Clinical Investigation

Effect of a Resident Physician Educational Program on Pediatric Emergency Department Pharmacy Interventions and Medication Errors

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PURPOSE To determine the effects of a resident physician educational program in a pediatric emergency department (ED) on pharmacy interventions and medication errors, particularly dose adjustments, order clarifications, and adverse drug events (ADE).

METHODS The ED pharmacist recorded all interventions and medication errors on weekdays from 3 to 11 PM during a 9-month period, consisting of a preobservational (Quarter 1), observational (Quarter 2), and interventional (Quarter 3) phases. Program implementation occurred in Quarter 3, with an initial 3-hour lecture during the ED orientation, followed by daily patient case discussions. Weekly interventions and errors were analyzed using statistical process control u-chart analyses. Chi-square analyses of independence were also performed. Resident and ED staff feedback on the program was obtained through anonymous internet-based surveys.

RESULTS A total of 3507 interventions were recorded during the 9-month period. Chi-square approximation and interval estimation of odds ratio showed a statistically significant decrease between Quarters 1 and 3 in the number of dose adjustments (95% confidence interval [CI], 0.324-0.689) and order clarifications (95% CI, 0.137 to 0.382) after initiation of the program. The decline in ADE, while not as substantial (95% CI, 0.003 to 1.078), still achieved a level of significance (90% CI, 0.006 to 0.674). Survey results were positive toward the program.

CONCLUSIONS The implementation of a resident physician educational program in our pediatric ED significantly decreased the number of medication errors, increased resident physician awareness of the potential for errors, and increased ED pharmacist utilization.

INDEX TERMS emergency medicine, medication errors, pediatrics, pharmacy, quality improvement

J Pediatr Pharmacol Ther 2013;18(1):53–62

INTRODUCTION

The emergency department (ED) atmosphere can be described as chaotic, hectic, and unpredictable. Health care providers are expected to care for multiple patients with different complaints or disease states. Frequent interruptions, the variable nature of each patient case, and the high stress level of the ED create an environment that is prone to medical errors. In addition, the care of a pediatric patient can cause a heightened level of anxiety for the health care provider. In an environment where the risk of error is high, it is imperative that solutions be developed and implemented to prevent these errors from occurring.

Several studies have shown that medication errors are the second most frequent and expensive errors involved in medical malpractice claims.[1] Since the Institute of Medicine published *To Err is Human: Building a Safer Health System*,[2] which describes medical errors as a major cause of death, there has been an increased awareness of patient safety among health care systems and providers,

the prevalence and incidence of medical errors, and the need to improve outcomes. Specifically, medication errors are a preventable cause of morbidity and mortality.

Pediatric medicine, and particularly pediatric emergency medicine, is a specialized area of practice in which many health care providers do not have experience. Pediatricians are trained in weight-based medication dosing rather than standardized doses used in adults. Pediatric patients with chronic diseases are often on multiple medications that are not commonly seen in the adult population. In addition, many medications are not approved by the US Food and Drug Administration for use in children, and dosing regimens stem from literature searches of small studies and case reports rather than package inserts. Taylor et al.[3] found that prescribing errors in their pediatric ED were very common and that the incidence of errors correlated with the degree of pediatric experience rather than the prescriber's level of training. Pacheco et al.[4] found similar results in a retrospective review of pediatric outpatient prescriptions, where error rates between the beginning and end of the academic year and among residents with various levels of training were not significantly different.[4]

Several studies have demonstrated that the presence of a pharmacist in the ED can decrease the number of medication and prescribing errors.[5–7] Pharmacists can improve medical care in the ED by providing therapeutic drug recommendations and dosing information, responding to traumas and resuscitations, identifying potential drug interactions or errors, and providing ongoing education to the entire ED staff.[8] Lesar et al.[9] showed that 57% of medication errors that were identified and prevented through pharmacist involvement had the potential for adverse patient consequences. Lada and Delgado[10] showed that the potential cost savings attributable to ED pharmacist interventions in an adult ED during a 4-month study period was more than $1-million.

