore, we indicate that the data captured by PDA is more bias free data compared to conservative data. And other study also could not detect wrong bottle errors caused by mixing error, because forgetting mixing drugs sometimes difficult to be found by human eyes. Single item management of drugs with serialized ID is essential for preventing and finding mixing errors [5]. Distinction of bottles and other drugs with single item level is an only method to distinguish mixed and unmixed bottle systematically.

It is possible to accumulate the data by wards and nurses to realize risky place and working style. In this study, we tried to investigate relationship between number of injections and injection warning rate by each ward. This analysis doesn't show clear

relationship between two indicators, because each ward provides health care service to different patients. When we focus on the difference of error rate by ward, we need to consider some risk adjustment method to compare fairly. This policy can be applied in comparing results among multi hospitals. Accumulating by nurses submitted new issues on privacy of workers. The system anonymized data of each nurse and their attribution, but researchers could sometimes identify nurse through patterns of work and other aspects. Researcher should be cautious to publish results.

Beside, the other issue is weighting of each activity. We treated injections and other activities as same workload activities, though actually there are quantitative and qualitative differences among activities. It is necessary to decide weighs of each activity to analyze more deeply and accurately with time study or other research methods.

5 Conclusion

This study showed general tendency of possible medical errors in practice with data captured in real time and accurately. The result suggested that high variation of activities might have negative effects for patient safety, though busyness is not one of the main causes of errors. Our study also demonstrated the effectiveness of bar code administration system. According to the result, injection warning rate was about 6% and these warning had been prevented nurses against errors and accidents with the system. In conclusion, bar code administration system is quite effective way not only to prevent medical error at point of care but also improve patient safety with analyses of data captured by them.

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