Anesthesia eJournal /AEJ
Volume 3 Issue 2 2015

Reducing Intravenous Narcotic Documentation Errors on the Electronic Anesthesia Record: A Quality Improvement Project

John M. Borza DNP, MBA, CRNA
Judith A. Kaufmann Dr.PH, FNP-BC
Thomas W. Cline Ph.D., MBA

Affiliation:

University of Pittsburgh Medical Center, Pittsburgh, PA, USA. Dr Borza is Clinical Director Nurse Anesthesia. Email: borzajm@upmc.edu

Funding/Conflict of Interest Disclosure:
None, IRB -University of Pittsburgh, Quality Improvement Review Committee, QI Review Number 0001579

Abstract

Medication errors are an important public health problem with high human and financial costs. Medication errors in anesthesia can result in patient morbidity or mortality and should be preventable. Evidence in the literature supports increasing computer access to reduce the number of medication errors. The purpose of this study was to determine if medication errors could be reduced in one university hospital through a clinical intervention of increasing computer access in the post-anesthesia care unit. A quantitative retrospective chart review was conducted. A statistical test of two independent proportions was used to examine the occurrence of schedule II (fentanyl) and IV (midazolam) controlled substance documentation errors before and after increasing computer access in the post-anesthesia care unit. Access to computers appeared to be associated with a reduction of medication errors from 2.3% to 1.5%. The compliance rate increased from 97.6% to 98.5%. The reduction in the error percentage was significant ($z = 2.045$, $p = 0.04$). Our findings provide objective evidence for the support of continuous process improvement to reduce medication errors in anesthesia.

KEYWORDS: medication errors; patient safety; anesthesia documentation; medication documentation; electronic anesthesia record

INTRODUCTION

Medication errors are important public health problems with high human and financial costs. Medication errors can result in patient morbidity or mortality and should be preventable. A medication error is defined as a failure in the treatment process that leads to, or has the potential, to lead to harm to the patient.[1] Yet the literature indicates that medication errors exist and must be addressed.[2] In anesthesia, medication errors are particularly problematic and are one of the most prevalent contributors to iatrogenic harm.[3] The Institute of Medicine (IOM) report To Err is Human identified patient safety as a significant problem and suggested that efforts to improve patient safety must focus on systems rather than providers.[5,6] Medication errors are an appropriate area on which to focus efforts for improving patient safety.[6] A substantial need exists for evaluation of interventions to reduce errors.

BACKGROUND AND SIGNIFICANCE

Medication errors in the practice of anesthesia have long afflicted the specialty.[7] The first documented medication error related to the administration of anesthesia was in 1848. A 15-year-old girl, Hannah Greener of the United Kingdom, died after receiving a chloroform anesthetic for a minor procedure.[8] From the time of that earliest report, medication errors during the administration of anesthesia have persisted. Cooper and Nossaman[7] observed that even though it is common knowledge that medication errors occur in anesthesia, there are few published studies on medication errors. Cooper and Nossaman's[7] systematic review contained only 14 articles, 3 of which were symposium reviews on medication errors. Only 5 articles using surveys specifically addressed medication errors during the administration of anesthesia. Despite the reports on medication errors and adverse events, few of the studies within the systematic review specifically addressed the rate of medication errors in anesthesia practice until 2001. Bowdle[9] reviewed nearly 6000 closed or settled anesthesia malpractice claims and found 205 medication errors. Medication errors resulted in 24% mortality and 34% morbidity with an estimated annual cost of $2.8 million for a 700-bed hospital. In 2011, Hanna and Levine[3] reported that 1 error occurs for every 133 anesthetics. Flynn et al[10] reported that there are 300 near misses for every error reported. The national cost of all hospital medication errors is estimated to exceed $3.5 billion dollars annually,[11] and up to 7000 patients die each year as a result of medication errors.[3]

On the basis of earlier reports on anesthesia errors, the Robert Wood Johnson Foundation reinforced the conclusion that a key to reducing patient risk is to shift the focus from individuals, who will always make some errors, to systems, which can be redesigned to help prevent errors.[7] The IOM report (2006), the Joint Commission (2008), and the Anesthesia Patient Safety Foundation (2010) recommended changes in work processes to reduce medication errors.[7]

