

The Impact of Dedicated Medication Nurses on the Medication Administration Error Rate

A Randomized Controlled Trial

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Background: Concerns about hospital medication safety mount as the pace of new drug releases accelerates.

Methods: We performed a randomized study at 2 hospitals (A and B) to examine whether the medication administration error rate could be decreased by having “dedicated” nurses focus exclusively on administering drugs. “Medication nurses,” after receiving a brief review course on safe medication use, were responsible solely for drug delivery for up to 18 patients each. “General nurses,” who did not attend the course, provided comprehensive care, including drug delivery, for 6 patients each. A direct observation technique was used to record drug errors, process-variation errors, and total errors.

Results: At both hospitals combined, the total error rate was 15.7% for medication nurses and 14.9% for general nurses ($P < .84$). Comparing hospitals, the total error rate

for medication nurses at hospital B was significantly higher than it was at hospital A (19.7% vs 11.2%; $P < .04$). At hospital A, there was a significantly lower error rate for medication nurses than for general nurses in the surgical units ($P < .01$) but no significant differences in total errors comparing nurse types in the medical units ($P < .77$).

Conclusions: This trial suggests that use of dedicated medication nurses does not reduce medication error rates. However, subgroup analysis indicates that medication nurses might be useful in some settings. The differences in findings at the 2 hospitals and their differences in medication-use processes reinforce the concept that medication errors are usually related to systems design issues.

Arch Intern Med. 2003;163:2359-2367

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IN AN ERA in which pharmaceutical products are released at a rising rate and there is an increase in reports of drug-related toxic effects and in the complexity of hospitalized patients, the medication-use process has come under public, governmental, and health care industry scrutiny. In hospital settings, where nurses have primary responsibility for medication administration as part of a disparate and demanding set of patient care duties, the concern about medication safety is especially paramount. The study reported herein used a direct observation process to examine the medication administration process by registered nurses.

Medication administration is an activity that is prone to errors, in part because of the proliferation of new devices and new drug products.¹ Medications are administered through a variety of routes, dosages, dosage forms, and dosing regimens, adding intricacy and variability. Moreover, medication orders are changed frequently, as pharmacists and medical specialists provide input into patient care based on changes in patient

clinical status and the results of diagnostic tests.

The literature has corroborated the fact that errors are common in the process of prescribing, transcribing, dispensing, and administering medications. In one study,² prescribing errors represented 56% of preventable adverse drug events in a 700-bed hospital. Errors in medication administration were the second most frequent type, accounting for 34% of preventable events.² Leape and colleagues³ found that whereas 48% of prescribing errors, 33% of transcription and verification errors, and 34% of dispensing errors were intercepted before they reached patients, only 2% of drug administration errors were detected before they occurred.

In the Harvard Medical Practice Study, adverse events occurred in nearly 4% of hospitalizations, with 19% of these being attributable to medication-related injuries.⁴ In a similar Australian study,⁵ adverse drug effects also accounted for 19% of adverse events. Despite the impressive statistics about adverse drug events,^{2,6,7} it is believed that the percentages reported

Table 1. Characteristics of Registered Nurses Studied at Each Hospital*

Characteristic	Medication Nurses			General Nurses		
	Hospital A (n = 5)	Hospital B (n = 5)	Total (N = 10)	Hospital A (n = 5)	Hospital B (n = 13)	Total (N = 18)
Age, mean, y	37	32	35	41	30	33
Women, No. (%)	3 (60)	5 (100)	8 (80)	4 (80)	13 (100)	17 (94)
Acute care nursing, mean, y	10	5	7	13	5	7
Worked at current hospital, mean, y	7	4	6	8	4	5
Previous experience as a medication nurse of those who worked, No. (%)	1 (20)	1 (20)	2 (20)	1 (20)	0	1 (6)

*Includes demographic information for nurses who actually worked during the study, including those who were recruited after randomization. Most nonrandomized nurses worked only 2 to 3 days to fill in for general nurses who were absent. For both hospitals combined, nonrandomized nurses worked a total of 18 days.

actually underestimate the problem because it is known that most errors go unreported.⁸⁻¹¹ This contention is supported by a recent study¹² that compared the number of errors identified using incident reports with those identified via an independent observation technique. It was found that more errors are detected by observation than by voluntary reports by a factor of 457:1.¹²

The observation technique for studying medication administration errors was originally developed in 1962,¹¹ and it has since been used in more than 40 studies. Research conducted since then has consistently demonstrated that the observation technique is the most accurate in detecting drug administration errors.^{8,12} Barker and colleagues,¹³ analyzing data from various studies, estimated that errors (excluding wrong-time errors) occur at a rate of approximately 1 per hospitalized patient per day.