Although the aforementioned studies demonstrated the safety and cost benefits of adult ED pharmacy services, our goal was to expand the role of the pediatric ED pharmacist through involvement in teaching medical students and residents at our pediatric institution. Prior to this study, the ED pharmacist provided drug information on an as-needed basis yet was not involved in any didactic teaching for medical students and residents. We wanted to determine whether using the ED pharmacist for didactic purposes initially during the ED orientation and on a daily basis throughout their monthly rotation decreased the number of medication errors and increased use of the ED pharmacist. To the best of our knowledge and through an extensive literature search, no studies at the time had specifically investigated implementation of a resident-focused program addressing medication safety, using the ED pharmacist, and evaluating the incidence of medication-related issues before and after program implementation. The primary objective of this study was to evaluate the effect of a resident physician-focused educational program involving the ED pharmacist on the incidence of ED medication errors and pharmacy interventions. The secondary objective was to assess the resident physician and ED staff outlook on the incorporation of the ED pharmacist into the program curriculum.

METHODS

This prospective study was conducted in the ED of a 225-bed, tertiary-care pediatric hospital with an annual ED census of approximately 75,000. A pharmacist was present in the ED on weekdays from 3 to 11 PM, when ED patient volumes are the highest. The ED pharmacist was responsible for reviewing all ED medication orders in addition to their clinical interventions performed. Interventions were recorded on a daily basis using a computerized database created by the pharmacy department at Methodist University Hospital in Memphis, Tennessee. This study was conducted over a 9-month period from January 1, 2009, to September 30, 2009, and was divided into 3-month intervals consisting of the preobservational (Quarter 1), observational (Quarter 2), and interventional (Quarter 3) phases. Quarter 1 served as the control period by which Quarters 2 and 3 were compared, as providers during Quarter 1 were unaware of the study and upcoming educational sessions. During Quarters 2 and 3, the frequency of medication errors and clinical interventions were compared before and after implementation of the program, which occurred at the beginning of Quarter 3. The Institutional Review Board at Le Bonheur Children's Hospital approved this study.

The educational program, titled *Quality 101*,

consisted of a 3-hour presentation during the ED resident orientation session, which occurred on the first day of each month from July to September 2009. The presentation, led by an ED attending physician and ED pharmacist, focused on current economic changes and effects on the health care environment, health care reform, patient satisfaction, intricacies of the electronic medical record, ED medication and prescription error rates, adverse drug event (ADE) reporting, malpractice liabilities of physicians and pharmacists, and interactive patient case scenarios. Medication error data presented included national, systemic, and hospital-wide averages and included actual examples with recommendations on how to avoid these types of errors in the future. In addition, daily discussions involving specific patient cases and medication therapy were generated between the ED pharmacist and attending and resident physicians. Residents rotated through the ED at 1-month intervals and ranged from first year (PGY1) through third year (PGY3) levels.

At the end of each month, feedback was obtained through an anonymous internet-based survey using a Likert-based scale, which asked the resident to evaluate the program, their training experience throughout the month, and the contribution of the ED pharmacist to the program curriculum. A second survey was given to the entire ED staff, including ED nurses, to assess the impact of a pharmacist's presence on medication safety and error rates. This anonymous internet-based survey asked the participant to assess the following using a five-level Likert-based scale, with 1 being the lowest score representing dissatisfaction and 5 being the maximal positive score. This survey inquired about the participant's job role, their perception of the importance of medication safety, the ED pharmacist's effect on medication errors, their use of the ED pharmacist for drug information, and their view on the expansion of ED pharmacy services and incorporation of the ED pharmacist into the residency curriculum. A final question allowed for open-ended comments. The survey link was emailed to the staff and was available online for a 1-month period, with one reminder email sent 2 weeks after initiation of the survey.

Pharmacist interventions were grouped based on the type of intervention performed and the level of training of the physician. Interventions were classified by type according to the following 10 categories: avoidance or detection of an ADE, discharge prescription management, dosage adjustments (DAs), drug information questions, home medication reconciliation, intravenous-to-oral conversion, formulary interchange, order clarification (OCs), route modification, and therapeutic interchange. Level of training data was recorded during Quarters 2 and 3 of the study period.

The process for ordering all ED medications was consistent throughout the entire 9-month period. Each patient seen in the ED had a paper chart, and the physician handwrote all medication orders. Once an order was written, the ED pharmacist reviewed it, and the chart was handed to the nurse to review and carry out the order. Most of the medications ordered were directly available to the ED nurses in automatic dispensing cabinets. However, any medication not readily available was retrieved from the inpatient pharmacy and delivered to the nurse via the ED pharmacist.

