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An Electronic Dashboard to Improve Nursing Care

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Abstract

With the introduction of CPOE systems, nurses in a Singapore hospital were facing difficulties monitoring key patient information such as critical tasks and alerts. Issues include unfriendly user interfaces of clinical systems, information overload, and the loss of visual cues for action due to paperless workflows. The hospital decided to implement an interactive electronic dashboard on top of their CPOE system to improve visibility of vital patient data. A post-implementation survey was performed to gather end-user feedback and evaluate factors that influence user satisfaction of the dashboard. Questionnaires were sent to all nurses of five pilot wards. 106 valid responses were received. User adoption was good with 86% of nurses using the dashboard every shift. Mean satisfaction score was 3.6 out of 5. User satisfaction was strongly and positively correlated to the system's perceived impact on work efficiency and care quality. From qualitative feedback, nurses generally agreed that the dashboard had improved their awareness of critical patient issues without the hassle of navigating a CPOE system. This study shows that an interactive clinical dashboard when properly integrated with a CPOE system could be a useful tool to improve daily patient care.

Keywords:

Nursing informatics; Medical order entry systems; Decision Support Systems, Clinical/organization and administration; Attitudes of health personnel; Consumer Satisfaction.

Introduction

The extensive use of electronic medical records (EMR) and computerized physician order entry (CPOE) systems in healthcare institutions had led to improved patient safety [1, 2]. They also obviated the need for paper forms and test result printouts. CPOE systems had allowed doctors to directly order and review tests with greater velocity by-passing nurses on the ground who traditionally handle these transactions.

This could result in the disruption of vital communication between clinical staff like doctors and nurses as reported in some studies [3, 4]. Since ward nurses played a vital role in the coordination of care among a team of multidisciplinary healthcare professionals, they should not be removed from key information exchanges. The loss of awareness of critical patient orders and results could lead to serious adverse outcomes. We noted this disturbing trend and termed it "CPOE-induced disintermediation". Disintermediation was a supply-chain terminology which refers to the cutting out of the middle-man. [5] Such phenomenon was widely seen with the rise of the internet and new information technologies where intermediaries such as travel agents or bookstores were being displaced as end-users buy services or products directly from the supplier. In our healthcare context, such "disintermediation" was not desirable. Frontline nursing care could not be easily replaced as nurses were the ones in closest contact with the patients, and were well placed to take quick action should things go wrong.

For nurses who were often busy attending to patients, it was also impractical for them to be constantly monitoring an EMR system to sieve out vital bits of patient information. Moreover, studies have shown that many EMRs and CPOEs could be difficult to navigate and could lead to information overload. [6, 7]

Several healthcare institutions experimented with clinical dashboards to improve the visibility of data and information. Some designed boards specifically for clinical alerting on the ground [8], while others incorporated administrative functions like bed tracking or workload indicators for management use [9].

Khoo Teck Puat Hospital in Singapore implemented a CPOE system since 2009. Over the past years, clinical users complained about the complexity of navigating a CPOE system. There were also concerns about nurses losing situational awareness of critical patient data. In 2011, the medical informatics and nursing teams designed an electronic nursing dashboard on top of the hospital's existing CPOE system. The project was code named "Andon Board", a Japanese-derived term (often used in Lean manufacturing) referring to a dashboard device which provides simplified visual management of a production line.

After studying existing processes on the ground, a decision was made to design an interactive nursing Andon board running on touch screen computers. It was unlike many passive "view only" electronic dashboards cited in other studies. The touch screens enabled the hospital to design interactive features and at the same time monitor actual usage through the clicks made by the users in real time.

The team had planned for a post-pilot study utilizing data from system usage logs and a survey questionnaire to gather end-user feedback and evaluate the factors that influenced user satisfaction of the Andon system.

Methods

In Toyota car assembly lines where Lean principles were developed, "Andon boards" were often used to provide simpli-

fied ways to track and monitor key issues, filtered from a complex web of data in daily operations [10]. Following this principle, we custom-built our Andon software on top of our CPOE system which collects large volumes of patients' data (e.g. laboratory, radiology, medication, clinical documents) daily across the hospital.