A variety of strategies have been developed to try to prevent medication errors, including computerized physician order entry,^{14,15} bar coding,^{14,16-18} unit dosing,¹⁹⁻²¹ and use of the computerized medication administration record.^{14,15,22} The first strategy does not focus on preventing administration errors, and the other 3 interventions do not address the subtle issues involved in delivering the right medication to the right patient using the right administration technique. Therefore, we undertook this study to determine whether administration errors could be decreased by using a more focused human approach to medication delivery.

We hypothesized that the drug administration error rate could be decreased by having “dedicated medication nurses,” who had received a brief review course on pharmacology and safe medication use, focus exclusively on administering drugs during their nursing shifts without increasing the existing complement of nursing staff.

METHODS

DESIGN AND STUDY PARTICIPANTS

This randomized study took place at 2 sites: an academic community hospital on the West Coast (hospital A) and a university teaching hospital in the Midwest (hospital B). Study participants were registered nurses who had at least 1 year of acute care nursing experience and a minimum of 6 months of full-time employment at the hospital (**Table 1**). Study partici-

pants were informed that they would be participating in a medication safety study designed to provide a greater understanding about the medication-use process and that they would be observed as they prepared and administered medications. This study was approved by the institutional review boards at the 2 participating hospitals, and all study participants provided informed consent.

TIME FRAME AND CHARACTERISTICS OF STUDY HOSPITALS

The study was conducted simultaneously at the 2 academic hospitals in 2 contiguous 6-week blocks, 5 days per week (excluding weekends), for 12 weeks (July 9, 2001, through September 28, 2001). Four separate nursing units were selected to participate at each institution, 2 participating during each 6-week block. At hospital A, the nursing units are aggregated to focus on either medical or surgical patients. At hospital B, all nursing units involved were mixed medical and surgical units. At hospital A, nurses worked 12-hour shifts generally 3 d/wk; at hospital B, nurses worked 8-hour shifts generally 5 d/wk.

MEDICATION-USE PROCESS

The medication-use processes at the 2 hospitals were different during the study. The **Figure** describes how medications were ordered at each hospital, highlighting the differences.

RECRUITMENT AND RANDOMIZATION

Before the study began, 4 nursing units at each hospital selected to participate in the study recruited and acquired consent from nurse volunteers from these units. Nurses were randomly assigned using a random-number generator to 1 of 2 groups: medication nurses or general nurses. Eight medication nurses and 8 general nurses were randomized to participate as principal study participants during the 12-week study; an additional 7 medication nurses and 3 general nurses were randomized to participate as backup study participants to fill in for the principal study participants if needed.

All nurses randomized to serve as medication nurses, including backup individuals, were trained in the medication safety program described in the “Medication Nurse Responsibilities” subsection. These nurses were assigned responsibility for medication administration 2 d/wk between 8 AM and 1 PM, during which time they were observed. Study nurses randomized to serve as general nurses were observed between 8 AM and 1 PM during the other 3 days of the week. The total number of nurses on a given study unit remained the same, regardless of whether the medication nurse or the general nurse was being observed.

Of the 16 principal study participants, 2 medication nurses dropped out of the study (1 because of a family death and another for administrative reasons) and were replaced by randomized backup medication nurses. It was occasionally necessary to recruit nurses to serve in the general nurse role when the randomized backup general nurses were unavailable. This occurred 12% of the time for total days worked by general nurses. These nurses were not randomized.

OBSERVERS AND OBSERVATION DESIGN

Study nurses were observed while administering medication by trained observers who were either registered nurses (hospital A) or pharmacy technicians (hospital B). All of the observers participated in a single 2-day training session in Los Angeles in June 2001, a month before the start of the study. The training session was conducted by an expert in the observation method (E.F.). The observers were responsible for following the study participants unobtrusively during the medication administration process and for recording all aspects of drug retrieval, preparation, and administration. Variations from safe medication practices also were documented by the observers, including failing to compare the patient's wristband with the medication administration record before medication administration, borrowing medication from another patient's medication cassette, and administering an unlabeled medication or syringe if the nurse put down the unlabeled item.