Weekly pharmacy intervention data were analyzed using statistical process control u-chart analyses in order to examine trends before and after the *Quality 101* intervention. The u-chart analysis was chosen given the attribute nature of the data, the varied number of weekly pharmacy interventions, and the fact that each order or patient visit could have resulted in multiple pharmacist interventions. The upper and lower control limits (CL) were determined based on the actual number of interventions in each category per week, which, again, were variable. The y-axis is the number (frequency) of pharmacy interventions, and the x-axis is the time period divided into weeks. Data present above or below the CL lines represented statistically significant changes. Data between the CL lines were considered insignificant. For example, u-charts showing trends in ADEs, DAs, and OC would ideally decrease in frequency (y-axis) throughout the study period (x-axis) and ultimately fall below the lower CL line to be determined statistically significant. All statistical analyses were performed using Excel (2007 version; Microsoft, Redmond, WA), Minitab version 15 (Minitab Inc., State College, PA), and QIMacros version 2012 (KnowWare International Inc., Denver, CO) software.

Chi-square analyses of independence were performed to evaluate the impact of the educa-

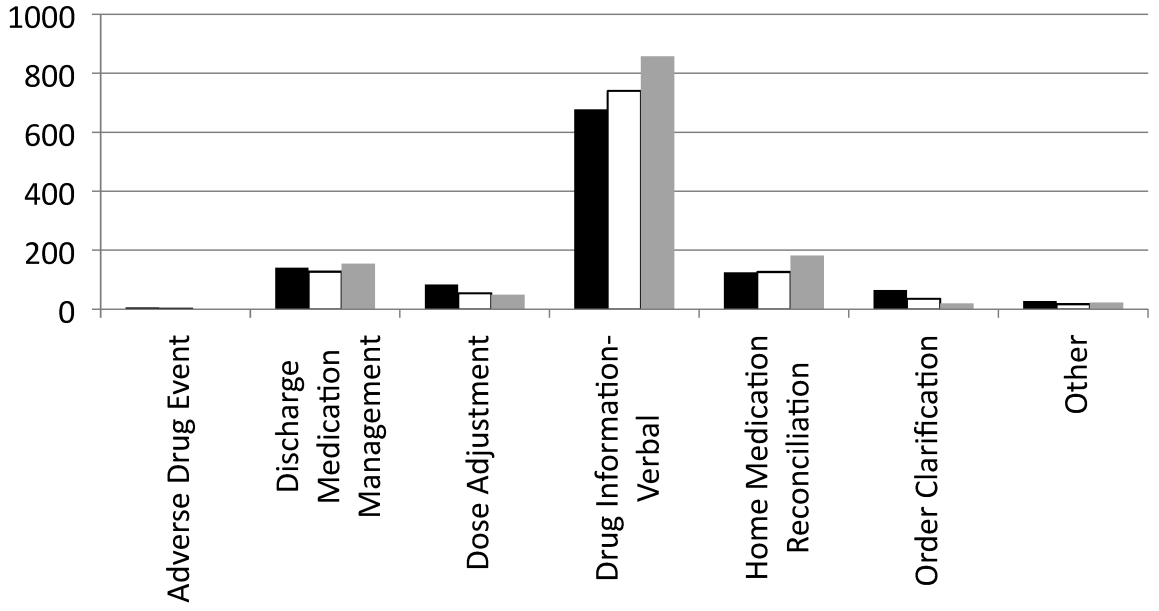

Figure 1. Total number of ED pharmacist interventions before and after Quality 101 program.

Black bar, Quarter 1; white bar, Quarter 2; Gray bar, Quarter 3

tional program. Chi-square approximation works better when samples are large and proportions are not close to either zero or one. In this case, although samples were large, proportions were closer to zero. Therefore, to confirm the findings by chi-square test of independence, the likelihood ratio chi-square test was used as described by Agresti.[11] To assess the effect on the individual type of intervention, interval estimation of odds ratio was performed. The confidence interval (CI) for odds ratio was used to determine the effect of the *Quality 101* program on each individual pharmacy intervention type.[11]

Estimated cost avoidance was applied to all ADEs identified by the ED pharmacist and included the following: average hourly wages for pharmacists, pharmacy technicians, and nurses; daily costs of an intensive care unit or floor bed admission; medication costs; laboratory costs, including drug levels; and supply costs. ADEs were classified based on the amount of time the ED pharmacist spent preventing or resolving the error, with minor interventions determined to be less than 30 minutes and major interventions greater than 30 minutes. Because major interventions require more time, they were considered clinically significant errors, whereas minor interventions that did not require as much time to resolve by the staff were thus considered minimally significant. All costs incurred for each ADE are specific to this region.

