The Impact of an Electronic Medication Administration Record On Medication Administration Efficiency and Medication Errors

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Abstract

A prospective, observational study utilizing time-and-motion technique and a retrospective review of hospital Midas+ database were conducted to compare the medication administration efficiency and monthly rate of medication errors before and after the implementation of electronic medication administration records (eMAR). The pre- and post-eMAR medication administration process time intervals were measured over approximately two-week periods before and after implementation of eMAR, with a 2-month break in-between (N=156). A significant increase was found in medication administration time pre- vs. post-implementation of eMAR (11.3 minutes vs. 14.4 minutes; $p = 0.039$). In multivariate analysis, the eMAR implementation showed no effect on medication administration time. As expected, the total number of medication, IV push medication, caring for the patient and interaction with physician were significant positive predictors of medication administration time. A retrospective review of the hospital Midas+ database for 6 months before and after implementation of eMAR revealed a statistically significant decrease in medication errors pre- vs. post-implementation of eMAR (mean events 11 vs. 5.3; $p = 0.034$). Although no improvement in medication administration efficiency was observed, implementation of eMAR appeared to improve the quality of care through a significant decrease in medication errors.

Keywords: medication administration, errors, efficiency, records, electronic

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Introduction

Medication administration is a complex process that can involve 50 to 100 steps from the time the order is written to the actual administration of the medication to the patient (Dwibedi et al., 2011; Kliger, Blegan, Gootee, & O'Neil, 2009). The potential for a medication error increased with each step in this process. The most common type of error in a hospital is medication errors which lead to approximately 7,000 deaths and harm 1.5 million Americans annually (Kliger et al., 2009; Tschannen, Talsma, Reinemeyer, Belt, & Schoville, 2011). The electronic medication administration record (eMAR) is a component of the electronic health record (EHR) and the rationale for implementing the eMAR is increased nursing efficiency, quality of care and improved patient safety by avoiding preventable errors (Blumenthal & Tavenner, 2010).

Background

Pressure is mounting on hospital leaders to lower costs and improve patient outcomes through increased efficiencies with health information technology (HIT) (Harrington, Porch, Acosta, & Wilkens, 2011). In 2004, Congress authorized the development of a plan to create a national HIT infrastructure (Smith, Morris, & Janke, 2011). The goal of this initiative was to computerize the medical records of all Americans by 2014 (Gardner & Pearce, 2013; Hoffman & Podgurski, 2011). Timely data entry at the point of care with electronic and standardized clinical documentation versus paper-based documentation is the basic assumption of an accurate EHR (Carlson, Catrambone, Oder, Nauseda, & Fogg, 2010; Lindgren, Elie, Vidal, & Vasserman, 2010).

In 2009, Congress and the President enacted the Health Information Technology Economic and Clinical Health Act (HITECH), part of the American Recovery and

Reinvestment Act (ARRA) (Blumenthal & Tavenner, 2010; Swanson, Cowan, & Blake 2011). A provision of HITECH commits $27 billion to fund incentive payments to eligible hospitals and clinicians and another $2 billion to create a national HIT infrastructure for the adoption of electronic health records (EHRs) over 10 years (Blumenthal, 2011; Harrison & Lyerla, 2012).

This act seeks to improve patient care in America by investing in HIT and participation in the health information exchange (HIE) (Jones, Friedberg, & Schneider, 2011; Swanson, Cowan & Blake 2011). Meaningful Use, a component of ARRA/HITECH, is successfully adopting, implementing and meaningfully using the EHR technology in delivering patient care by professionals and organizations (Blumenthal, 2010; Swanson et al., 2011). Incentive payments will be paid to hospitals and clinicians during 2011-2015 through the Centers for Medicare and Medicaid Services (CMS) when they meet specific core objectives in the three stages of Meaningful Use (Appari, Johnson, & Anthony, 2013; Jones et al., 2011; Stark, 2010).

The EHR can improve healthcare by being a central repository for patient information, provide safety alerts, drug interaction alerts and drug-dose recommendations that can be utilized to assist staff in providing safe patient care (Hoffman & Podgurski, 2011). EHRs have improved legibility, reduced clinician documentation time and errors compared to paper based systems (Carrington & Effken, 2011).

In order to meet the challenges of healthcare reform and the anticipated needs of the growing patient population, the nursing profession must also change (The National Academies, 2013). The Institute of Medicine (IOM) issued a report in October 2010 called *The Future of Nursing*: *Leading Change*, *Advancing Health* that identified obstacles that all nurses face with the evolution of healthcare reform. The five recommendations in this report include (1) support the removal of scope-of-practice barriers, specifically for advanced practice registered nurses (2) increase opportunities for leadership and collaborative improvement efforts for nurses (3) implement and expand nurse residency programs (4) increase to 80 percent the number of baccalaureate prepared nurses by 2020 (5) double the amount of doctorate prepared nurses by 2020 (IOM, 2010). This report recommends further studies be done to see what role nursing will play in the integration of clinical applications and HITs (Carrington & Tiase, 2013).