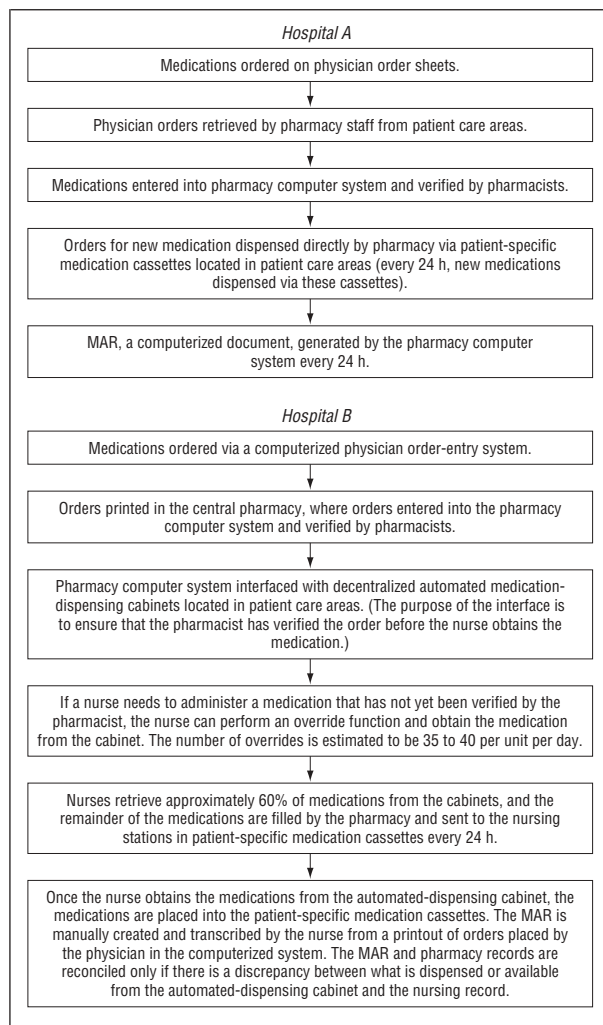
A data collection form was used to record all observations during the medication administration process. At the conclusion of each observation shift, the observers performed a "reconciliation" of their observations, comparing their medication administration information recorded during the shift with the physicians' orders in the medical records. Discrepancies based on the observer's record vis-à-vis the physicians' orders were noted as medication administration errors.

Therefore, with respect to new patients, observers were masked during the observation and unaware of errors until after reviewing the physicians' orders. However, if observers happened to follow a nurse covering the same patient(s) from a previous day, they may no longer have been masked. Observers were taught that if they thought they were about to witness a serious error, with the potential for patient harm, they should intervene to prevent the error in the interest of patient safety. Specific examples were supplied, and explicit criteria from the National Coordinating Council for Medication Error Reporting and Prevention were used to define patient harm.

Medication errors were recorded by the observers for drug (unauthorized), dose, dosage form, route, rate of administration (for intravenous drugs), dose preparation, administration technique, and omitted drugs (**Table 2**). Drug administration time was recorded for informational reasons only but was not analyzed as an error. Two individuals from hospital A and 2 from hospital B served as observers, working 8 h/d 5 d/wk for the study duration. At hospital A, there was also a third observer, who filled in as backup when necessary. (No more than 2 observers worked on any given day.) The actual daily observation period was 5 hours, and the remainder of the observer time was spent in reconciliation of medications administered with the physicians' orders. Each observer was assigned to cover a single nursing unit for 3 weeks at a time and then switched units to cover the other study unit for another 3 weeks. The days of the week for observing each nurse type varied in a balanced design throughout each 6-week block.

MEDICATION NURSE RESPONSIBILITIES

Participants randomized to the medication nurse group attended a 1-day (8-hour) medication safety program. The course,



Medication-use process at each hospital. MAR indicates medication administration record.

covering basic pharmacology and the principles of safe medication administration, was taught by a multidisciplinary team of clinical pharmacists, nurse educators, and a physician, including some of us (R.S., P.S., and N.L.G.). The content of the educational program was based on information derived from the Institute for Safe Medication Practices, pharmacology texts, and the current scientific literature. The course also covered the importance of adhering to safe medication practices, described in the "Observers and Observation Design" subsection. Although each study site used faculty from its own institution, both used the identical education syllabus, developed collaboratively. The medication safety program was given on the first day of each study block in which the medication nurse was participating.

