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An Overview of Intravenous-related Medication Administration Errors as Reported to MEDMARX(R), a National Medication Error-reporting Program  
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Abstract

Medication errors can be harmful, especially if they involve the intravenous (IV) route of administration. A mixed-methodology study using a 5-year review of

73,769 IV-related medication errors from a national medication error reporting

program indicates that between 3% and 5% of these errors were harmful. The leading type of error was omission, and the leading cause of error involved clinician performance deficit. Using content analysis, three themes-product shortage, calculation errors, and tubing interconnectivity-emerge and appear to

predispose patients to harm. Nurses often participate in IV therapy, and these

findings have implications for practice and patient safety. Voluntary medication

error-reporting programs afford an opportunity to improve patient care and to further understanding about the nature of IV-related medication errors.

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The United States has the world's most advanced healthcare delivery system, which includes access to state-of-the-art technology, a highly skilled workforce, and the wide use of intravenous (IV) pharmacologic agents. These desirable attributes have played a part in the transformation of healthcare over the past several decades. Although the United States has the capacity to produce the finest healthcare services in the world, failures in the delivery system have been widely reported, and these failures occur with some regularity. 1 One such failure is medication errors. 2

Medication errors threaten patient safety, and the evidence is abundant that they have been associated with increases in morbidity, mortality, and healthcare costs. 2 Perhaps the most serious of all medication errors are those that involve the IV route of administration, 3 partly because medications administered intravenously have immediate bioavailability, a pharmacologic principle that contributes to the danger. 4 Many "high-alert" medications, which have a narrow therapeutic range, also are given via infusion, thus contributing to the seriousness of an error. Additionally, IV therapy involves complex healthcare technologies, 5 and clinical practice requires the use of many different IV medications

The healthcare professional's knowledge in all areas of medication errors has increased substantially, partly in response to widely publicized national reports, various activities of leading organizations, and medication error reporting programs. Yet the true nature of IV-related medication errors is relatively unknown, and represents an area that demands more investigation. The prevention of IV-related medication administration errors should be a primary focus in preventing patient harm. 6

#### BACKGROUND AND SIGNIFICANCE

Medication errors are not a new occurrence in healthcare. Literature dating back to the late 1950s and early 1960s contains astute observations by pharmacists, nurses, and physicians that medication errors were occurring and sometimes resulting in unfavorable outcomes. 7 Even after four decades of mounting evidence of medication errors harming patients, the public remained unaware of the dangers from medication errors that lurked within the healthcare system.

In 1999, the Institute of Medicine (IOM), the nonprofit scientific advisory body of the National Academy of Sciences, asserted that as many as 98,000 hospitalized patients die annually because of medical errors, making premature death attributable to medical mistakes the 8th leading cause of death in the United States, ahead of traffic accidents, breast cancer, and HIV/AIDS combined. 2 A more recent report has suggested that the original IOM study underestimated the number of iatrogenic injuries by approximately 50%. 8

Regardless which figures are used, the number of patient deaths attributable to medical errors in the world's most advanced, complex, and expensive healthcare system is too high. Although the problem of medical errors was not new, these reports focused national attention on the human toll of errors and sparked significant interest by consumers, policymakers, payers, providers, administrators, and others in the healthcare industry, making patient safety a contemporary issue

Medication errors represent the largest subset of medical errors. 2 The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP), an independent body of 24 national organizations that addresses the interdisciplinary nature of medication errors, defines a medication error as

any event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Such events may be related to professional practice, healthcare products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use. 9

Medication errors strike at the heart of the healthcare system—the responsibility to do good and avoid harm. 10 They occur in all healthcare settings, affecting patients, family members, health professionals, and the entire healthcare system. Although most medication errors do not result in harm, some medication errors do cause harm and even death

The IOM report ascertained that the healthcare system harbored a culture of blame for individuals involved in medical (including medication) errors, and called for performance standards and for health professionals to shift focus to a culture of safety. 2 As one means of changing the current culture, the IOM

recommends that healthcare facilities and practitioners participate in voluntary, external reporting programs that collect adverse event data. 2 Participation in medication error-reporting programs is one mechanism that expands knowledge about medication errors and the underlying factors that contribute to these events. To facilitate medication error reporting, the United States Pharmacopeia (USP) established two nationally recognized medication error-reporting programs: the USP Medication Errors Reporting (MER) program, presented in cooperation with the Institute for Safe Medication Practices, and MEDMARX. 11 Both the MER and MEDMARX programs use NCC MERP's definition of a medication error as the cornerstone for reporting errors. The MER program, which began in 1991, is offered as a free service for the voluntary reporting of medication errors by practitioners from any clinical setting. Begun in 1998, MEDMARX is a subscription service for use primarily by hospitals and related health systems