RESULTS

The ED pharmacist documented a total of 3507 pharmacy interventions during the 9-month study period: 1123 in Quarter 1 (control or pre-observational period); 1101 in Quarter 2 (observational period immediately before initiation of the program); and 1283 in Quarter 3 (program initiation period). Overall, 86 residents rotated through the ED during the 9-month study period: 27 in Quarter 1, 27 in Quarter 2, and 32 in Quarter 3. Total ED patient volume during the 3- to 11-PM period was 6881 in Quarter 1, 7217 in Quarter 2, and 8150 in Quarter 3. Figure 1 shows the breakdown of each quarter and the type of intervention performed. Overall, chi-square approximation and interval estimation of odds ratio showed a statistically significant decrease between Quarters 1 and 3 in the number of DAs (95% CI, 0.324 to 0.689) and OC (95% CI, 0.137 to 0.382) after the initiation of the *Quality 101* program. The decline in ADE, while not as substantial (95% CI, 0.003 to 1.078), still achieved a level of significance (90% CI, 0.006 to 0.674). The remaining categories did

Table 1. Estimated Cost Avoidance of Adverse Drug Events

Number of Incidents	Adverse Drug Effect	ED Pharmacist Intervention	Estimated Cost Avoidance per Incident*
5	Patient with a true penicillin allergy was prescribed a penicillin-type drug	Interviewed patient or family to determine if it was a true allergy; recommended alternative therapy	$5980
1	Dopamine drip was ordered for 15 mcg/kg/min but was only running at 7.5 mcg/kg/min	Double-checked rate upon patient arrival and discovered drip was only running at half dose; increased drip to correct dose	$4840
1	Incorrect discharge instructions given that told the parent to double the patient's warfarin dose.	Noted incorrect instructions and prevented family from leaving with incorrect advice; told the parent to keep the dose the same	$10,585
1	Fosphenytoin was mistakenly retrieved instead of lorazepam for active seizure	Noted order was for lorazepam and saw the wrong vial at the patient's bedside; prevented the wrong drug from being administered; retrieved lorazepam.	$3580

ED, emergency department
**In USD.*

not produce a statistically significant change in frequency throughout the study period.

The pharmacist in Quarter 1 detected six ADEs, yet this declined to zero in Quarter 3 with implementation of the educational program. Seven of the eight ADEs were identified by the pharmacist before reaching the patient, thus inflicting no patient harm. One ADE did reach the patient, resulting in the administration of a subtherapeutic dose of a vasopressor agent. Although the error was corrected immediately, the patient's lack of response to the agent led to discontinuation of the drug, and alternative agents were started.

Five ADEs involved ordering a penicillin agent for a patient with a documented penicillin allergy. The type of reaction was identified by the pharmacist through questioning the patient or family in order to determine the severity of the documented allergy. Reactions that were deemed side effects, such as nausea, diarrhea, and gastrointestinal upset, were not recorded as ADEs. Any order for a cephalosporin was excluded as well because of the low incidence of cross-reactivity in patients allergic to penicillin.

The remaining ADEs involved one of the Five Rights of Administration, as deemed necessary for review by the Institute of Medicine.[2] One ADE involved retrieval of the wrong medication from the automatic dispensing cabinet for a patient who was actively seizing. The order was written for lorazepam, but fosphenytoin was mistakenly retrieved instead. The pharmacist caught this error before the administration of the incorrect medication. Notably, the seventh ADE involved a rate miscalculation for a dopamine drip, which was already running when the pharmacist identified the error. The order was written for 15 mcg/kg/minute, but the drip was only running at 7.5 mcg/kg/minute. Finally, the eighth ADE involved an incorrect statement detected on a patient's discharge instructions, which could have resulted in a twofold overdose of warfarin. Overall, five ADEs involved attending physicians, two involved nurses, and one involved a resident physician. The estimated cost avoidance for ADEs detected or avoided ranged from $3580 up to $10,585 per event (Table 1).