The Andon board was primarily designed to alert nurses of the following:

- Urgent ("STAT") orders, including laboratory, radiology, medication, ECG orders
- Abnormal laboratory or radiology results
- Infection control alerts

Additional operational functions include:

- Discharge process tracking
- Radiology scheduler with pre-scan checklist

Data was pulled from the CPOE system at one minute intervals and displayed on the Andon. The touch screen dashboards were mounted in strategic locations within the wards, covering each nurse's area of care, functioning like a "heads-up" display, and allowing a quick view of their patients' pertinent issues as they worked.

Figure 1 below shows a screen shot of the Andon board which displays several icons or flags with different color statuses to indicate criticality.

Nurses could click on the various icons on the screen to bring up more information. For example, clicking on the laboratory order ("lab flask") icon would show the order item name. For more detailed information, they would still have to log into the CPOE system. The design team was conscious of the fact that the dashboard's primary aim was to flag and alert key patient issues and not to replace CPOE functions.

Figure 1 – Screenshot of the dashboard on a touch screen computer

In addition, a radiology scan scheduling function was incorporated to facilitate better communication between inpatient nurses and the radiology department. This was because the coordination of certain radiological investigations like CT, MRI scans could be laborious, with the nurse having to provide by phone or fax, numerous patient details like the availability of an intravenous cannula for contrast, consent and fasting status to the radiology department for every scan. The radiology would also have to call upon receipt of the information, and inform the nurse of the time schedule for the scan as well as necessary patient preparation instructions. For every scan, several phone calls or faxes were needed between the ward and the radiology department.

Using the Andon's touch screen as shown in Figure 2 below, the nurses could quickly indicate the type of intravenous access available, consent and fasting status of the patient to the radiology staff, who will see this information on their corresponding Andon board mounted in the radiology department. The radiology staff can then schedule the scan for the patient and inform the nurse of the schedule by putting up a 'clock icon' on the Andon board.

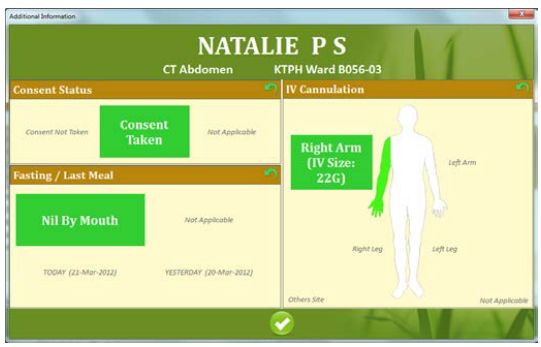

Figure 2 – Screen shot of the dashboard's radiology scheduling function with the pre-scan checklist

The Andon system was implemented in five pilot wards and the radiology department between January and February 2012. As nurses were the primary users of the dashboard, they were selected to participate in this post-pilot survey on March 2012. All participants must have used the CPOE and the dashboard systems in one of the five pilot wards for at least 3 months in order to be included in the study.

A validated questionnaire was adapted from a prior local study evaluating user satisfaction with a CPOE system. [11] The number of demographic questions was reduced from the original questionnaire and removed survey items like ratings for CPOE features that were not relevant to our study. The final questionnaire consisted of 12 statements covering various broad system attributes. Users were asked to rate their level of agreement to the statements using a five-point Likert scale, where "1" corresponded to "disagree strongly" and "5" corresponded to "agree strongly". The survey tool was designed to measure users' perception of several attributes:

- Overall user satisfaction;
- Usage frequency;
- System quality (e.g. Speed, ease of use, stability);
- System information quality (e.g. Accuracy, relevancy of data);
- Impact on work efficiency;
- Impact on care quality (e.g. Effectiveness, safety);

Two open-ended questions were included to gather further user feedback from the nurses:

- "What is the one thing you like most about the Andon Board?
- "If there is one thing you could change about the Andon Board to make it better, what would it be?"