Medication documentation errors occur despite knowledgeable and competent anesthesia providers. The problem of medication administration in anesthesia is of particular concern because of the potent agents administered. For the present study, a baseline evaluation of medication errors was undertaken. In an analysis of 2 months of electronic anesthesia records compared with pharmacy controlled substance sheets of schedule II (fentanyl) and IV (midazolam) medications at a university medical center, 63 intravenous narcotic medication errors were identified among 2495 anesthetic cases. Three types of medication documentation errors were identified. The least common medication documentation error, with an error rate of 7.6 per 1000, was that the anesthesia provider did not sign the pharmacy controlled substance sheet. The second most common error, with an error rate of 6.4 per 1000, was that the anesthesia provider miscounted on the pharmacy narcotic sheet, but the correct medication dosage was administered to the patient. In most cases found in the data, with an error rate of 15.3 per 1000, the patient was administered the medication, but the medication was not recorded on the electronic anesthesia record. There was no reported harm to patients, but medication errors place the patient at risk. Intravenous narcotic medication documentation errors on the electronic anesthesia record may result in patient morbidity or mortality. Inaccurate or incomplete documentation can lead to over-medication or under-medication, resulting in potential harm.

Cause analysis revealed several factors that contributed to the documentation errors. These factors encompassed technology, policies and regulations, system processes, and accountability. There was a lack of computer access in patient care areas, a lack of real-time decision support, a lack of anesthesia providers who adhered to documentation policy, an inefficient electronic record conversion process that did not include all patient care areas, a lack of a clear documentation process that included a process to detect documentation errors, and a lack of counseling after identification of a documentation error.

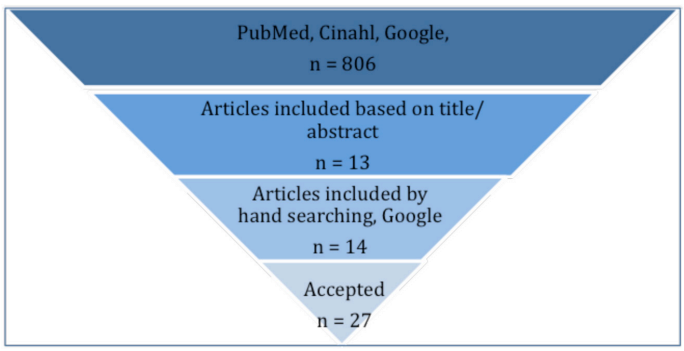
PURPOSE OF STUDY

Based on the above baseline evaluation of anesthesia-related medication errors, the primary aim of this quality improvement project was to achieve 100% accuracy in documenting intravenous schedule II and IV controlled substances on the electronic anesthesia record within the facility. This quality improvement project will enable the university medical center to meet US Drug Enforcement Agency requirements and comply with university medical center policies.

REVIEW OF THE LITERATURE

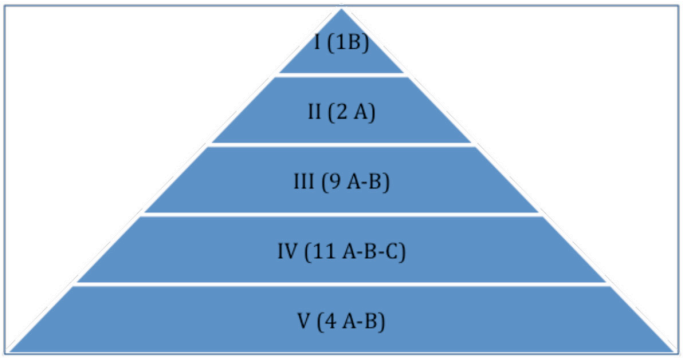
In preparation for the planning of this research translation study, a comprehensive evaluation of the literature for medication errors, medication reconciliation, and quality improvement design was performed. No inclusion or exclusion criteria were utilized because of the limited number of articles published on medication errors in anesthesia. Databases utilized for the search were PubMed and CINAHL. Search terms entered into PubMed were ("medication reconciliation methods" AND "anesthesia"), causes of reconciliation errors, anesthesia AND safety AND decrease morbidity, medication reconciliation, PDSA, and documentation errors on the anesthesia record. The search term entered into CINAHL was "develop a medication reconciliation process." The search strategy identified 806 citations. After title and abstract review, 13 articles were considered relevant. By hand searching the reference lists of relevant articles and by use of the Google search engine, 14 additional articles were found to be relevant. A total of 27 articles were pertinent to the study (Figure 1).

