Relationship between the Use of an Electronic Commercial Prescribing System and Medical Errors and Medication Errors in a Teaching Hospital

Hiroyuki FURUYA[*1, 4], Tsuyoshi MORIMOTO[*2, 4] and Yoshiaki OGAWA[*3, 4]

*Departments of [*1]Basic Clinical Science and Public Health, [*2]Pediatrics and [*3]Hematology, and [*4]Information Systems Division, Isehara Campus, Tokai University School of Medicine*

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Objective: To investigate the effects of a commercial electronic prescribing system on medical and medication errors.

Methods: We conducted a retrospective before-and-after study in a teaching hospital by applying a U control chart to monthly error rates that were calculated from the number of both medical and medication errors divided by the number of patient days.

Results: The process mean medical error rate from April 2008 to December 2010 was 0.0213 ± 0.0004 (mean ± SD), and consecutive data points after September in 2010 were under the process mean from April 2008 to December 2010. The process mean value from January 2011 to March 2012 was 0.0177 ± 0.0005. A significant difference was seen in the process mean medical error rate between consecutive months before December 2010 and values after January 2011 ($p < 0.001$). From April 2008 to December 2010, the process mean medication error rate was 0.0060 ± 0.0002, and from January 2011 to March 2012, the mean value was 0.0045 ± 0.0002 ($p < 0.001$).

Conclusion: We showed that it requires time to reach a significant reduction in medical and medication error rates after implementation of an electronic prescribing system. It is important to check and support ways to adjust to procedures involved in using a new system.

Key words: Electronic prescribing system, medical errors, medication errors, statistical control charts

INTRODUCTION

Health information systems or electronic medical records have been introduced to improve patient safety and increase the efficiency of clinical practices. The medication prescription process consists of several phases, including prescribing, dispensing, administering, and monitoring. Medication errors account for 33.3% of all types of error reports in Japan [1]. Although several reviews have shown the positive effects of electronic prescribing (e-prescribing) on medication errors and adverse drug events, the effect of e-prescribing on all phases of the prescription process is unknown [2–5]. However, a "closed-loop" system that consists of automated dispending, barcode scanning to confirm patient identity, and electronic medication administration records (EMARs), has been reported to have had a positive effect in a London teaching hospital [6].

In this study, we evaluated the effect of a commercial e-prescribing system and compared the number of errors that occurred before and after the system was installed.

MATERIALS AND METHODS

Setting

The study was conducted in a teaching hospital with 804 beds. In this hospital, 913, 969, and 996 doctors and 956, 996, and 1011 nurses worked in April 2008, April 2009, and April 2010, respectively. There were 783, 799, and 800 inpatients being treated per day, and the average length of hospital stay was 13, 12, and 12 days in 2008, 2009, and 2010, respectively. This study was approved by the Institutional Review Board for Clinical Research at Tokai University Hospital.

Data collection

Error reports were gathered and investigated in the patient safety division of the hospital. After validation of these reports, the number of errors related to patient safety was reported to the committee every month. The monthly error rate was then calculated based on the number of errors divided by the number of patient days. Data collected from April 2008 to March 2012 were used for analysis.

Intervention

The commercial e-prescribing system (MegaOak Assist Rakuraku Kanngoshisan; NEC, Tokyo) was implemented into inpatient wards in November 2009, and includes barcode scanning technology for patient identification. Barcode wristbands are now given to blood transfusion and chemotherapy patients, while either visual or verbal identification is used to identify patients for other types of treatment.

One nurse leader checked the medication-related tasks in a ward, and the other nurses accessed electronic patient records as well as medication records for drug

Hiroyuki FURUYA, Basic Clinical Science and Public Health, Tokai University School of Medicine, 143 Shimokasuya, Isehara, Kanagawa 259-1193, Japan
Tel: +81-463-93-1121(ext. 2622) Fax: +81-463-92-3549 E-mail: furuya@is.icc.u-tokai.ac.jp

administration. The drugs administered were then registered in the medication administration record. Before the e-prescribing system, medication orders had been handwritten throughout the entire prescription process. Nurse leaders in each ward were given 1.5 hours of training on the new system, and these nurse leaders then trained the other nurses to operate the system before it was used. Doctors also received 1.5 hours of training.

Study design

We retrospectively reviewed number of error reports monthly before and after the e-prescribing system was implemented. Data collected monthly from April 2008 to March 2012 were used for statistical analysis.

Statistical analysis

The U control chart was used to evaluate the performance of the e-prescribing system. The U control chart is used for ratio data, and the upper control limit (UCL) was calculated by adding three times the standard deviation (SD) to the overall process mean. The lower control limit (LCL) was calculated by subtracting three times the SD from the overall process mean. Wilcoxon rank sum test was used to compare the mean error rates between pre- and post-intervention.