Many hospitals are replacing the paper medication administration record (MAR) with the electronic medication administration record (eMAR) due to the implementation of the EHR and government incentive payments (Kelley, Brandon, & Docherty, 2011). The use of the eMAR in the hospital setting is considered a centerpiece of nurses' workflow and is essential since delivery of patient care is associated with medication administration (Moreland, Gallagher, Bena, Morrison, & Albert, 2012).

Medication errors can occur during the medication administration process and some factors that contribute to them include multiple care givers, incomplete medication orders, illegible handwriting, similar packaging and sounding drug names and nurse interruptions (Donahue, Brown, & Fitzpatrick, 2009; Richardson, Bromirski, & Hayden 2012). Some reasons why the utilization of the eMAR prevents medication errors include a reduction in transcription errors, improved access to patient data and expedited communication via email to pharmacy (Culler, Jose, Kohler, & Rask, 2011). The use of the eMAR supports nursing strategy to prevent medication errors by verifying the completeness of the medication order prior to administration, identifying the patient's five rights of medication administration (patient, drug, dose, route, time), providing medication resource links and standard hospital calculations for dosing (Moreland et al., 2012; Tschannen et al., 2011).

This active decision support provided by the eMAR at the point of care is why nurses feel that the EHR provides more efficient nursing care and improved patient safety (Culler et al., 2011; Kutney-Lee & Kelly, 2011). The eMAR is also associated with a higher quality of documentation, more complete charting and the improved delivery of care (Yee et al., 2012). Nurses felt that their efficiency and organization were improved with the eMAR when they received medication and new order alerts and updated medication profiles, which were connected to the automated medication dispensing system (eg, Pyxis) (Kossman & Scheidenhelm, 2008).

Medication administration is one of the most frequent nursing activities and is the most interrupted (Biron, Lavoie-Tremblay, & Loiselle, 2009). On average, during each med pass, 11% of the time was spent dealing with distractions and interruptions (Kreckler, Catchpole, Bottomly, Handa, & McCulloch, 2008). This can contribute to medication errors which have the potential to increase hospital length of stay due to patient harm, disability and death (Biron, Loiselle, & Lavoie-Tremblay, 2009; Stamp, & Willis, 2009). During a 12 hour shift, nurses are interrupted between 4-10 times per hour with each interruption reflecting an operational loss estimated to cost $95.00 (Redding, & Robinson, 2009; Rochman, Aebersold, Tschannen, & Cambridge, 2012). A recent study showed that as interruptions increased during a single med pass, so did the number and severity of errors (Westbrook, Woods, Rob, Dunsmuir, & Day, 2010).

Many times nurses are inundated with multiple requests from physicians, nurses, other healthcare workers, patients, and family members of patients when they are in the process of medication administration. For the nurse, these distractions and interruptions in the work environment can have a profound and detrimental impact on patient safety (Hall, Pedersen, & Fairley, 2010; Redding, & Robinson, 2009). Nurses experienced the greatest number of distractions and interruptions from patients who were demanding care or because other aspects of care were delivered during the time for medication administration (Kreckler et al., 2008). This presents a real challenge for nurses to deliver safe and efficient care while constantly being confronted with distractions and interruptions in their work environment. A reduction in nursing distractions and interruptions improved nurse efficiency, quality of care and increased patient safety (Conrad, Fields, McNamara, Cone, & Atkins, 2010; Redding, & Robinson, 2009).

The transition to the eMAR using computer technology will cause interruptions in nurses' workflow with potential risk to patient care processes (Ward, Vartak, Schwichtenberg, & Wakefield, 2011). Implementation of this new technology requires adequate training of staff to promote increased user acceptance and proficiency (Sassen, 2009). Nursing informatics can be a driving force for change in healthcare by delivering and maintaining technology and satisfying nurses with improved ease of documentation, efficiency and communication (Carrington & Tiase, 2013; Moreland et al., 2012). Overall, nurses felt that the EHR enhanced patient safety by preventing errors, improved access to patient data for all clinicians and better legibility and quality of patient information (Kossman & Scheidenhelm, 2008; Top & Gider, 2011). Nursing efficiency was further improved with the utilization of portable workstations, which allowed quicker documentation and information retrieval (Kossman & Scheidenhelm, 2008).

Methods

Aims

The aims of this study were: (a) to evaluate the impact of eMAR implementation on medication administration efficiency and medication errors and (b) to investigate the predictors of medication administration efficiency in an acute care setting.

Study design

A prospective, observational study utilizing time-and-motion technique was conducted to compare medication administration efficiency before and after the implementation of eMAR and investigate the predictors of medication administration efficiency. The pre- and post-eMAR medication administration process time intervals were measured over approximately two-week periods before and after implementation of eMAR, with a 2-month break in-between. A retrospective review of the hospital Midas+ database was performed to collect the rates and nature of medication errors 6 months before and after the implementation of eMAR.

Setting

The study was performed on a 40-bed medical/oncology unit in a not-for-profit, Magnet®-designated community hospital located in southern California. All clinical staff members who charted medications were required to take a mandatory 4-hour education class, which included didactic sessions and hands-on eMAR training. When the unit went live with medication charting, a group of “super users” were deployed to assist staff with any questions or problems that might occur. In addition, a 2-hour online medication administration module was made available as a refresher on the hospital intranet. The medical/oncology unit was the last acute care unit to go live with electronic med charting on November 14th, 2011.