Figure 1. Results of the Literature Search: Evidence Base for the Intervention.



The level and the quality of the accepted articles were judged by using the Johns Hopkins Evidence Level and Quality Rating Scale.[12] Rating scales present a structured way to differentiate evidence of varying strengths and quality. Strong evidence of high quality more likely represents best practice than evidence of lower strength and less quality. Level I of the 5 levels used in the rating schemes indicates evidence obtained from an experimental study, randomized controlled trial (RCT), or systematic review of RCTs, with or without meta-analysis. Level II indicates evidence obtained from a quasi-experimental study or systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis. Level III indicates evidence from a quantitative nonexperimental study; systematic review of a combination of RCTs, quasi-experimental, and nonexperimental studies, or nonexperimental studies only with or without meta-analysis; or qualitative study or systematic review of qualitative studies, with or without a meta-synthesis. Level IV indicates expert opinion of respected authorities and/or nationally recognized expert committees or consensus panels based on scientific evidence. Level V, being the lowest level, indicates experiential and nonresearch evidence. Quality is based on a scale from A to C with A being the highest and C being the lowest. Evidence with a quality rating of A is consistent; has generalizable results, a sufficient sample size for the study design, and adequate control; has definitive conclusions; and has consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence. Evidence with a quality rating of B has reasonably consistent results, a sufficient sample size for study design, some control, fairly definitive conclusions, and reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence. Evidence with a quality rating of C has inconsistent results, insufficient sample size for the study design, and a lack of conclusions.[12] Of the relevant articles identified, 1 ranked at level I, 2 at level II, 9 at level III, 11 at level IV, and 4 at level V. All varied from A to C in quality (Figure 2).

Figure 2. Johns Hopkins Evidence Level and Quality Rating Scale.



The consistent findings from these articles, guidelines, and best practices suggested that individual and system factors contribute to medication errors. In health care, accountability for medication errors is commonly attributed to the individual, and the "five rights" in medication administration is commonly used as the benchmark for individual performance. The "person" approach seeks to attribute causes to the individual, whereas the "systems" approach attributes that human error is to be expected. It is suggested that when system barriers are not effective, errors will occur.[13] Information technology is recommended to overcome such system barriers. Information technology can improve anesthesia patient safety by minimizing medication errors and adverse events.[14] Implementing a multimodal system that includes real-time charting was proven to be effective in reducing medication errors in a prospective randomized open label clinical trial.[4] It is also recommended that technology be implemented at every anesthesia location.[2,7]

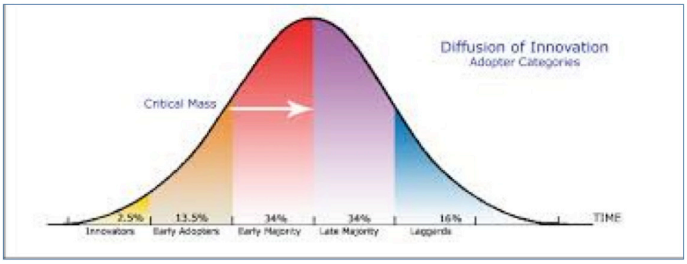
There were a number of limitations to the review of the literature. These limitations were that the definition of a medication error is debatable,[6] the studies performed were at single health care facilities,[15] staff were resistant to change,[11] errors were reported on a voluntary basis,[7] and studies were not blinded.[4]

THEORETICAL MODELS

Two theoretical models were used to develop this quality improvement project: the Diffusion of Innovation theory of Rogers[16] and the translation framework Plan-Do-Study-Act (PDSA) Cycle. Rogers' Diffusion of Innovation was selected because it outlines a process for change, which starts with an initial few and grows until critical mass is achieved. The PDSA Cycle is the accepted format used when implanting a new process improvement in the work setting.