On the 2 days each week that the medication nurses worked, they were responsible for administering medications to assigned patients. At hospital A, medication nurses were assigned 16 to 18 patients each, and at hospital B, medication nurses were assigned 15 patients each. (The difference in number of patients assigned was a result of differences in the medication-use process between the 2 hospitals [Figure].) Unit census varied during the study; therefore, the maximum number of patients was not always present in a given unit each day. Nurses administered all scheduled medications with few exceptions, unless they were unable to administer time-critical

Table 2. Definitions of Medication Errors and Process Variation Errors

Error Type	Definition
Medication Errors	
Drug (unauthorized)	Administration to the patient of a medication not authorized for that patient. This category includes a drug given to the wrong patient, duplicate doses and extra doses not ordered but administered, administration of an unordered drug, and a dose given outside a stated set of clinical parameters (eg, medication order to administer only if the patient's blood pressure falls below a predetermined level).
Dose	Any dose that is the wrong number of preformed units (eg, tablets) or, for oral liquids and injectables, any dose greater or less than the ordered dose by a predetermined amount (eg, 20%). In the case of ointments, topical solutions, and sprays, an error occurs only if the medication order expresses the dose quantitatively, eg, 1 inch of ointment or two 1-s sprays.
Dosage form	Administration of a drug by the correct route but in a different dosage form than that specified or implied by the physician. Examples of this error type include use of an ophthalmic ointment when a solution was ordered or administration of an immediate-release medication when sustained release was ordered. Purposeful alteration (eg, crushing of a tablet) or substitution (eg, substituting a liquid for a tablet) of an oral dosage form to facilitate administration is generally not an error.
Route	Administration of a drug by a route other than that ordered by the physician (eg, oral administration of a drug ordered as intramuscular). Also included are doses given via the correct route but at the wrong site (eg, left eye instead of right eye).
Rate of administration	Administration of a drug at the wrong rate, the correct rate being that given in the physician's order or as established by hospital policy.
Dose preparation	Incorrect preparation of the medication dose, eg, incorrect dilution or reconstitution, not shaking a suspension, using an expired drug, not keeping a light-sensitive drug protected from light, and mixing drugs that are physically or chemically incompatible.
Administration technique	Situations when the drug is given via the correct route, site, etc, but improper technique is used, eg, not using Z-track injection technique when indicated for a drug, incorrect instillation of an ophthalmic ointment, drugs given with food that were not ordered to be given with food, and incorrect use of an administration device. Also includes failure to follow parameters specified in orders, eg, lack of heart rate or blood pressure measurement before medication administration.
Omitted drugs	Failure to administer an ordered dose. However, if the patient refused to take the medication, no error has occurred. Likewise, if the dose is not administered because of recognized contraindications, no error has occurred. Omission of a dose was documented when the medication order was in the medical chart but was not given because the nurse administering medications neglected it or because it was not transcribed onto the medication administration record.
Process-Variation Errors	
System process policy on wristband	Nurse does not check patient wristband before administration of drug to ensure correct patient; check the box if you see that policy violation. 1 = Yes, indicates no check done and that is an error.
System process policy on patient medication drawer	Nurse borrows medication from another patient's drawer; check the box if you see that policy violation. 1 = Yes, indicates medication was borrowed.
System process policy on medication cup or syringe	Nurse administers oral medication whose unit dose labeling has been discarded from a medicine cup or nurse administers medication from an unlabeled syringe; check the box if you see that policy violation. 1 = Yes, indicates that this error was made.
Not Analyzed as an Error	
Administration time	Administration of a drug dose greater than ± 1 h from its scheduled administration time as set by hospital policy.

medications (eg, insulin and antibiotics), in which case they were instructed to ask for assistance from the staff nurses on the unit. Medication nurses did not administer STAT medications, total parenteral nutrition, hydration, or bolus medications; these were handled by staff nurses who were not followed by observers.

GENERAL NURSE RESPONSIBILITIES

Participants who served in the general nurse role provided nursing care in the usual manner, covering an average of 6 patients each. They did not receive training in medication safety. They were observed only when they administered medications, not when they were providing other patient care services.

MAIN OUTCOME MEASURES: ERROR RATES

For each individual error type, the error rate was determined by dividing the number of errors detected by the total number of opportunities for error based on the established definition in the literature.^{8,19} Each dose administered was considered to be a single opportunity for error, and total number of opportunities for error represented the total number of doses administered plus those omitted. This method for computing error rates enabled comparison of rates between medication nurses and general nurses by correcting for the differences in the number of medications administered by each nurse group.

Using this definition, error rates were computed for the primary outcome measures: total errors (the sum of medication errors and process-variation errors), medication errors, and process-variation errors. To compute total errors, each dose was scored as having no errors or as having at least 1 error, and the percentage of doses with an error of any type was computed. To compute medication errors, each dose was scored as having no medication errors or as having at least 1 medication error, and the percentage of doses with a medication error of any type was computed. To compute process-variation errors, each dose was scored as having no process-variation errors or as having at least 1 process-variation error, and the percentage of doses with a process-variation error of any type was computed.