Measures

The time-motion data collection form consisted of 28 items specifically addressing the entire medication administration process (Appendix A). This form recorded the time interval from the start to the end of medication administration, administration-related tasks and any distractions/interruptions that occurred during the medication administration process delivered by a nurse for each patient. The start of this process began when the nurse went into the medication room to obtain the medication. Key observations in this process were the availability of the Pyxis machine and medications for the nurse, the types and number of medications to be administered, whether the medication required prepping either in the medication room or at the bedside, time of medication administration and the process for documenting the medication. Nursing interruptions during the medication administration process were observed and documented. Some of these included caring for a patient, phone calls, obtaining supplies, computer problems, and conversations with physicians, health care workers and the patient's family members. The time-motion data collection form was created by the principal investigator and the face validity of the tool was evaluated to review all the activities related to medication administration process.

To collect the medication error events, the data were extracted directly from the hospital Midas+ database and exported into Excel format. This form included incident type, type of event, degree of injury, drug category, origin of error such as prescribing, transcribing, dispensing, administration, monitoring and harm index.

Data collection procedures

This project was reviewed by the Institutional Review Board, which determined this study to be a performance improvement project that does not fall under the oversight of IRB (Appendices B and C). A convenience sample of registered nurses employed on the Medical/Oncology Unit was invited to participate in the study via email. Since participation in this performance improvement project was entirely voluntary, participants were able to refuse to participate or withdrawal at any time without penalty or affecting their employment. All participants were encouraged to ask questions and express concerns prior to participation in this project.

The nursing staff that agreed to participate in this project, the process of medication administration was observed by the principal investigator using the time-motion data collection form. The time interval from the start of medication administration to the end of medication administration and administration-related tasks were measured with a stopwatch. Any distractions or interruptions that the nursing staff encountered during this process were also measured. Furthermore, any challenges with information technology that the nursing staff had were also observed and documented.

The pre-eMAR medication administration efficiency data were collected for approximately two weeks from October to November 2011 and post-eMAR data were collected for approximately two weeks after the 2-month eMAR implementation period when all nursing staff became proficient with this new electronic medication administration process. Random direct observations of the nurses administering medications were made on both the day shift (7:00 A.M. - 7:00 P.M.) and the night shift (7:00 P.M. - 7:00 A.M.) by the principal investigator. All data were kept confidential in a password-protected computer. Each form was assigned a sequential number to protect the identity of the data and the hard copies of the data were kept in a secure locked office.

The retrospective review of the hospital Midas+ database was used to collect the medication errors. The pre-eMAR medication error data were collected for a 6-month period prior to eMAR implementation between May 2011 and October 2011 and the post-eMAR medication error data were collected for a 6-month period beginning two months after eMAR implementation from January 2012 to June 2012. Medical error data were not collected during the 2-month eMAR implementation period.

Data analysis

Descriptive statistics were utilized to calculate the frequencies, percentages, means and standard error of the means. Independent *t*-tests were performed to compare the mean medication administration times and the rates of medication errors during pre- and post-eMAR implementation periods. To investigate the predictors of medication administration efficiency, bivariate Pearson product-moment correlation procedures were first performed among the independent variables and medication administration time. Dummy codes were assigned for categorical independent variables, such as medication administration method (e.g. pre-eMAR = 0; post-eMAR = 1). The statistically significant variables were selected as the potential predictor variables, and they were entered into the first step of the hierarchical multiple regression model. The eMAR was then entered into the second step of hierarchical multiple regression model to determine its strength alone as a predictor variable. Analyses were performed using SPSS version 20.0 (SPSS Inc., Chicago, IL). For the purpose of this study, the significance level was be set at 0.05.

Results

Medication administration efficiency

A total of 156 cases of medication administration activities involving 38 nurses were observed at the point of care by the principal investigator; 78 pre- and 78 post-eMAR implementation. Table 1 shows the characteristics of medication administration pre- and post-eMAR implementation. There were many differences between the two groups: higher use of multiple Pyxis, more missing medications in Pyxis, higher bedside preparation of medications, fewer oral medications, higher double checking of patient's identification, patient education given more often and greater distractions/interruptions for the post-eMAR group.

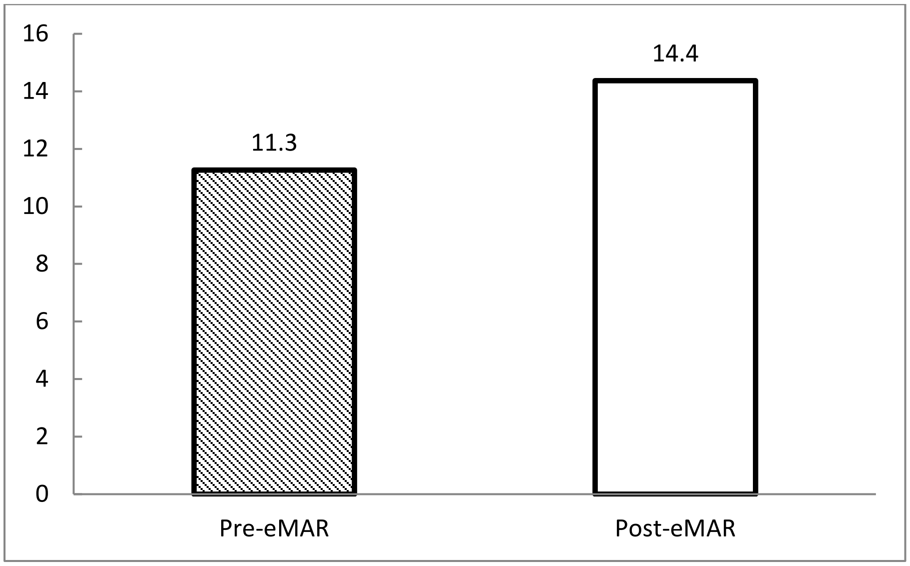
Table 1 Characteristics of medication administrations (*N*=156)