Medication errors can occur at any point in the medication use process (Figure 1). This process identifies the progression of steps commonly undertaken to process a medication order. The process begins when the medication is prescribed, then transcribed; dispensed, then administered; and concludes at the point that the medication's effects on the patient are monitored. Nurses are most familiar with the administration phase of the medication use process and follow the policy of "5 rights": the right drug, the right patient, the right time, the right route, and the right dose

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Figure 1. The medication use process.

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#### PURPOSE

The purpose of this study was to examine IV-related medication errors by volume, type of error, cause of error, and patient outcome from a national medication error reporting program. This study also sought to examine why such errors were occurring in the clinical setting

#### METHODS

The USP Center for the Advancement of Patient Safety gave permission to conduct this mixed-methodology study using secondary data. Using the query-building functions of Crystal Reports, Version 9, (Business Objects, Inc., San Jose,

Calif) researchers were able to identify reported medication errors in the MEDMARX database that met preestablished criteria (Table 1). A machine count of the unique record numbers determined the convenient sample for analysis. Determination of the severity for each medication error occurred using the NCC MERP Index for Categorizing Medication Errors. Database functions of grouping and counting determined the number of medication errors reports that involved at least one type of error and at least one cause of error. Descriptive statistics were applied to these findings. Unobtrusive measures and cluster analysis (a grouping of similar themes into respective categories) of free text error descriptions were performed for the purposes of additional insight into why these errors occurred

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Table 1 Criteria for Extracting Intravenous-related Medication

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## RESULTS

According to MEDMARX data submitted by hospitals between January 1, 2000 and December 31, 2004, there were 73,769 unique IV-related medication errors reported (Figure 2). The percentage of errors resulting in harm ranged from 2.92% (2004) to 5.03% (2000). Although the percentage of harmful IV-related medication errors has steadily declined, it remains greater than the percentage of harmful errors reported overall during the same periods (Figure 3).

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Figure 2. Intravenous-related medication errors reported to MEDMARX, 2000-2004.

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Figure 3. Comparison of harmful intravenous-related errors to harmful errors, 2000-2004. 12-14

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The MEDMARX program has 13 selections available for type of error, and 9 were present in this 5-year sample (Table 2). The 3 most commonly reported types of IV-related medication errors were omission error (28.5%), improper dose/quantity (22.9%), and prescribing error (16.2%). Together, these account for 67% of the selections. A comparison is offered for all the medication errors reported in 2003. As a percentage of reported errors, 6 types of IV-related errors were reported more frequently than the overall rate reported for 2003

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Table 2 Type of Error Associated With Intravenous-related Medication Errors Compared to MEDMARX 2003 12

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Three causes of error accounted for 89% of the errors reported. "Performance deficit" (ie, the provider had the requisite skills and knowledge to correctly discharge his or her duty, but failed to do so in this instance) was selected most often (48%), followed by "procedure/protocol not followed" (28%) and "transcription inaccurate/omitted" (14%). Less common, but still noteworthy, were IV-related errors associated with communication, computer entry, knowledge deficit, and documentation

Healthcare professionals who report errors to MEDMARX provide written narration to supplement the medication error experience. The narrative component of the medication errors, as evaluated by cluster analysis, indicates that 3 factors apparently predispose patients to harmful IV-related medication errors: drug shortages, interconnectivity of tubings, and mistakes in calculations

#### Product Shortage

Reporters to MEDMARX indicate that the IV drugs albumin, hydromorphone, methotrexate, and methylprednisolone were involved in medication errors as a result of drug shortages.