Therefore, since a single opportunity for error could have had errors of varying types, for example, 2 medication errors and 1 process-variation error, the percentage of opportunities showing at least 1 medication error plus the percentage of opportunities showing at least 1 process-variation error will be somewhat larger than the percentage of opportunities showing at least 1 total error.

STATISTICAL METHODS

Since individual opportunities for error (doses) are not independent of each other, standard statistical methods, such as a $2 \times 2 \chi^2$ test, which are based on the assumption that each opportunity for error is independent, would not be valid. Based on the complexities of the study design involving factors for

Table 3. Total Error Rates, by Study Site and Nurse Type

Study Site	Medication Nurses		General Nurses		Medication Nurse Errors > General Nurse Errors, wk	P Value (Medication vs General Nurses)*
	Errors, No. (%)	Opportunities for Error, No.	Errors, No. (%)	Opportunities for Error, No.		
Hospital A						
Medical units	224 (13.6)	1644	121 (12.4)	975	7/12	<.77
Surgical units	78 (7.4)	1052	134 (17.7)	756	1/12	<.01
Subtotal	302 (11.2)	2696	255 (14.7)	1731	4/12	<.39
Hospital B (all units)	610 (19.7)	3096	290 (15.0)	1930	9/12	<.15
Total	912 (15.7)	5792	545 (14.9)	3661	13/24	<.84

*Statistical significance was calculated using the sign test, which is based on the weekly differences in error rates. For example, in 7 of 12 weeks, medication nurses made more errors than general nurses on hospital A medical units, a difference that is not significant using the sign test.

Table 4. Medication Error Rates, by Study Site and Nurse Type

Study Site	Medication Nurses		General Nurses		Medication Nurse Errors > General Nurse Errors, wk	P Value (Medication vs General Nurses)*
	Errors, No. (%)	Opportunities for Error, No.	Errors, No. (%)	Opportunities for Error, No.		
Hospital A						
Medical units	133 (8.1)	1644	58 (5.9)	975	7/12	<.77
Surgical units	56 (5.3)	1052	77 (10.2)	756	2/12	<.04
Subtotal	189 (7.0)	2696	135 (7.8)	1731	5/12	<.77
Hospital B (all units)	462 (14.9)	3096	118 (6.1)	1930	11/12	<.01
Total	651 (11.2)	5792	253 (6.9)	3661	16/24	<.15

*Statistical significance was calculated using the sign test, which is based on the weekly differences in error rates. For example, in 11 of 12 weeks, medication nurses made more errors than general nurses on all of the hospital B units combined, a difference that is statistically significant using the sign test.

patient, nurse type, nurse, observer, site, day, week, and unit, a simple model for data analysis was used.

The error rate (as a percentage) was computed for each nursing unit for each hospital for each study week for each nurse type (medication or general). At hospital A, error rates for medication and general nurses were computed separately for the medical and surgical units for each week of the study (and then were also pooled), whereas at hospital B, where all of the units were mixed medical and surgical, error rates for the 2 different nurse types were computed only by pooling all of the units together for each week of the study. Comparisons between error rates for medication and general nurses were based on the weekly differences in error rates for the 2 nurse types for each of the 12 study weeks.

Statistical significance was assessed using the sign test, which is a test of the null hypothesis that the probability of a positive difference is 50%; P values were computed based on the binomial distribution. Thus, conclusions are based on the consistency of differences across the 12-week period. For example, if medication nurses had a higher error rate than general nurses in 11 of 12 weeks, this would be strong evidence that medication nurses made consistently more errors than general nurses (the sign test gives a $P < .01$), whereas if medication nurses had a higher error rate than general nurses in only 6 of 12 weeks, this would suggest that their error rates are similar (results are not consistent and the sign test would not be significant).

RESULTS

TOTAL ERRORS

Total error rates, defined as the percentage of opportunities in which a medication error, a process-variation error, or both occurred, varied from a low of less than 1%

per week to a high of 56% per week. **Table 3** displays total error rates by study site and nurse type. At both hospitals combined, medication nurses had a 15.7% total error rate and general nurses had a 14.9% total error rate; this difference was not significant ($P < .84$), as rates were higher for medication nurses in about half the weeks.

When analyzing results by unit type, we saw no significant differences in total errors between medication and general nurses for hospital A medical units, whereas there was a significantly lower error rate for medication nurses than for general nurses in hospital A surgical units and a nonsignificant tendency for a higher error rate for medication nurses than for general nurses in the mixed medical and surgical units at hospital B.