	Pre-eMAR (*n*=78)	Post-eMAR (*n*=78)
Is the Pyxis machine available for use by the RN?		
Yes	71 (91.0)	77 (98.7)
No	7 (9.0)	1 (1.3)
Does the RN have to go to more than one Pyxis?		
Yes	9 (11.5)	15 (19.2)
No	69 (88.5)	63 (80.8)
Is medication missing in Pyxis?		
Yes	5 (6.4)	16 (20.5)
No	73 (93.6)	62 (79.5)
Medications prepped at bedside?		
Yes	7 (9.0)	15 (19.2)
No	71 (91.0)	63 (80.8)
Total number of medications, mean (range)	2.5 (1-11)	2.7 (1-15)
Types of medications		
Oral	49 (62.8)	35 (44.9)
IV	24 (30.8)	14 (17.9)
IVP	32 (41.0)	38 (48.7)
SQ	10 (12.8)	15 (19.2)
Topical, eye drops	6 (7.7)	1 (1.3)
Does the RN perform double check of patient's identification?		
Yes	60 (76.9)	71 (91.0)
No	18 (23.1)	7 (9.0)
Is patient education given by RN?		
Yes	51 (65.4)	70 (89.7)
No	27 (34.6)	8 (10.3)
Does the RN experience distractions/interruptions during the medications administration process?		
Yes	51 (65.4)	62 (79.5)
No	27 (34.6)	16 (20.5)

Note: Values are expressed as n (%) unless otherwise indicated. Number (%) may add up more than 100% due to multiple options.

The mean medication administration time per patient was 11.3 minutes and 14.4 minutes for pre- and post-eMAR implementation, respectively (Figure 1); this difference was a statistically significant (t = 2.080; *p* = 0.039).

Figure 1 Medications administration time, minutes *(N*=156)



Note: eMAR, Electronic Medication Administration Record.

The comparison of medication administration components between pre- and post-eMAR implementation using independent *t* test is shown in Table 2. The mean difference between the two groups ranged from +0.9 minutes to +1.7 minutes with a longer time interval for the post-eMAR implementation with statistically significant difference for documentation time (mean difference = +0.9 minutes; *p* = 0.001).

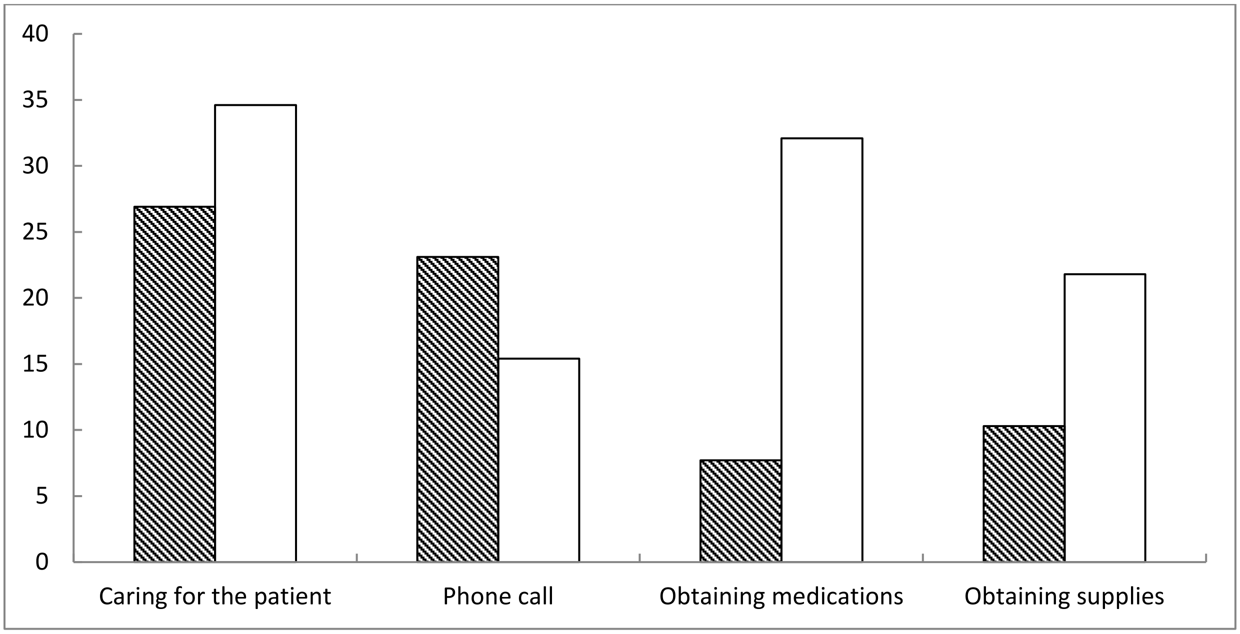
Table 2 Comparison of medication administration components in minutes (mean±SD)