As one error description indicates:

Methylprednisolone sodium succinate, 500 milligrams (mg), had been ordered but

was out of stock due to a national drug shortage. The facility had hydrocortisone sodium succinate, 500 mg, on hand, which was automatically substituted. A note dosage sticker was on the outer bag that accompanied the product to the floor. The patient received the entire dose. After the patient received the medication, the pharmacist notified the clinical unit that the two drugs were not bioequivalent

#### Tubing Interconnectivity

Another error involved the interconnectivity of IV tubing and was described in more than 300 records. Peripheral IV lines and epidural lines often were switched, as one report indicates:

A patient had an epidural line for pain management and a peripheral IV line containing insulin. The nurse caring for the patient was busy and asked a second nurse to retrieve the next scheduled epidural infusion bag. The second nurse delivered a new bag of insulin to the patient's bedside. Without checking the label, the primary nurse hung the insulin infusion to the epidural line. About 30 milliliters infused prior to the detection of the error.

Infusions intended for peripheral IV infusions and continuous bladder irrigations use similar tubing that can result in error when misconnected to the other device, as shown by the following examples:

The patient was to receive a continuous bladder infusion of neomycin and amphotericin. The patient also had a primary IV solution connected to an infusion pump. A dose of antibiotics mistakenly ran as a secondary IV piggyback through the bladder tubing instead of the IV tubing

A physician ordered a continuous bladder irrigation containing amphotericin. The nurse obtained the infusion and thought the solution was instilling through the patient's indwelling catheter. It was later discovered that the irrigation was connected to the patient's primary IV.

Practitioners use syringes to transfer vial contents. Unlabeled syringes can mistakenly result in erroneous IV infusions as the following case highlights:

The nurse drew up the solution from albuterol nebule (a medication for inhalation therapy) and other IV medications into separate syringes. The albuterol was injected into the IV container in error. The mistake was noticed immediately, and the nurse discontinued the infusion so that no medication

reached the patient. Generally, the nurse would label each IV medication with a medication sticker, but did not do so this time

Unlabeled tubing can lead to IV-related medication errors. A nurse anesthetist explained:

While interviewing a patient for surgery, it was noted that the patient had a catheter on the right side of his chest. It was assumed that this was a Hickman catheter. An infusion of 1,000 milliliters was started through the red port on the catheter. The surgeon entered the room and explained that the catheter was for dialysis and not for infusions

Another case indicates that IV tubing can easily be connected to other types of tubing. The IV tubing was inadvertently connected to the air port of a nasogastric tube. The entire dose of the medication was administered through the tube

#### Mistakes in Calculations

Several cases highlight how calculations can be associated with IV-related errors. For example, a nurse reported the following:

A patient was scheduled to receive hydrocortisone 125 milligrams IV push every six hours. The pharmacy supplied two vials of hydrocortisone, each containing 100 milligrams to cover the first dose. The pharmacist also attached a "note dose" sticker on the plastic bag indicating the correct dosing. The patient received only one vial (100 milligrams). When it was time for the second dose to be given, the original error was discovered

Pediatric patients frequently were involved in IV-related medication errors because of miscalculations, often resulting in 10-fold variances. One such case occurred as follows:

A nurse was caring for a 9-month-old child in the recovery room following surgery. For pain control, the surgeon had ordered 0.08 milligrams of hydromorphone. Two nurses independently performed the dose calculations and concluded that the dose was equivalent to 0.8 milligrams of hydromorphone. The error was detected when the infant developed respiratory suppression. The error was reversed and the child had no permanent harm.

Products supplied in different drug concentrations represented another

error-prone area. This is illustrated in the following case:

An infusion of 100 units of insulin in 100 milliliters of normal saline was set to infuse at 7 milliliters per hour (7 units/hour). The replacement infusion was mixed with 50 units of insulin in 250 milliliters of normal saline. The pump was not adjusted to reflect the new concentration and delivered only 1.4 units per hour.

Multiple cases described problems that resulted from the confusion of weight and volume (ie, mg vs mL). These errors were disproportionately associated with the pediatric population. One reporter wrote:

Morphine sulfate, 1 milligram (mg), had been ordered and the hospital purchased pre-packaged morphine sulfate as 10 mg/mL. The dose ordered was 1 milligram, and 0.1 milliliter should have been given; however, the volume was confused and the patient was given 1 milliliter, resulting in a 10-fold overdose.

Other examples of interconnectivity errors were discovered; Figure 4 presents these findings

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Figure 4. Other examples of interconnectivity errors, based on MEDMARX records. PEG, percutaneous endoscopic gastrostomy.