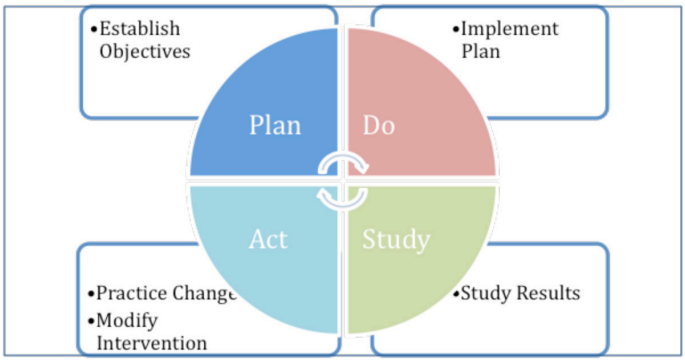
The Diffusion of Innovation Theory is often regarded as a valuable change model for guiding technological innovation when the innovation itself is modified and presented in ways that meet across all levels of adopters. It also stresses the importance of communication and peer networking within the adoption process.[17] Diffusion of innovation refers to the process that occurs as people adopt new ideas. Bridging the evidence gap will not be achieved simply by informing clinicians about the evidence.[18] Rogers outlined this process of change and stressed that, in most cases, an initial few are open to the new idea and adopt its use. As these early innovators "spread the word," more people become open to the idea and a critical mass is reached. Over time, the innovative idea diffuses among the staff until a saturation point is achieved. Rogers distinguished 5 categories of adopters of an innovation: innovators, early adopters, early majority, late majority, and laggards. Rogers estimated the percentages for each category, which take the shape of a normal bell curve (Figure 3).

Figure 3. Diffusion of Innovation Adopter Categories. Source: Kaminski, 2011.17



The PDSA cycle is used to develop and test rapid change for quality improvement. The main objective in PDSA quality improvement is to assess whether an intervention that changes a process produces an improvement outcome. The PDSA cycle uses the scientific method to answer, "How will we know that a change is an improvement?" The PDSA model advocates the formation of a hypothesis for improvement (Plan), a study protocol with collection of data (Do), analysis and interpretation of the results (Study), and the iteration for what to do next (Act) (Figure 4). For the present study, the "Plan" was to reduce the number of documentation errors of schedule II and IV controlled narcotic substances on the electronic anesthesia record. The "Do" was to increase access to computers in the post-anesthesia area. The "Study" was to statistically analyze the results, and the "Act" was to determine whether the cycle needed to be performed again with a modified intervention or whether a process change could proceed in practice.

Figure 4. Plan-Do-Study-Act Cycle.



METHODS

Study Design

The study design was a quantitative retrospective chart review to examine the occurrence of schedule II and IV controlled substance documentation errors before and after increasing computer access in the post-anesthesia care unit.

POPULATION AND SETTING

The study received Institutional Review Board approval from the university and the university medical center. A retrospective chart review included all surgical patients undergoing anesthesia in the main operating suite from March 3, 2014, to April 2, 2014. Charts for patients who had endoscopy procedures, off-site procedures, and procedures such as cardiac catheterizations in the special procedure unit were excluded.

SAMPLE SIZE ESTIMATION

For this study we used the alpha significance level of 0.05, and the standard power of 80 percent, as well as a compliance rate of 0.03 for the pre-intervention month and a zero for the post-intervention month as one for 100% compliance. A final sample size of 320 was calculated for the pre-intervention month and the same sample size for the post-intervention month.

INTERVENTION

The intervention was designed to increase access to computers in the post-anesthesia care unit at the bedside during the transfer of care process. There were dedicated computers for the anesthesia providers. If a computer was unavailable because another anesthesia provider was using the machine, the post-anesthesia care unit registered nurse provided access to the bedside computer. The anesthesia providers completed documentation and used their computer screen to provide a transfer of care to the post-anesthesia care unit registered nurse.

The study was introduced at an operating suite meeting, which included the post-anesthesia care unit staff, anesthesia staff, and the operating suite staff as well as the operating suite leadership. After a slide presentation of the capstone project, a question and answer period was available to address concerns and questions.