	Pre-eMAR (n=78)	Post-eMAR (n=78)	Mean difference[a]	t value[b]	p value
Medication preparation time	3.3±2.7	5.0±4.9	+1.7	2.815	0.06
Medication administration time at bedside	4.5±4.1	6.4±8.0	+1.9	1.906	0.059
Documentation time	0.5±0.7	1.4±2.0	+0.9	3.381	0.001
Total time (including interruptions)	**11.3±8.4**	**14.4±10.2**	**+3.1**	**2.080**	**0.039**

Note.
[a]Post-eMAR minus pre-eMAR.
[b] t value by independent t test.

There were several types of distractions and interruptions experienced during the medication administration process at the point of care. The most commonly observed distractions and interruptions were caring for the patient, phone call, and obtaining medications and supplies for both pre- and post-eMAR groups with substantially higher rates of obtaining medications and supplies for the post-eMAR group (Figure 2).

Figure 2 Types of distractions/interruptions during medication administration process, % (*N*=156)



Notes: Crosshatch bars, pre-eMAR; white bars, post-eMAR.

Predictors of medication administration efficiency

Because of the substantial differences in the nature of medication administration between pre- and post-eMAR groups, multivariate analysis was conducted to determine whether implementation of eMAR was a predictor of medication administration efficiency. Table 3 shows the bivariate correlations among independent variables and medication administration time. Among the independent variables, the total number of medications had the strongest significant positive correlations (r = 0.556) followed by medication missing in Pyxis and interruption with patient's self-care during the administration process. In contrast, the implementation of eMAR had weak positive correlation with the medication administration time (r = 0.165).

Table 3 Correlations among variables (*N*=156)

	Medication administration time
eMAR	0.165*
Medication missing in Pyxis	0.390**
Medications prepped at bedside	0.283**
Total number of medications	0.556**
Medications per IV push	0.232**
Patient education by RN	0.196*
Distractions/Interruptions	
Caring for RN's patient	0.166*
Caring for another patient	0.231**
Phone call	0.216**
Assist co-worker	0.288**
Patient's family member	0.218**
Obtaining medications	0.174*
Physician	0.263**
Self-care	0.376**
Student	0.217**

Note: * $p < 0.05$; ** $p<0.01$; *** $p<0.001$

The results of hierarchical multiple regression analysis to determine the predictors of medication administration time is shown in Table 4. The statistically significant predictor variables from correlation procedures were entered in the first block that explained 64.3 % of the variance in medication administration time (R^2 = 0.643; $p <$ 0.001). No change in the variance of medication administration time was found after the entry of eMAR implementation in the second step of hierarchical multiple regression procedure (R^2 = 0), indicating that the eMAR implementation was not a predictor of medication administration efficiency. However, the combination of predictors other than e-MAR explained 64.3% of variance in medication administration time. Among the predictor variables, medication missing in Pyxis (*beta* = 0.17; p=0.004), total number of medications (*beta* = 0.27; p<0.001), IV push medications (*beta* = 0.18; p=0.001), caring for the patient (*beta* = 0.16; p=0.004), caring for another patient (*beta* = 0.18; p=0.002), obtaining medications (*beta* = 0.14; p=0.020), patient's self-care (*beta* = 0.27; p<0.001), and interaction with physician (*beta* = 0.18; p=0.002) reached statistical significance.

Table 4 Hierarchical multiple regression analyses predicting medications administration time *(N*=156)

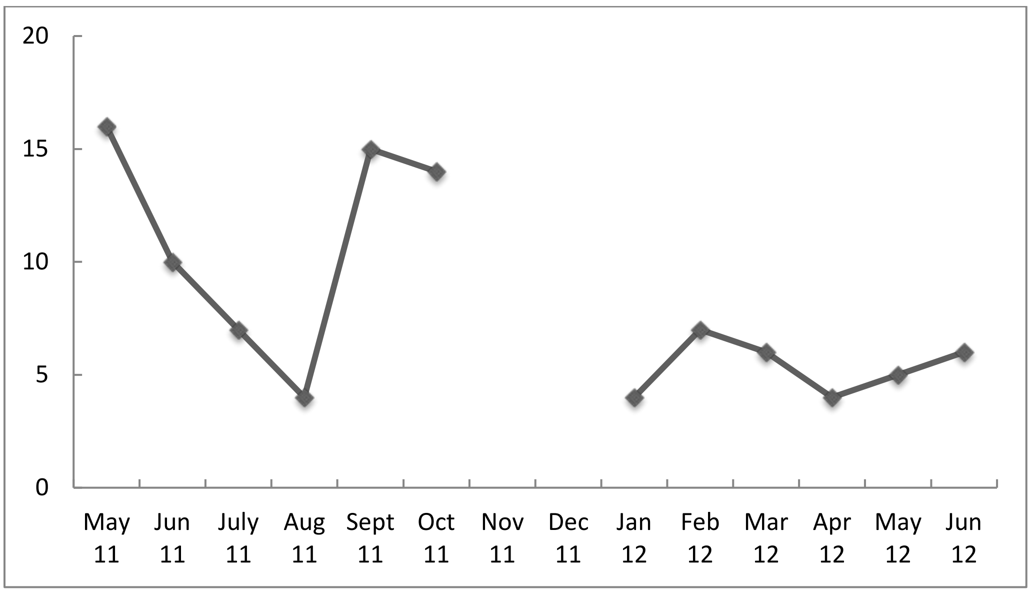
Predictor	Medication administration time	
	Δ R^2	*β*
Step 1[a]	0.643***	
Step 2[b]	0.000	
eMAR		0.008
Medication missing in Pyxis		0.17**
Total number of medications		0.27***
Medications per IV push		0.18**
Distractions/Interruptions		
Caring for RN's patient		0.16**
Caring for another patient		0.18**
Obtaining medications		0.14*
Physician		0.18**
Self-care		0.27***
Total R^2	0.643***	