All nurses from the five pilot wards were invited to participate in the survey. They were briefed by the study team and given hard copies of the survey to complete. The questionnaire contained a simple introduction and instructions. The survey responses were anonymous and participants were told that no

individuals would be identified in the study. All nurses selected in the random sample had the right to refuse to participate without prejudice. This study was further reviewed and endorsed by the Clinician IT Committee as a form of post-implementation user feedback.

Once the questionnaire was completed, the data was validated, edited for consistency and encoded into a spreadsheet for analysis.

Results

One Hundred & Twenty-two nurses out of a total of 170 eligible staff responded to the survey, giving a response rate of 72%. However, only 106 respondents were included into the study, as 16 survey forms were returned incomplete.

Table 1 below shows the demographic characteristics of the nursing respondents with a predominance of females over males, and a median age of 26 years.

Cronbach alpha of the data collection tool was measured to assess internal consistency of the questionnaire, i.e. 0.885. Factor analysis of the data collection tool revealed its reliability in measuring four constructs, namely, system quality, system information quality, perceived impact on work efficiency, and impact on care quality.

Table 1 – Demographic characteristics of nursing respondents

Variable	Number (%)
Age (years)	
Below 30	60 (56.6)
30-40	11 (10.4)
More than 40	6 (5.7)
Not declared	29 (27.3)
Gender	
Female	82 (77.4)
Male	3 (2.8)
Not declared	21 (19.8)
Job Grade (in increasing seniority)	
Assistant nurse	25 (23.6)
Senior assistant nurse	3 (2.8)
Staff nurse	59 (55.7)
Senior staff nurse	17 (16)
Nursing manager, equivalents and above	2 (1.9)

The overall usage of the system was high with 86% of nurses using it every shift. Figure 3 shows that 25 (24%) nurses claimed that they would look at the Andon once every hour, while 9 (8%) would look once every 30 minutes. This meant that 32% (24% + 8%) or 1 in 3 nurses would look at the dashboard at least once every hour.

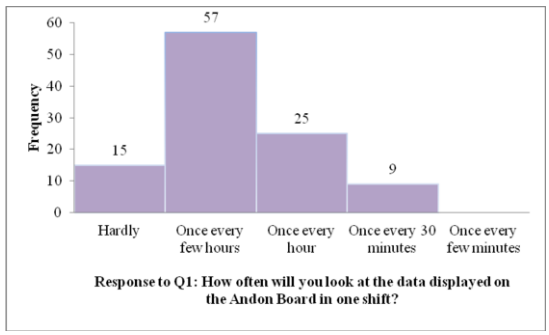

Figure 3 – Distribution of usage frequency of the dashboard

The nurses were generally satisfied with the Andon, with a mean user satisfaction score of 3.6 out of a scale of 5. Figure 4 illustrates the distribution of the scores.

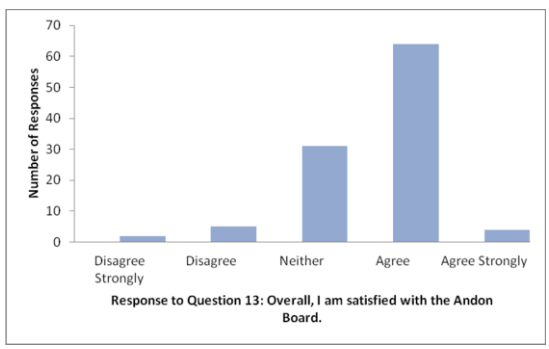

Figure 4 – Distribution of Overall Satisfaction of Users.