The total error rate for medication nurses was significantly higher at hospital B vs hospital A (19.7% vs 11.2%; $P < .04$). Rates for general nurses were essentially the same at each site (15.0% and 14.7%, respectively).

MEDICATION ERRORS

Medication error rates (excluding wrong-time errors) varied from a low of less than 1% per week to a high of 37% per week. Medication errors by study site and nurse type are given in **Table 4**. At both hospitals combined, medication nurses had an 11.2% medication error rate and general nurses had a 6.9% medication error rate; this difference was not statistically significant. Analyses of rates by unit type were essentially the same as for total errors except that the higher rates for medication nurses at hos-

Table 5. Error Rates for Specific Medication Error Types, by Nurse Type for Each Hospital, and Error Rates and Raw Numbers of Errors for All Nurses Combined*

Study Site and Nurse Type	Medication Error Type							
	Dosage	Dosage Form	Route	Intravenous Rate	Dose Preparation	Administration Technique	Omitted Drug	Unauthorized Drug
Hospital A								
Medication nurse	1.1	0.1	0.2	0.2	0.7	3.4	0.6	0.2
General nurse	0.8	0.1	0.5	0.5	0.1	4.9	0.6	0
Hospital B								
Medication nurse	0.7	0.1	1.4	0.2	2.7	11.6	1.5	0
General nurse	0.5	0	0	0	1.7	3.8	0.5	0.1
All nurse types combined (raw No. of errors)	0.8 (73)	0.1 (7)	0.6 (55)	0.2 (19)	1.4 (134)	6.4 (607)	0.9 (81)	0.1 (7)

*Error rates are given as mean percentages.

Table 6. Process-Variation Error Rates, by Study Site and Nurse Type

Study Site	Medication Nurses		General Nurses		Medication Nurse Errors > General Nurse Errors, wk	P Value (Medication vs General Nurses)*
	Errors, No. (%)	Opportunities for Error, No.	Errors, No. (%)	Opportunities for Error, No.		
Hospital A						
Medical units	96 (5.8)	1644	66 (6.8)	975	5/8†	<.73
Surgical units	23 (2.2)	1052	62 (8.2)	756	2/11†	<.07
Subtotal	119 (4.4)	2696	128 (7.4)	1731	6/12	<.10
Hospital B (all units)	162 (5.2)	3096	178 (9.2)	1930	1/12	<.01
Total	281 (4.9)	5792	306 (8.4)	3661	7/24	<.06

*Statistical significance was calculated using the sign test, which is based on the weekly differences in error rates. For example, in 5 of 8 weeks (in which errors were recorded), medication nurses made more errors than general nurses on hospital A medical units, a difference that is not significant using the sign test.

†At hospital A, there were no process variations recorded in the first 4 weeks on the medical units or during 1 week on the surgical units, facts that have been reflected in the statistical calculation.

pital B were significant ($P < .01$). Comparisons between sites showed the same pattern as for total errors.

Table 5 gives the breakdown of rates by medication error type. The most common medication error types were administration technique (6.4%), dose preparation (1.4%), omitted drugs (0.9%), and incorrect dosage (0.8%). Dosage form errors (0.1%), route errors (0.6%), intravenous drug administration rate errors (0.2%), and unauthorized drug errors (0.1%) were all uncommon. Examples of administration technique and dose preparation errors are given in Table 2.

PROCESS-VARIATION ERRORS

Process-variation error rates varied from a low of 0% per week to a high of 53% per week. Process-variation errors by study site and nurse type are given in **Table 6**. At both hospitals combined, medication nurses had a 4.9% process-variation error rate and general nurses had an 8.4% process-variation error rate; this difference was not statistically significant using the sign test.

The overall pattern of results differed somewhat from that seen for total errors and medication errors. For hospital A surgical units, medication nurses had a lower rate of process-variation errors than general nurses, which did not reach statistical significance. At hospital B, in the mixed medical and surgical units, medication nurses had a significantly lower rate of process-variation errors than

general nurses ($P < .01$). No statistically significant differences were found when comparing hospital A and hospital B process-variation error rates for medication nurses (4.4% and 5.2%, respectively) and general nurses (7.4% and 9.2%, respectively). The analysis of process-variation errors is limited by the relatively low number of these errors recorded by the observers and the variation in recording these errors from one observer to another. The most common process-variation errors were failure to check patient wristband identification (4.0%) and unlabeled medication (1.8%).

PATIENT OUTCOME

There were no known cases in which observers intervened to prevent a serious error. Although this study was not designed to measure patient outcome, there was no known association between the drug administration errors recorded during the study observation periods and patient harm or death.