Note. *p < 0.05; **p < 0.01; ***p < 0.001
[a] for Step 1, all variables that were statistically significant from correlation procedures were entered.
[b] For Step 2, eMAR implementation was entered.

Rates of medication errors

Figure 3 depicts the number of actual events of medication errors by month between pre-eMAR and post-eMAR periods. There were statistically significant decreases in the number of monthly actual medication error events in post-eMAR period from a mean of 11.0 (±4.8) events per month to 5.3 (±1.2) events per month in pre-eMAR periods (*t*=2.795; *p*=0.034).

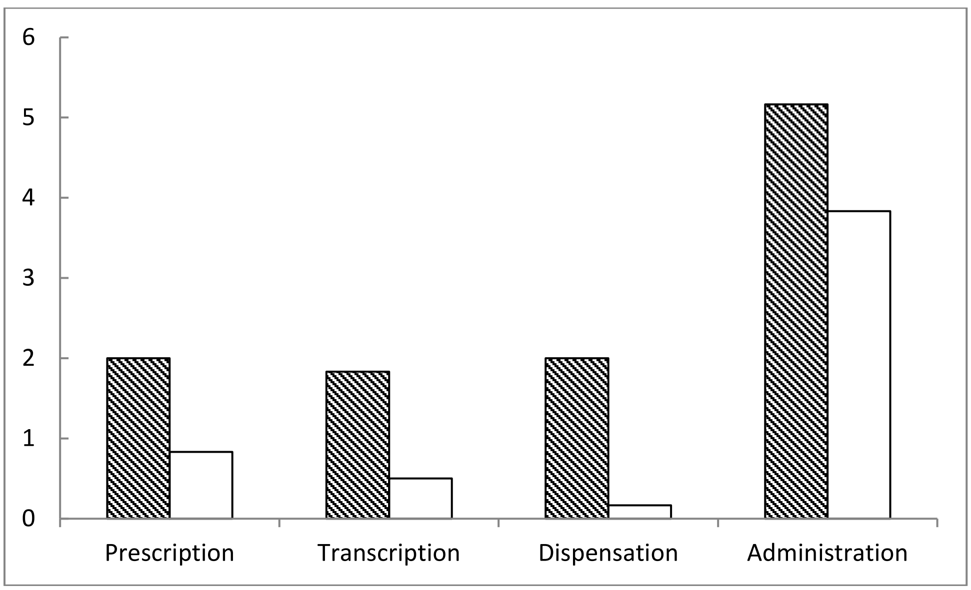
Figure 3 Actual events of medication errors by month



Note. Pre-eMAR periods: May 2011 – October 2011;
Post-eMAR: January 2012 – June 2012.

Various origins of medication errors per month are shown in Figure 4. All categories of origins were decreased after implementation of eMAR. The most common origins of medication errors were medication administration done by nurses or respiratory therapists (5.1 incidence vs. 3.8 incidence per month for pre- and post-eMAR, respectively), followed by medication prescription errors (2 incidence vs. 0.8 incidence per month, respectively). The greatest decrease in post-eMAR period compared to pre-eMAR period was medication dispensation (-1.83 incidence per month). The injuries to patients were also decreased from 0.67 per month in pre-eMAR period to 0.33 per month in post-eMAR period.

Figure 4 Origin of medication errors, incidence per month



Note. MAR, Medication Administration Record;
Crosshatch bars, pre-eMAR; white bars, post-eMAR.

Discussion

It was an unexpected finding in this study that the medication administration efficiency appeared to decrease post-eMAR implementation with an apparent lengthening of mean medication administration time from 11.3 minutes to 14.4 minutes and all 3 components of the administration increasing in duration (Table 2). However, a close examination of the characteristics of the 2 groups show that the post-eMAR group happened to have more delays in completing administration processes such as having to use multiple Pyxis machines, missing medications in Pyxis, bedside preparation of medications and other distractions/interruptions. In fact, multivariate analysis showed that these delays explained 60% of variance in the medication administration time. In addition, multivariate analysis showed that the implementation of eMAR was not a predictor of medication administration time. Therefore, eMAR had no real effect on medication administration efficiency when other confounding variables were accounted for in the multivariate analysis.