Table 2 – Summary Table of Responses (n=106) (based on the five-point Likert Scale)

Survey Statements	Mean	SD
Q2. I can use the Andon Board on my own even if there was nobody around to show me how to use it.	3.75	0.90
Q3. The Andon Board saves me time.	3.47	0.79
Q4. The Andon Board enables me to accomplish tasks more quickly.	3.44	0.81
Q5. The Andon Board enhances my efficiency in the job.	3.51	0.74
Q6. The Andon Board helps me to improve patient safety.	3.38	0.79
Q7. The Andon Board helps me to care better for patients.	3.39	0.71
Q8. The Andon Board always does what it should.	3.52	0.72
Q9. The Andon Board is very fast.	3.38	0.75
Q10. The Andon Board is easy to use.	3.89	0.51
Q11. Information from the Andon Board is relevant.	3.93	0.47
Q12. Information from the Andon Board is accurate.	3.81	0.56
Q13. Overall, I am satisfied with the Andon Board.	3.58	0.72

Table 2 above further illustrates the mean scores of the various survey statements. The dashboard system scored well in many aspects, with its information quality ranked highest. The nurses gave high scores to two statements – Information from the Andon board was relevant (Q11. Mean score = 3.93); and accurate (Q12. Mean score = 3.81). The statement - "The Andon Board was easy to use" scored 3.89 out of 5 (Q10).

From the qualitative feedback, 21% of respondents liked the ability to quickly view all critical patient tasks and alerts in one screen, without the hassle of logging into the hospital's EMR. Twenty percent also stated that the Andon was easy to use and understand. Further, 12% of the respondents reported that lesser phone calls and faxes were needed between the wards and the radiology department as the system facilitated clearer communication between the two parties. From system usage statistics, we found that the radiology scheduling feature with the pre-scan checklist was extensively used: 282 and 370 radiology scans were performed using the Andon's checklist in March and April 2012 respectively, just months after the Andon went live. We postulate that, if with every scan scheduled, the staff could save one to two unnecessary phone calls the Andon could have potentially eliminated several hundred calls monthly.

On the flip side, the nurses noted some teething issues with the new dashboard system. Some complained that the system hung occasionally, and the touch screens were too sensitive. Nurses further suggested improvements in the display format and suggested new locations for the dashboards to optimize visibility.

Correlation analysis (using Spearman's rank correlation coefficient) was done to determine which system attributes were strongly associated with nursing user satisfaction. Table 3 shows five attributes that were strongly and positively correlated with user satisfaction. These attributes were related to two main constructs – (i) perceived impact on work efficiency (Q3, Q4, Q5), and (ii) perceived impact on care quality (Q6, Q7).

Table 3 – Attributes of the Andon board with the strongest correlations to user satisfaction. ($p<0.01$)

Survey Statements	Correlation Coefficient
Attributes relating to impact on work efficiency	
Q3. The Andon Board saves me time.	0.70
Q4. The Andon Board enables me to accomplish tasks more quickly.	0.68
Q5. The Andon Board enhances my efficiency in the job.	0.70
Attributes relating to impact on care quality	
Q6. The Andon Board helps me to improve patient safety.	0.62
Q7. The Andon Board helps me to care better for patients.	0.63

Discussion & Conclusions

The survey was limited to five pilot wards (four medical, and one multi-disciplinary ward with both medical and surgical patients), and conducted just one month after the system went live. Many post-implementation studies were conducted typically several months after implementation to allow the system to stabilize and people to be comfortable with the workflow changes. However, this study was designed to gather quick feedback from nurses after the pilot run, so that the project team could learn and fix issues prior to full implementation across all wards of the hospital. As a result we might not be able to fully extrapolate or generalize these results across the institution. Nevertheless, the positive results demonstrated the usefulness of the dashboard system, even in its infancy.

The high usage rate of the system in the early pilot phase was remarkable in contrast to many studies which showed a high level of user resistance to new clinical system implementations [12, 13]. From the study findings, the system had provided perceivable benefits which could account for its high adoption rate: (i) nurses generally agreed that the Andon system provided relevant and accurate patient information; (ii) nurses felt that the Andon board had simplified their access to vital information without the hassle of navigating a complex EMR; (iii) the Andon system had improved the coordination of radiology scans between the wards and radiology department by providing an end-to-end signalling tool.