Reliability of documentation and adherence to the intervention protocol was maximized by the support of anesthesia leadership, who observed the compliance of anesthesia providers using the dedicated computers. Anesthesia providers who chose not to participate were encouraged to do so, but participation for the purposes of this study period was not mandated. Although exact compliance rates were not obtained, a general consensus was that nearly all of the anesthesia providers participated on various shifts. Overall, the post-anesthesia care nurses observed a consistent use of the computers.

TIME PERIOD

The period for the study was from January 2013 through April 2014. During the intervention period, 2 emails were sent to the anesthesia staff to motivate and reinforce engagement.

MEASUREMENTS

The study compared narcotic medication documentation errors before and after the initiation of increased computer access in the post-anesthesia care unit. Data were collected by using a custom-designed Microsoft Excel (Microsoft Corp, Redmond, WA) spreadsheet (Appendix I). Demographic variables were collected. The outcome variables were schedule II and IV controlled substance documentation errors. The data sources were the electronic anesthesia record, the pharmacy narcotic form, and the intraoperative note on the electronic anesthesia record.

The data abstractors who reviewed and coded each chart had an important role with respect to data quality.[19] Two data abstractors were trained to collect the data with one abstractor having no anesthesia background to reduce bias. Inter-rater reliability was achieved by using Cohen's kappa. With the range of -1, which demonstrates perfect disagreement, to +1, which demonstrates perfect agreement, the study rated a score of +1 for reviewing 1612 charts.[19]

DATA COLLECTION

All data were collected on paper and computers. All data were de-identified and protected in a locked office and on computers that were password protected. All participants and individuals associated with the quality improvement study adhered to the university medical center's policies on confidential information, proper handling of protected health information outside of the medical center, and electronic mail and messaging.

RESULTS

Pre- and post-intervention compliance rates and medication errors of schedule II and IV controlled substances were collected from January 2013 to April 2014. A total of 4107 anesthetic cases were included in the study. Additional demographic variables collected included assigned study identification number, surgical date, patient FIN number, gender, age, American Society of Anesthesiologists (ASA) physical status, types of error, surgical procedure, operating room number, medication variance, anesthesia providers, surgeon, circulating registered nurse, scrub technician, type of narcotic storage, and whether the event was in the AM or PM for future studies.

Medication errors decreased from a combined January-February 2013 error rate of 23.6 per 1000 to an error rate of 14.9 per 1000 in March 2014. The January error rate was 30.0 and the February error rate was 16.7 per 1000, respectively. The compliance rate in March increased to 98.5% from the combined rate of 97.6% for January-February. The January compliance rate was 97.0% and that for February was 98.3%. The error percentage rate decreased in March to 1.48% from 2.36% for January-February combined. The January error percentage rate was 3.0% and that for February was 1.67%. Comparing the medication error rate to the national average, real-time bedside computer access reduced the error rate from 3.15 times the national average in January-February combined to 1.98 times the national average for the intervention month (March). The error rate for January represented 3.99 times the national average, whereas that for February was 2.23 times the national average (Table 1).

Table 1. Medication Error Rate

	Errors	Cases	Error %	Compliance %	Compared to National	Errors/1000
National	1	133	0.752%	99.248%	1.00	7.5
Jan 2013	39	1300	3.000%	97.000%	3.99	30.0
Feb 2013	20	1195	1.674%	98.326%	2.23	16.7
2013 Combined	*59*	*2495*	*2.365%*	*97.635%*	*3.15*	*23.6*
March 2014	24	1612	1.489%	98.511%	1.98	14.9

March showed a significant reduction in error percentage compared with January 2013 (z= 2.69, p = 0.007). Thus, we can conclude that the proportion of errors in March is significantly lower than errors in January, at the 0.01 level of significance. March also showed a reduction in error percentage compared with February; however, the difference in the two proportions was not statistically significant (z = 0.38, p = 0.699). Comparing March with January and February combined showed a significant reduction in error percentage (z = 2.04, p = 0.04; Table 2).Table 2. Significance of Medication Error Rates