RESULTS

We applied the U control chart to the total monthly medical error rate and monthly medication error rate for this time series analysis. In terms of the total monthly medical error rate, a series of 12 consecutives data points from April 2008 to March 2009, and from April 2009 to March 2010, showed similar patterns; the error rate during either June or July of each year was over the UCL (Fig. 1). The process mean medical error rate from April 2008 to December 2010 was 0.0213 ± 0.0004 (mean ± SD), and all consecutive data points after September 2010 were under the process mean from April 2008 to December 2010 (Fig. 1). The process mean error rate from January 2011 to March 2012 was 0.0177 ± 0.0005 (Fig. 1). Compared with the process mean values before December 2010, a 17% reduction of the process mean medical error rate for consecutive months was seen after January 2011 ($p < 0.001$).

In terms of medication errors, we also observed a peak error rate over the UCL in every June or July (Fig. 2). The process mean error rate from April 2008 to December 2010 was 0.0060 ± 0.0002, and all consecutive months after July 2010 were under the process mean from April 2008 to December 2010 (Fig. 2). The process mean error rate from January 2011 to March 2012 was 0.0045 ± 0.0002 (Fig. 2). Compared with the process mean values before December 2010, a 25% reduction in the process mean medication error rate for consecutive months after January 2011 was observed ($p < 0.001$).

DISCUSSION

In this study, we observed a mean shift in monthly medical error rates after introducing a commercial e-prescribing system. The variation in monthly medical error rates paralleled the variation in monthly medication error rates, as the number of medication errors represented about one third of the total number of medical errors. It might take more than 6 months of adjustment to an e-prescribing system before a significantly continuous reduction in monthly error rates can be seen, even if nurses and physicians receive training on its use. Medical and mediation error rates were over the UCL every June or July due to the fact that new nurses started to work in each ward around this time. After implementation of the e-prescribing system, monthly mean medication error rates were within the control limit, even if the rates in June or July were higher than in other months. After implementation of the e-prescribing system, monthly mean medication error rates were within the control limit, even if the rates in June or July were higher than in other months.

Errors common to handwritten orders, such as misspellings, unclear handwriting, unclear verbal orders, and non-identification of prescribers were avoided with the e-prescribing system. Bates *et al.* [7] showed that computerized physician order entries reduced medication errors in 1998. Ammenwerth *et al.* [2] performed a systematic review to investigate the effect of e-prescribing on the risk of medication errors and adverse drug events; 23 of 25 studies from 1996 to 2005 showed a significant relative risk reduction. Reckmann *et al.* [3] performed a systematic review regarding evidence that computerized provider order entry systems reduced prescribing errors among hospital inpatients, and reported that 12 studies provided evidence of the effectiveness of these systems at reducing prescribing errors. However, both reports indicated limitations based on the study sample sizes and designs. Fewer studies have evaluated the effect of the whole prescribing process being performed within a "closed-loop" system. Dean-Franklin *et al.* [6] examined the effectiveness of a "closed-loop" system and showed that the combination of e-prescribing with automated dispensing, bar coded patient identification, and EMARs significantly reduced prescribing and administration errors. Westbrook *et al.* [8] investigated the effects of commercial e-prescribing systems on prescribing error rates in hospital inpatients and showed statistically significant reductions in prescribing errors. They insisted that system-related errors require close attention, as they are frequent, but are potentially remediable by system redesign and user training. The reason it took more than 6 months to note a significant reduction in error rates in our study is likely related to system issues and user training.

The strength of our study is that we used a statistical control chart to evaluate monthly variations in the e-prescribing process. The limitation of the study is that we cannot generalize findings from our hospital to other hospitals or use of one version of an e-prescribing to other versions. Further studies are needed to establish better evidence regarding the value of an e-prescribing system on all phases of the medication prescribing process.