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#### DISCUSSION

The mixed methodologies in this study afforded an opportunity to gather more information about the volume of IV-related medication errors and the context in which the errors occurred. The unstructured free text in the error description field provided additional context to elucidate why the error occurred

#### Volume and Severity of IV-related Medication Errors

The findings confirm that some IV-related medication errors result in harmful outcomes. The percentage of IV-related errors resulting in patient harm, as measured by the NCC MERP Index for Categorizing Medication Errors (Error

Category Indices E through I), was higher for each year (Figure 3), as compared with overall medication errors reported to MEDMARX during the same periods. 12

No conclusion can be drawn that the percentage of harmful errors actually is declining. Rather, the volume increase in reported nonharmful medication errors was, in part, the result of more facilities participating in MEDMARX, as well as the willingness of practitioners openly to report medication errors to an anonymous system

#### Types of IV-related Medication Errors

The Type of Error field within the MEDMARX program captures the manifestation of an action, regardless of the cause or causes, and characterizes the basic description of a medication error. 12 This study found 9 different error types (out of a possible 14) associated with IV-related medication errors. It also found omission errors in 28.5% of the records, a finding that is somewhat higher than the 24% reported in the recent 2003 MEDMARX summary. 12 This type of error implies that patients did not receive the ordered IV product.

The percentage of IV-related medication errors involving improper dose/quantity (22.9%) is essentially equal to the 23% seen in overall medication error reporting. These errors reflect that the amount of IV medication involved in the error differs from what was ordered. This is troubling because even minor variations in the dosages can result in serious adverse effects. 3 In 2002, the USP reviewed 1,846 medication errors involving infusion devices, and 8.7% of them resulted in harm. 13 In the majority of cases, the infusion device (IV infusion pump, infusion pump for epidural solutions, infusion syringe, or patient-controlled analgesia pump) was responsible for delivering the wrong amount of the medication because of incorrect programming. Programming errors of IV-related devices increase the likelihood of error and the potential for harm

As a percentage, IV-related medication errors were less frequently (16.2% vs 22%) identified as prescribing errors, as compared with the 2003 summary. This finding indicates that many IV-related errors originate beyond the prescribing phase of the medication use process, namely during the administration phase

Five other types of IV-related medication errors (wrong time, incorrect preparation of a drug, wrong patient, wrong administration technique, and wrong route) had percentages of occurrence higher than the 2003 MEDMARX summary 12 and have significant implications for nursing professionals. Many institutions have

policies and procedures that outline medication administration times, and a wrong-time error is one that falls outside the established policy. Recent emphasis by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) targeting proper patient identification may reduce future wrong-patient errors. The greatest threat to patient safety involves IV-related medication errors associated with either the wrong administration technique or the wrong route. These 2 types of errors often result in more severe outcomes than other types of errors 12,13 and signal an important area for quality improvement activities

#### Causes of IV-related Medication Errors

Reporters using MEDMARX are offered 60 possible selections that can be assigned to an error. The field is multiselect, indicating that the reporters can select more than 1 cause related to the error. The 3 leading selections (performance deficit, procedure/protocol not followed, and transcription inaccurate/omitted) had higher percentages of occurrences for IV-related medication errors than in the overall MEDMARX data set for 2003. 12 The findings presented in this report indicate an opportunity for organizations to examine the policies and procedures for alignment with national standards. Numerous resources are available to assist practitioners with this effort. One source is the Infusion Nurses Society (INS) ([www.ins1.org](http://www.ins1.org)). INS publishes The Infusion Nursing Standards of Practice and Policies and Procedures for Infusion Nursing, which use evidence-based approaches to ensure patient safety.