Test of two Independent Proportions	
March 2014 Error %	1.5%
Jan 2013 Error %	3.0%
n (March 2014)	1612
n (Jan 2013)	1300
standard error	0.006
z score	2.693
p-value (one side)	0.003538
p-value (two tails)	0.007076
Confidence	99.3%

month	
March 2014 Error %	1.5%
Feb 2013 Error %	1.7%
n (March 2014)	1612
n (Feb 2013)	1195
standard error	0.005
z score	0.386
p-value (one side)	0.349583
p-value (two tails)	0.699166

month	
March 2014 Error %	1.5%
Jan/Feb 2013 Error %	2.4%
n (March 2014)	1612
n (Jan/Feb 2013)	2495
standard error	0.004
z score	2.045
p-value (one side)	0.020447
p-value (two tails)	0.040894

DISCUSSION

Compared with a lack of computer access at the bedside in the post-anesthesia care unit, access to computers appeared to be associated with a reduction of medication errors from 2.3% to 1.5%. The compliance rate increased from 97.6% to 98.5%. It is unknown why January 2013 had an error rate of 3% and February 1.67% with compliance rates of 97% and 98.3%, respectively, while the same documentation process occurred. Owing to the disparity in errors between January and February 2013 with no known cause, the 2 months were combined for the purposes of this study, assuming that January could have been a month with less vigilance in documentation than February. Although it was shown that the intervention was associated with statistically significant (p=0.04) improvement in the error rate, the results were still below the national average of 0.752 error percentage and 99.2% compliance. The question arises of whether making participation in the study mandatory would have decreased the error rate and increased compliance more to meet or exceed the national averages.

Our findings were also consistent with a previous study by Merry et al,[4] which described a reduction in medication errors by using a multimodal approach, whereas the present study implemented a single intervention. Merry et al did not identify which intervention had the largest impact.

Previous studies that addressed medication errors in anesthesia were limited to voluntary surveys. Even though our study was voluntary, the medication errors were extracted from the electronic anesthesia record and pharmacy narcotic sheet, which maximized objectivity and the accuracy of the results.

LIMITATIONS

The study was implemented at a single university setting. One of the data abstractors was an anesthesia provider who could have been a source of bias. Anesthesia leadership designed and conducted the study, which may have been a source of bias. The anesthesia providers may have felt pressured to participate. Comparisons of study results with previous studies are limited owing to a lack of a clear definition of medication errors. Last, participation in the study was voluntary, which may have influenced the number of medication errors.

FUTURE RESEARCH

Our results suggest a need for improvement in the accuracy of medication recording in anesthesia. Our findings provide objective evidence for the support of continuous process improvement. There is a lack of computer access in patient care areas, a lack of real-time decision support, a lack of anesthesia providers who adhere to documentation policy, an inefficient electronic record conversion process that does not include all patient care areas, a lack of a clear documentation process that includes a process to detect documentation errors, and a lack of counseling after identification of a documentation error. Use of a multimodal approach in future interventions is warranted.

IMPLICATIONS

Errors in medication administration are an ongoing source of concern in anesthesia and in health care in general.[4] This study demonstrates that having computer access at the bedside reduces medication errors. No patients sustained increased morbidity or died as the result of medication errors during the time frame. The implications for practice are focused on patients, anesthesia staff, and systems. The first and foremost is improved patient safety and outcomes. Reducing medication errors maximizes safe care of the patient. Anesthesia providers must be provided with the tools needed to provide safe care and to document in real time. Policies and laws are in place to protect the patient and anesthesia staff from making errors. Increasing compliance in medication errors will meet university medical center medication policies and the laws of the US Drug Enforcement Agency.

CONCLUSION

Medication errors in the practice of anesthesia have long afflicted the specialty. Medication errors may result in patient morbidity or mortality and should be preventable. Given the adverse effects of medication errors, there is a substantial need for evaluation of interventions to reduce errors through process improvement. Cause analysis revealed a number of factors that contribute to documentation errors. Addressing one factor, the lack of computer access in patient care areas, by increasing computer access in the post-anesthesia care units did reduce the number of medication errors.

ACKNOWLEDGEMENTS

Many thanks to the faculty of Robert Morris University, specifically, Judith Kaufmann, DrPH, FNP-BC. Their guidance and support throughout this study was instrumental. In addition, thank you to Dr. Daniel Sullivan, Dr. Mark Hudson, Dr. Jacques Chelly, and Ms. Janet Lindner for their mentorship and assistance throughout. Also, thank you to the anesthesia leadership and staff at the University of Pittsburgh Medical Center, Passavant for their support. And of course, many thanks to my wife, Katherine, daughter, Melissa, and son, Tyler, for their unwavering moral and emotional support of my academic pursuits; without them this journey would not have been possible.