Our user satisfaction findings shared similarities with prior evaluation studies on clinical systems [14, 15], because user satisfaction was strongly and positively associated with the system's perceived impact on work efficiency and care quality. Though the nursing users gave high scores to the dashboard's information quality and ease of use, the users were more concerned with its impact on work efficiency and quality of care. Therefore, these factors should form important considerations for future clinical system development in order to improve adoption and reduce user resistance.

The decision to create an interactive electronic dashboard running on touch screen computers turned out to be advantageous. The touch screen computers enabled the team to develop functions like the radiology pre-scan checklist which was used in about 300 scans monthly. In addition, unlike passive "view-only" dashboards, our hospital could monitor active usage based on the clicks made by the users around the clock. The variation in usage patterns in different wards over time may yield interesting insights in future.

From the qualitative feedback, some nurses did express that the Andon board's flags and alerts had somewhat mitigated the issues of EMR-induced information overload and disintermediation. A follow-up qualitative study may be more suitable to assess these issues in-depth as a quantitative study may not be able to fully measure these factors effectively. Besides our post-pilot study's primary aims were to evaluate usage, user satisfaction and to gather quick feedback for improvements.

Nevertheless, our study shows that an interactive clinical dashboard when properly integrated with a CPOE system could be a useful tool to improve daily patient care.

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References

[1] Ammenwerth E, Schnell-Inderst P, Machan C, Siebert U. The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. J Am Med Inform Assoc 2008; 15:585-600.

[2] Bates DW, Kuperman G, Teich JM. Computerized physician order entry and quality of care. Qua1 Manag HealthCare.1994;2(4):8-27.

[3] Pelayo S, Anceaux F, Rogalski J, Beuscart-Zephir MC. Does CPOE actually disrupt physicians-nurses communications? Stud Health Technol Inform. 2010;160(Pt 1):173- 177.

[4] Pirnejad H, Niazkhani Z, van der Sijs H, Berg M, Bal R. Impact of a computerized physician order entry system on nurse-physician collaboration in the medication process. Int J Med Inform. 2008 Nov;77(11):735-44.

[5] Graham, Mark. Warped Geographies of Development: The Internet and Theories of Economic Development. Geography Compass, 2008; 771–789.

[6] Niazkhani Z, Pirnejad H, van der Sijs H, Aarts J. Evaluating the medication process in the context of CPOE use: the significance of working around the system. Int J Med Inform. 2011 Jul;80(7):490-506.

[7] Khajouei R, de Jongh D, Jaspers MW. Usability evaluation of a computerized physician order entry for medication ordering. Stud Health Technol Inform. 2009;150:532-536.

[8] Egan M. Clinical dashboards: impact on workflow, care quality, and patient safety. Crit Care Nurs Q. 2006 Oct-Dec;29(4):354-61.

[9] Fram N, Morgan B. Ontario: linking nursing outcomes, workload and staffing decisions in the workplace: the Dashboard Project. Nursing Leadership. 2012:114-25.

[10] Liker, J. The Toyota Way. New York: McGraw Hill, 2004.

[11] Ng BY, Kankanhalli A, Yip JWL. Use of Healthcare IS by Multiple User Groups: An Empirical Study of a Medication Management System. ICIS 2011.

[12] Ash JS, Gorman PN, Hersh WR. Physician order entry in U.S. hospitals. Proc AMIA Annu Symp. 1998:235–9.

[13] Murff HJ, Kannry J. Physician satisfaction with two order entry systems. J Am Med Inform Assoc. 2001. Sep-Oct;8(5):499-509.

[14] Lee F, Teich JM, Spurr CD, Bates DW. Implementation of Physician Order Entry: User Satisfaction and Self-reported Usage Patterns. JAMIA. 1996; 3:42-55.

[15] Tan YM, Flores JV, Tay ML. Usability of clinician order entry systems in Singapore: an assessment of end-user satisfaction. Stud Health Technol Inform. 2010;160(Pt 2):1202-5.

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