Additionally, information technology has been implicated as one means to reduce errors. This study found errors associated with computer entry, in which the order was entered incorrectly. Developers of such systems must take care to ensure that internal logic and decision support are adequate for avoidance of such errors

#### Product Shortages

Since 1997, periodic national drug shortages have resulted in serious public health concerns. The United States Food and Drug Administration ([www.fda.gov](http://www.fda.gov)) and the American Society for Health-System Pharmacists ([www.ashp.org](http://www.ashp.org)) maintain the most comprehensive lists of known drug shortages. Intravenous products are particularly susceptible to shortages for two reasons. First, market concentration

has reduced the number of suppliers. Second, few companies have the capability to produce sterile products. 15

Pharmacists play an important role in maintaining adequate product inventory for patient care. Product shortages are most often beyond the control of the pharmacy department, and pharmacists must turn to alternative suppliers to meet operational needs. Nurses have an important role in IV medication safety as they resolve questions about product names and doses that differ from the original order with pharmacists and understand these differences

#### Tubing Interconnectivity

The International Organization for Standardization (ISO) requires manufacturers to produce connections that are standard in size. For example, two different manufacturers may produce a medical device that uses tubing. One manufacturer's device may be related to feeding tubes, whereas the other manufacturer's device may be designed for bladder catheters. As a result of standardization, connections from one device can easily and rapidly connect to various ports of other devices regardless of the manufacturer's intent or the intended use of the device.

The Institute for Safe Medication Practices ([www.ismp.org](http://www.ismp.org)) has issued several safety alerts addressing interconnectivity and its propensity to create error-prone situations. All healthcare professionals should be aware of the possibility of misconnecting tubings from one device to another, and they must trace the origin of the tubing to the point of insertion or connection to ascertain the proper location of each tube

#### Calculation Errors

Many IV medications require weight-based dosing or dilutions, especially for the pediatric population. Manufacturers often supply medications in commonly used strengths or dosages. When the desired dose differs from what is commercially available, additional manipulations and calculations are required. Some doses may require only partial vial contents for the correct dose, whereas others may require more than one vial. Errors in calculating drug doses for hospitalized infants and pediatric clients, who receive most of their doses by the IV route of administration, can increase morbidity and mortality. 16

Many healthcare practitioners must demonstrate math competency during their formal education processes. This implies that basic competency is not the problem. Rather, IV medication errors often are the result of calculation mistakes. The influence of other factors such as distractions, interruptions, and busy workloads are worthy of further investigation. Whereas it is unlikely that a clinician would give 100 tablets to a single patient as a dose, the same clinician could inadvertently give a 100-fold overdose of an IV medication by not recognizing the miscalculated dose. 17

In a review article, levels of staff experience, calculation skills, and the influence on error rates were equivocal. 18 Although many articles show decreases in calculation errors as experience increases, the converse also is true. Rowe et al 16 elucidated test results from 64 residents using a paper and pencil instrument that was reflective of actual clinical care and found 7 residents (11%) making 10-fold errors. According to the interpretations of the researchers, these errors would expose 10% of the infants in daily care to at least 1 medication error attributable to miscalculations.

Recent advances in technology offer some protection against calculation errors associated with the IV route of drug administration. 3 A major teaching hospital recently introduced technology known as "smart pumps" that offer both error-prevention and data-collection technology. A smart pump has an internal drug library that requires users to program dose parameters into the unit before drug administration. In 1 year, IV drug administration accounted for 25% of all medications administered, representing 1.25 million opportunities for error. The researchers examined 100 smart pump devices used during a 6-month period. The pumps recorded 506 programming (calculation) errors, forcing the nurse to correct the error before initiation of the infusion. An important finding was that in 12% of the cases reviewed, the pumps canceled the drug administration because of the alert. 3 Significant cost avoidance and patient harm from the potential medication errors were recognized

Errors with weight-based dosing are prevalent because the process often requires a practitioner to perform a series of calculations, with each calculation step representing an opportunity for error. Erroneous calculations involving decimal

points can result in a 10-fold (or greater) variation. This study affirms that miscalculations often are responsible for IV-related medication errors. Developing and implementing preprinted conversion charts offer an inexpensive way to reduce calculation errors and advance patient safety. Generating such conversion charts with popular software, such as Excel, ensures correct calculations and removes the burden from the practitioner

#### STUDY LIMITATIONS

Secondary data analysis of infusion-related medication errors has inherent limitations. It is fairly well known that underreporting of spontaneous medication errors occurs. Therefore, it is impossible to establish a rate of harmful IV-related medication errors. There was variance in the length of the error descriptions, and the researchers were unable to contact the initial reporters for more details. Adjustment for spelling errors and abbreviations, although unlikely, may have affected the content. Despite the limitations associated with using existing data sets and self-reported data, the MEDMARX data set provides the most cost-effective and time-efficient resource for examining the impact of infusion-related medication errors on patient safety