COMMENT

Results of this randomized controlled trial suggest that use of a dedicated medication nurse does not reduce medication administration error rates. However, subgroup analysis revealed some findings that suggest that a medi-

cation nurse might be useful in some settings and with certain types of workloads.

Unlike at hospital B, where the nursing units in the study included a mixture of medical and surgical patients, at hospital A it was possible to analyze the 2 nursing models for medication administration on discrete medical and surgical units. On hospital A surgical units, there was a statistically significant difference in total error rates and in medication error rates between medication and general nurses, with lower error rates seen for medication nurses. In contrast, there were no statistically significant differences in total error rates or in medication error rates between these nurse types on the medical units. It can be postulated that medical patients have a more complicated drug regimen than do surgical patients, driven by greater comorbidities and multiple physician consults and orders, leading to more errors in drug administration. In addition, most surgical populations at hospital A had preprinted order sets, which may have helped facilitate a consistent approach to care.

When we compared the mean number of medications administered by the 2 different nurse types on the 2 different unit types at hospital A, there were many more opportunities for error, or medications administered, by medication nurses on medical units (an average of 75 opportunities per day) compared with medication nurses on surgical units (48 per day); there were also more opportunities for error by medication nurses compared with general nurses in each unit type (26 and 20 per day for general nurses on medical and surgical units, respectively). It is probable that medication nurses on surgical units had sufficient time to concentrate on medication administration, as opposed to their counterparts on medical units. Yet, on surgical units, medication nurses made fewer errors than general nurses, although the former had more opportunities for error. This is perhaps a reflection of the fact that general nurses—who were charged with the total care of the patient, including support for recovery from anesthesia and for resumption of activities of daily living—were more likely to make medication errors as a result of having multiple responsibilities. It may be that there is a threshold number of medications, activities, and patients that a nurse can manage, above which the error rate increases. There is evidence in studies^{23,24} of pharmacy dispensing errors supporting a relationship between prescription workload and errors.

At hospital B, medication nurses had a higher medication error rate than general nurses, a statistically significant finding. A possible explanation for this is that the nurses obtain approximately 60% of doses from automated medication-dispensing cabinets, resulting in an increase in workload that may contribute to a higher rate of medication administration errors than when the medications are supplied in patient-specific cassettes. Furthermore, although the dispensing cabinets are interfaced with the pharmacy computer system, the nurse can access medications that have not been verified by the pharmacist, which can contribute to errors. A previous study²⁵ examining error rates associated with retrieving medications from automated dispensing cabinets demonstrated an error rate of 16.3% compared with a 5.4% error rate for doses retrieved from patient medication drawers.

Conversely, medication nurses at hospital B had a lower process-variation error rate than general nurses, a finding that was statistically significant. When the results of both study sites are combined, there is a trend toward a reduced rate of process-variation errors by medication nurses, although the results are not statistically significant (Table 6). This suggests that the medication safety education (provided as part of this study) had an impact on the medication administration process, with improved adherence to safe medication practices, including patient verification, maintaining package integrity to the bedside, and not borrowing doses from other patients. Despite improvements in work processes at hospital B, the observed medication error rates were higher, suggesting that although dedicated medication nurses focused their attention on medication safety, other factors resulted in this performance. This paradoxical difference between process and medication errors was not noted at hospital A, where medications are provided in patient-specific cassettes. It is possible, therefore, that responsibility for obtaining medications from an automated cabinet and for administration creates a more complex system of work, which has been shown to increase the chance of failure.²⁶

We analyzed the data to see whether there was a correlation between medication errors and process-variation errors. There was no evidence that having one type of error made it more likely to have another type of error, with no correlation coefficient being greater than 0.04 in absolute value.

Differences in error rates between hospitals possibly may be attributed to the fact that registered nurses at hospital A were, on average, more experienced than those at hospital B (Table 1).

Conducting a randomized study in 2 separate hospitals with different medication-use processes proved to be challenging. Several limitations need to be acknowledged and described.

Medication nurses had relatively little training for their roles. They received only a 1-day didactic course, and they did not have the opportunity to develop proficiency in their roles on the nursing units before being observed. Thus, the findings of this study should not be interpreted to apply to medication nurses who may receive much more extensive training, perform this role full-time, and develop expertise over time.

However, what we really wanted to study was whether nurses “focusing” on drug administration would have a lower error rate than general nurses. Indeed, we had been concerned that if we provided extensive training to medication nurses and consequently found that they made significantly fewer errors than general nurses, we would not know (due to confounding variables) whether the medication nurses were less error-prone because they were focusing on medication administration or because they had been specially trained, or both.