Similar study findings regarding the lengthening of medication administration time were reported by Moreland et al., (2012) that found the eMAR was more detailed with multiple screens to view compared to the MAR and did not improve timeliness in medication administration and documentation. Kelley (2011) stated that electronic documentation time increased 14 minutes during a shift compared to paper documentation. Computer related issues such as speed, availability, familiarity and functionality also affected medication administration and documentation (Kossman & Scheidenhelm, 2008). If a nurse is interrupted during the preparation stage of medication administration the odds of a medication error increase to 60% (Biron, Lavoie-Tremblay, & Loiselle, 2009). The medication room is where 22% of all interruptions occurred

(Biron, Loiselle, & Lavoie-Tremblay, 2009). Here nurses frequently interrupted each other while preparing medications to discuss coordination of care, exchange clinical information and discuss personal matters (Biron, Lavoie-Tremblay, & Loiselle, 2009).

Similar study findings were reported by Biron, Lavoie-Tremblay, & Loiselle, (2009) regarding missing medications which can be a multifactorial problem for the organization and probably context specific that needs administrators, nurses and pharmacists to address in order to prevent further system failure and medication errors. Nurses are frequently interrupted in the medication room by having to search in multiple Pyxis machines for missing medications or wait for medications to be restocked (Hall et al., 2010). These interruptions created the potential for medication errors and the unintentional omissions in the delivery of patient care for nurses (Redding & Robinson, 2009). Preparing medications closer to the bedside increased the risk of medication errors because of communication with patients and providing direct patient care which is the most interrupted task for nurses (Biron, Lavoie-Tremblay, & Loiselle, 2009; Hall et al., 2010).

Although the implementation of eMAR had no real impact on medication administration efficiency, it appeared to improve the quality of care in reducing the medication errors. The comparison of average actual events of medication errors showed that there was a statistically significant decrease in errors after eMAR implementation. It is quite interesting to observe that medication administration remained the most common origin of medication errors even after implementation of eMAR. These study findings are supported by research that found of all the medication errors, one-third occurred during the medication administration stage and were primarily due to nursing interruptions in delivering direct patient care (Biron, Lavoie-Tremblay, & Loiselle, 2009; Westbrook et al., 2010).

The administration stage only has the nurse as the final safety check to intercept any possible errors before administering the medication to the patient and is therefore most vulnerable to error (Marini, Hasman, Huijer, & Dimassi, 2010). Unfortunately, there is a lack of comprehensive data in research studies regarding a direct causal relationship between the implementation of the eMAR and a reduction in medication errors during the same time period. There were only anecdotal references found where nurses felt that the use of electronic documentation improved patient safety and prevented errors primarily due to a reduction in transcription errors (Culler et al., 2011; Kossman & Scheidenhelm, 2008; Moreland et al., 2012). Organizations that use the eMAR with computerized provider order entry (CPOE) and bar-code-assisted medication administration (BCMA) show strong evidence of a reduction in medication errors due to the built-in safety features of these systems (Dwibedi et al., 2011; Kutney-Lee & Kelly, 2011; Marini, et al., 2010). This study did not evaluate those two systems because they were not present in the hospital.

Limitations

There were some limitations to this study. First, no validation of data collection procedures was performed for the medication administration efficiency and the data was collected by a single observer, which could have introduced bias. However, the likelihood of bias was low in view of the longer time of administration in the post-eMAR group. Second, the presence of the observer, well known to the staff could have influenced the behavior of the nurses. Third, some nurses asked the observer for assistance during the medication administration process, such as witnessing for dose verification or fetching needed supplies. Since the observer always denied such requests, this denial could have negatively influenced their medication administration process. These interactions were reflected in the time interval collection and may have added to distractions or interruptions. Fourth, this study was not a randomized controlled study and the study findings should not be interpreted as a cause-and-effect relationship. Finally, this study was only conducted on a single medical unit and therefore limited the generalizability of the findings to other settings.

The sheer number of medications that nurses have to administer safely and without error can be a daunting task. Unfortunately, distractions and interruptions are prevalent in the hospital and increase the potential for medications errors. Nurses and patient care issues cause most of these interruptions during medication administration. Medications and supplies need to be readily available for nurses on a consistent basis to prevent the interruptions in the medication administration process.

All hospital staff need education on how their interactions with nurses during medication administration increase the probability for medication errors and patient harm. A culture of awareness and change must occur in hospitals to start minimizing distractions and interruptions during medication administration. Future studies could implement distraction and interruption reduction measures to see if there is a decrease in medication errors.

Conclusions

Initial analysis results seemed to indicate that the eMAR implementation worsened the medication administration efficiency with lengthening of medication administration time. However, after adjusting for confounding variables through multivariate analysis, the results showed that the implementation of eMAR had neither positive nor negative effect on the medication administration efficiency. In contrast, there was a marked decrease in the monthly rate of medication error events. The decrease in errors was apparent in multiple categories of errors, including omissions of medications, patient injuries as well as actual medication related events following the implementation of eMAR. In conclusion, although no improvement in medication administration efficiency was observed, implementation of eMAR appeared to improve the quality of care through a significant decrease in medication errors.