#### SUMMARY

In summary, medication errors involving the IV administration of products are prevalent and often harmful, but they can be prevented. The circumstances by which some of these errors occur, including product shortage, interconnectivity of IV and device tubing, and calculations, indicate areas in which quality improvement activities may advance patient safety. Reporting medication errors to a national program, such as MER or MEDMARX, is paramount in the quest for heightened quality of care and increased patient safety. Reporting medication errors presents an opportunity for clinicians to learn from the unfortunate events of others in the hopes of preventing future errors

#### REFERENCES

1. Becher EC, Chassin MR. Improving quality, minimizing error: making it happen. *Health Aff.* 2001;20(3):68-81 Bibliographic Links Library Holdings
2. Kohn LT, Corrigan JM, Donaldson MS. *To Err Is Human: Building a Safer Health System.* Washington, DC: National Academy Press; 2000.
3. Fields M, Peterman J. Intravenous medication safety systems averts high-risk medication errors and provides actionable data. *Nurs Adm Q.* 2005;29(1):78-87 Ovid Full Text Bibliographic Links Library Holdings
4. Page C, Curtis M, Sutter M, Walker M, Hoffman B. *Integrated Pharmacology.* 2nd

ed. Edinburgh: Mosby; 2002.

5. Taxis K, Barber N. Ethnographic study of incidence and severity of intravenous drug errors. *BMJ*. 2003;326:684-688
6. Williams CK, Maddox RR. Implementation of an IV medication safety system. *Am J Health-Syst Pharm*. 2005;62:530-536 Ovid Full Text Bibliographic Links Library Holdings
7. 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 Ovid Full Text Bibliographic Links Library Holdings
8. Health Grades Quality Study. Patient Safety in American Hospitals. Available at: [http://www.healthgrades.com/media/english/pdf/HG\\_Patient\\_Safety\\_Study\\_Final.pdf](http://www.healthgrades.com/media/english/pdf/HG_Patient_Safety_Study_Final.pdf). Accessed March 1, 2005.
9. National Coordinating Council for Medication Error Reporting and Prevention. About Medication Errors. Available at: <http://www.nccmerp.org/> . Accessed February 25, 2005.
10. Mayo AM, Duncan D. Nurse perceptions of medication errors: what we need to know for patient safety. *J Nurs Care Qual*. 2004;19(3):209-217
11. Santell JP. Medication errors: experience of the United States Pharmacopeia (USP). *Jt Comm J Qual Patient Saf*. 2005;31(2):114-119 Bibliographic Links
12. Hicks RW, Santell JP, Cousins DD, Williams RL. MEDMARX 5th Anniversary Data Report: A Chartbook of 2003 Findings and Trends 1999-2003. Rockville, MD: The United States Pharmacopeia Center for the Advancement of Patient Safety; 2004.
13. Hicks RW, Cousins DD, Williams RL. Summary of Information Submitted to MEDMARX in the Year 2002: The Quest for Quality. Rockville, MD: The United States Pharmacopeia Center for the Advancement of Patient Safety; 2003.
14. Santell JP, Hicks RW, Cousins DD. MEDMARX Data Report: A Chartbook of 2000-2004 Findings From Intensive Care Units and Radiological Services. Rockville, MD: USP Center for the Advancement of Patient Safety; 2005.
15. Jensen V, Kimzey LM, Goldberger MJ. FDA's role in responding to drug shortages. *Am J Health-Syst Pharm*. 2002;59(15):1423-1425 Ovid Full Text

Bibliographic Links Library Holdings

16. Rowe C, Koren T, Koren G. Errors by paediatric residents in calculating drug doses. Arch Dis Child. 1998;79:56-58 Ovid Full Text Bibliographic Links Library Holdings

17. Thurman S, Sullivan M, Williams MA, Gaffney A. Intravenous medication safety systems help prevent harm and career-ending mistakes. Extensive nursing input helps design easy-to-use system that intercepts critical errors. J Nurs Adm. 2004;34(Suppl):2-4 Ovid Full Text Bibliographic Links Library Holdings

18. Allard J, Carthey J, Cope J, Pitt M, Woodward S. Medication errors: causes, prevention, and reduction. Br J Haematol. 2002;116(2):255-265. Ovid Full Text Bibliographic Links Library Holdings

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