Nurses were observed between 8 AM and 1 PM only, which was believed to represent the busiest time for administering medication. The observation period was followed by a reconciliation period. When doses were found to have been omitted, there was no way to conclude definitively that the dose was not administered later in the

Authors' Note

Although progress is being made with respect to encouraging institutions to share stories about medical error and transforming the "culture of blaming" into one of learning and prevention, there remains considerable discomfort regarding publication of institution-specific information on error rates. While it is recognized that the hospitals featured in this study can be identified, we decided to try to take the spotlight off those involved, calling them hospital A and hospital B throughout the text. It is believed that these hospitals may be representative of many institutions worldwide and that the focus should be on safety improvement strategies rather than on issues of culpability. This article examines the area of medication administration; it is acknowledged that numerous individuals may contribute to errors occurring at the administration phase and that most errors are the result of flaws in systems. Our intent is not to single out groups of individuals who make certain error types but rather to understand better the challenges inherent in the medication administration process as a whole, which may lead to the development of potential safety improvement solutions.

day by another nurse. To address this issue, we did not count as omitted any drug with a "Q day" order (one time per day); consequently, the number of true drug omissions may have been underestimated.

Because the observers involved in the study were aware of the study design, they may have interjected their own biases in documenting errors made. In addition, although the specific hypotheses of the research were not shared with the study participants, the study was not masked, and it is believed that most of the nurses knew or inferred the purpose of the study.

Although all the nurses were observed during the same 8 AM to 1 PM time frame, at each hospital they worked different shift lengths and different numbers of days per week. As indicated previously, hospital A units studied had either medical or surgical patients; hospital B units studied had a mix of medical and surgical patients. Three registered nurses served as observers at hospital A, and 2 pharmacy technicians served as observers at hospital B. A recent study¹² of technicians and nurses serving as observers to evaluate medication errors demonstrated that detection rates among the 2 disciplines were comparable.

Because of differences in the medication-use systems at each institution (Figure), the observers followed different processes in medication administration and performed a different reconciliation process to check for errors at the end of the observation shift. At hospital A, the observers checked the actual physician orders on the medical chart; at hospital B, the observers checked the computer printouts from the computer prescriber order-entry system.

Owing to budget constraints that exist in the current health care environment and the nursing shortage, we wanted to test our hypothesis by keeping the total number of nurses constant, without increasing the nurse-patient staffing ratio. Therefore, we did not

address the issue of whether dedicated medication nurses added to the current nursing staff complement would result in decreased errors. We also did not explore whether licensed vocational nurses could assume some of the medication nurse responsibilities and reduce medication errors.

CONCLUSIONS

Simple changes in work design and a modest educational intervention do not seem to lead to decreased medication administration error rates in diverse hospital populations with complex medication-use systems. In fact, at one site, the medication administration error rate was significantly higher for medication nurses. However, a dedicated medication nurse with minimal training may make fewer errors where fewer scheduled medications are administered, such as on surgical units.

It is likely that more substantive system changes to the medication-use system and training are required to reduce the rate of medication errors.²⁷⁻²⁹ In this study, it seems that consolidating dispensing and drug administration activities at one site resulted in workload and complexity challenges that increased medication error rates despite improved procedural adherence to safe medication practices. Medication nurses who obtain medication from patient-specific drawers may make fewer errors than those who obtain medications from automated medication-dispensing cabinets. Even if the cabinets are interfaced with the pharmacy computer, the ability for the nurse to perform overrides can contribute to errors.

Attempting to reduce the medication error rate by providing a comprehensive educational program, which would train nurses to become specialists in medication administration, requires further study.

Accepted for publication December 17, 2002.

This study was supported by a grant from the National Patient Safety Foundation, Chicago, Ill, and by the 2 academic hospitals participating in the study.

Dr Greengold is the Chief Medical Officer for Clinical Tools Division of Wolters Kluwer Health. Drs Flynn and Barker are consultants on medication systems, patient safety, and facilities design.

We thank Janis Bomar, MS, RN; Duong Donna Luong, PharmD; Sylvia Martin-Stone, PharmD, BCPS; Susan Strickland, RN; JoAnn Whitaker, RN; the nurses at both hospitals who volunteered to participate and the many nurses and nurse managers who supported them during the study hours; and David Bates, MD, MSc, Chief, Division of General Medicine, Brigham & Women's Hospital, Boston, Mass, and Ginette A. Pepper, PhD, RN, Director, Nursing Doctorate Program (Interim), School of Nursing, University of Colorado Health Sciences Center, Denver, who provided valuable advice on study design and manuscript preparation.

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