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Appendix A

Scripps

Time-Motion Data Collection Form

Date and time of observations: Staff ID:	Unit Location:
Question	
Start time of medication administration process.	
Arrival time at Pyxis.	
Time when RN starts using Pyxis.	
Is the Pyxis machine available for use by the RN?	Yes No
Does the RN have to go to more than one Pyxis station?	Yes No
Is med missing in Pyxis?	Yes No
If med is missing, what action does the RN take?	1. Communication form 2. Phone 3. Other Pyxis machine 4. Patient bin
Time when RN completes med pull from Pyxis.	
Time when RN completes med preparation.	
Are needed supplies available for the RN?	Yes No
If the supplies are not available for the RN, where does the RN have to go to find them?	1. AMMA cart 2. Respiratory cart 3. Nursing station 4. Supply room
What supplies are not available for the RN?	1. IV tubing 2. IV caps 3. Syringes 4. NS flushes 5. IV start kit 6. Needle connector 7. Alcohol pads 8. Med cups 9. Labels 10. Pill cutter
Arrival time to patient's bedside.	
Medications prepped at bedside?	Yes No
Total number of meds administered to patient.	
Types of meds given to the patient?	1. Oral 2. IV 3. IVP 4. IM 5. SQ 6. NG 7. FT 8. Topical 9. Eye drops
Does the RN perform double check of patient's identification?	Yes No
Is patient education given by RN?	Yes No
Time when RN administers meds or hands the meds to patient.	
Time when med administration is complete.	
Time when RN starts documentation.	
Time when RN completes documentation.	
What device does the RN use to document the medication?	1. Paper MAR 2. C5 3. COW 4. WOW 5. Desktop PC 6. NOW
Is the device available for the RN?	Yes No
What type of charting does the RN do?	1. Paper 2. "G"-Given 3. "B"-Back Charting 4. "P"-Paper Chart 5. "A"-Administered by Other 6. "N"-Not Given 7. "D"-Discontinued
End time of medication administration process.	
Does the nurse experience distractions/interruptions during the medication administration process?	Yes No
If the RN does experience distractions/interruptions, what are the types.	1. Caring for RN's patient 2. Caring for another patient 3. Phone call 4. Assist co-worker 5. Patient's family member 6. Physician 7. Other health care worker 8. RN's personal activities 9. Computer problems 10. Obtaining medications 11. Obtaining supplies

Appendix B

PLNU IRB
Acknowledgement of Performance Improvement Study
(Non-Human Subject Research)
942

Date: Friday, October 28th, 2011

PI: Jeff McComas

Additional Investigators: N/A

Faculty Advisor: Michelle Ringen & Son Kim

Title: Impact of electronic medication administration record on nursing workflow.

The research proposal was reviewed and verified as a Performance Improvement Project, and not as human subjects research. Therefore, this type of research does not fall under the oversight of PLNU's IRB, as stated in federal requirements pertaining to human subjects protections within the **Federal Law 45 CFR 46.101 b**. Therefore, as concerns PLNU's IRB, you have no further requirements or obligations regarding this project.

For questions related to this correspondence, please contact the IRB Chair, Ross A. Oakes Mueller, Ph.D., at the contact information below. To access relevant policies and guidelines related to the involvement of human subjects in research, please visit the PLNU IRB web site.

Best wishes on your study,

Ross A. Oakes Mueller, Ph.D.
Associate Professor
Department of Psychology
IRB Chair

Point Loma Nazarene University 3900 Lomaland Dr. San Diego, CA 92106 619.849.2905
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Appendix C

Scripps

Scripps Memorial Hospital La Jolla
Administration
9888 Genesee Avenue
La Jolla, CA 92037-1276
Tel 858-457-4123

October 24, 2011

Dr. Ross Oakes-Mueller
Chairman of IRB Approval
Point Loma Nazarene University
3900 Lomaland Dr.
San Diego, CA 92106

Dear Dr. Oakes-Mueller:

This letter is to confirm that Scripps Health supports **JEFFERY D. MC COMAS, RN**, and his thesis project, "The Impact of Medication Administration on Nursing Workflow" at Point Loma Nazarene University. The scope of his Performance Improvement project includes conducting time-and-motion studies both pre- and post-implementation of the electronic medication administration record. He will observe registered nurses during the medication administration process on a Medical/Oncology unit at Scripps Memorial Hospital La Jolla. Currently this unit is using a paper medication administration record and by mid-November 2011, it will transition to using an electronic medication administration record. He will then return once the staff is proficient at this new process and conduct another time-and-motion study. These results will be compared to determine how change has affected the medication administration process for the RN staff. Also included in his study will be measuring the effects of interruptions during the medication administration process and the challenges with information technology in nursing.

He has full support of this hospital's administration and his project does not require Scripps Health's IRB approval.

Sincerely,

Cynthia Steckel, PhD, RN, NEA-BC
Vice President / Chief Nursing &
Operations Executive

Tamara Winkler, RN
Director, Performance Improvement