REFERENCES

1. Aronson JK. Medication errors: definitions and classification. *Br J Clin Pharmacol*. 2009;67(6):599-604. doi:10.1111/j.1365-2125.2009.03415.x.
2. Eichhorn JH. APSF hosts medication safety conference: consensus group defines challenges and opportunities for improved practice. *APSF Newsletter*. 2010;25(1,1-20):1-8. http://www.apsf.org/newsletters/html/2010/spring/01_conference.htm. Accessed October 16, 2015.
3. Hanna GM, Levine WC. Medication safety in the perioperative setting. *Anesthesiol Clin*. 2011;29(1):135-144. doi:10.1016/j.anclin.2010.11.009.
4. Merry AF, Webster CS, Hannam J, et al. Multimodal system designed to reduce errors in recording and administration of drugs in anaesthesia: prospective randomised clinical evaluation. *BMJ*. 2011;343:d5543. doi:10.1136/bmj.d5543.
5. Kohn LT, Corrigan JM, Donaldson MS, eds. *To Err is Human: Building a Safer Health System*. Washington, DC: National Academy Press; 2000.
6. Pronovost P, Weast B, Schwarz M, et al. Medication reconciliation: a practical tool to reduce the risk of medication errors. *J Crit Care*. 2003;18(4):201-205. http://dx.doi.org/10.1016/j.jcrc.2003.10.001.
7. Cooper L, Nossaman B. Medication errors in anesthesia: a review. *Int Anesthesiol Clin*. 2013;51(1):1-12. doi:10.1097/AIA.0b013e31827d6486.
8. Knight PR 3rd, Bacon DR. An unexplained death: Hannah Greener and chloroform. *Anesthesiology*. 2002;96(5):1250-1253. http://dx.doi.org/10.1097/00000542-200205000-00030.
9. Bowdle TA. Drug administration errors from the asa closed claims project. *ASA Newsl*. 2003;67(6):11-13.
10. Flynn EA, Barker KN, Pepper GA, Bates DW, Mikeal RL. Comparison of methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. *Am J Health Syst Pharm*. 2002;59(5):436-446.
11. Young B. Medication reconciliation matters. *Medsurg Nurs*. 2008;17(5):332-336.
12. Dearholt S, Dang D. *Johns Hopkins Nursing Evidence-Based Practice: Models and Guidelines. Indianapolis*, IN: Sigma Theta Tau International; 2012.
13. Brady AM, Malone AM, Fleming S. A literature review of the individual and systems factors that contribute to medication errors in nursing practice. *J Nurs Manag*. 2009;17(6):679-697. doi:10.1111/j.1365-2834.2009.00995.x.
14. Bloomfield EL, Feinglass NG. The anesthesia information management system for electronic documentation: what are we waiting for? *J Anesth*. 2008;22(4):404-411. doi:10.1007/s00540-008-0643-1.
15. Vogelsmeier A, Pepper GA, Oderda L, Weir C. Medication reconciliation: a qualitative analysis of clinicians' perceptions. *Res Soc Adm Pharm*. 2012;9(4):419-430. doi:10.1016/j.sapharm.2012.08.002.
16. Rogers EM. *Diffusion of Innovations*. 5th ed. New York: Free Press; 2003.
17. Kaminski J. Diffusion of innovation theory. *Canadian Journal of Nursing Informatics*. 2011. http://cjni.net/journal/?p=1444. Accessed April 19, 2014.
18. Sanson-Fisher RW. Diffusion of innovation theory for clinical change. *Med J Aust.* 2004;180(6). https://www.mja.com.au/journal/2004/180/6/diffusion-innovation-theory-clinical-change. Accessed April 19, 2014.
19. Vassar M, Holzmann M. The retrospective chart review: important methodological considerations. *J Educ Eval Health Prof*. 2013;10:12. doi:10.3352/jeehp.2013.10.12.

Appendix I: Measurement Instrument