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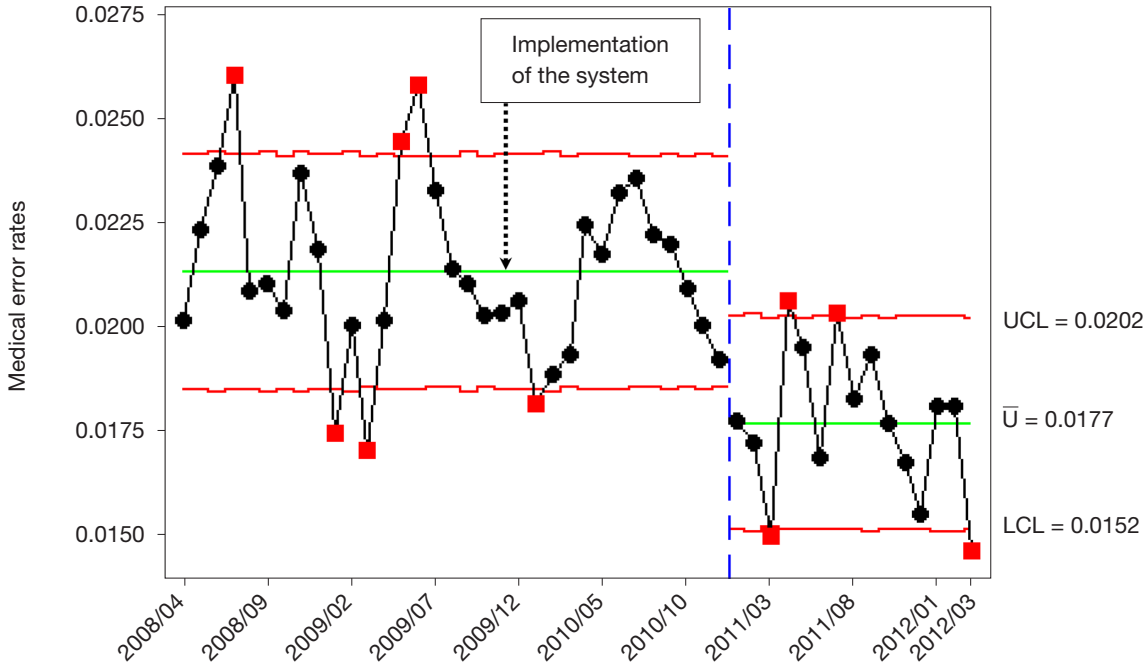

Fig. 1 Monthly medical error rates from April 2008 to December 2010 and from January 2011 to March 2012 were separately analyzed by U control chart. The red square box shows that the medical error rate was over or under the control limit. LCL, lower control limit; $\bar{U}$, center line; UCL, upper control limit.

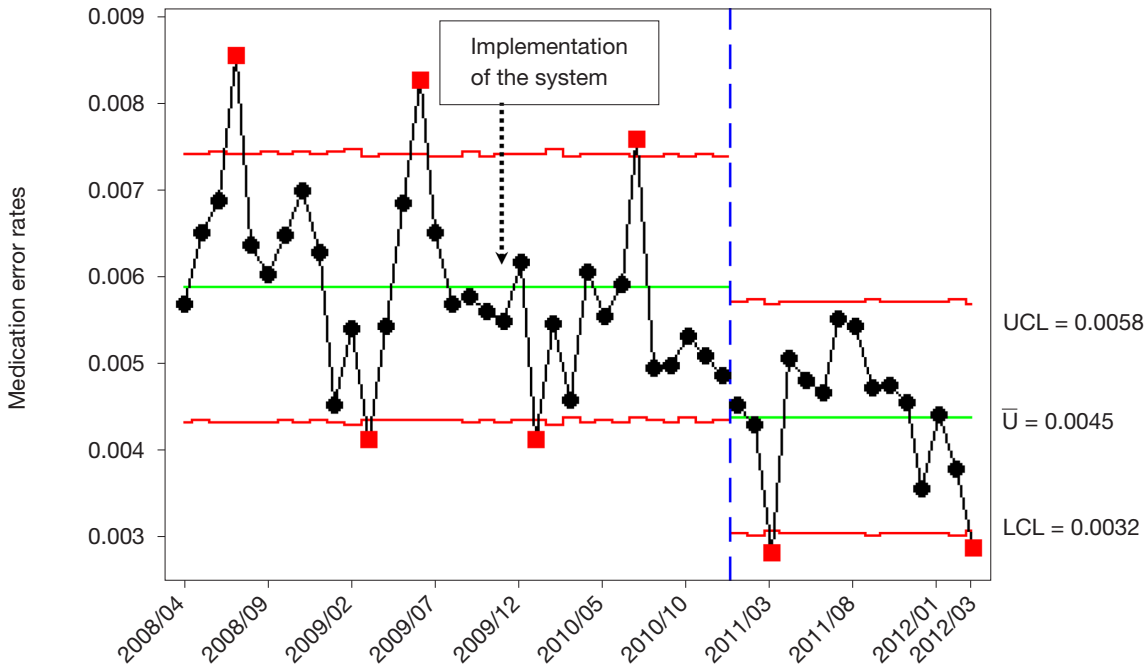

Fig. 2 Monthly medication error rates from April 2008 to December 2010 and from January 2011 to March 2012 were analyzed separately by the U control chart. The red square box shows that the medication error rate was over or under the control limit. LCL, lower control limit; $\bar{U}$. center line; UCL, upper control limit.

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