During Quarter 3, the number of DAs declined in frequency and variability, as shown in the statistical process control (SPC) u-chart analysis (Figure 2). The u-chart shows two areas of significance: one at the beginning of the study period and the aforementioned decline during Quarter 3. Data for this intervention type were further divided into three subgroups based on the reason for the DAs: high dose, subtherapeutic dose, or product availability. The number of medication orders written at a subtherapeutic dose declined during Quarter 3, whereas orders changed due to high doses or product availability remained

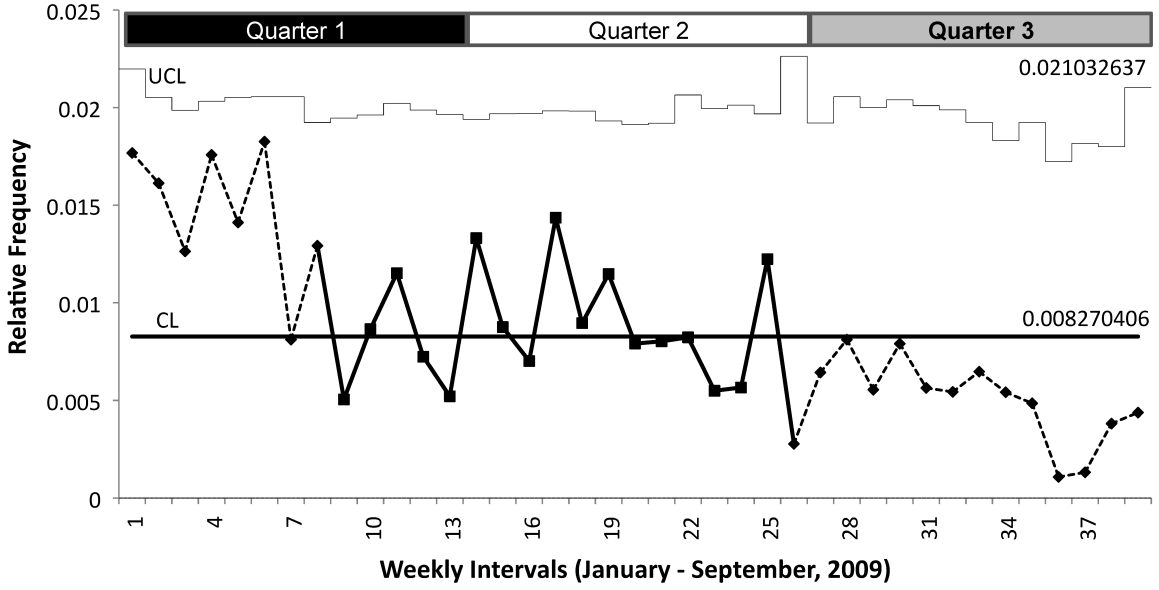

Figure 2. U-chart analysis of dose adjustments (DA) over the 9 month period. The areas of statistical significance are shown by a dotted line.

invariable. The pharmacist also evaluated data to determine the most common type of medications that required DAs. Most of the orders involved antibiotic or antiviral agents (51%). This was followed by medications for pain and/or fever control (16%), such as acetaminophen, non-steroidal anti-inflammatory agents, or opioids; and antiemetic agents (9%) such as ondansetron. The remaining 24% of orders involved one or more of the following: anticholinergic agents, anticonvulsants, antidotes, antithrombotic agents, bronchodilators, cough/cold medications, electrolytes, intravenous fluids, laxatives, sedatives, and vasopressors.

Finally, u-chart analysis of OCs revealed two areas of statistical significance with a decline in variability and frequency (Figure 3). The first area occurred at the start of the study and the second during Quarter 3. Medication orders required clarification for one or more of the following reasons: illegible handwriting; absence of a dose, route, and/or frequency (incomplete order); unapproved abbreviation; duplicate therapy; incorrect patient; and/or directions deemed unclear by either the nurse or the pharmacist. No statistically significant differences were seen in the type of OC throughout the study period. The most common OC in all three quarters included incomplete orders and those deemed unclear to the nurse or ED pharmacist.

Table 2 illustrates the breakdown of pharmacy interventions per level of physician training and other staff, including nurses, nurse practitioner (NPs), and physician assistants (PAs). There was no statistically significant difference in the frequency of errors occurring between resident versus attending physicians. However, the number of ADEs, DAs, and OCs in all groups declined or remained constant along with implementation of the educational program. The number of DAs and OCs that involved NPs or nurses writing a verbal order for a physician declined to zero during Quarter 3. Although these particular staff members did not attend the educational program, they were aware of the program and the ongoing emphasis on medication safety in the ED. Thus, by creating an environment that is more aware of prescribing errors, we believe this explains the decline in medication errors involving NPs and PAs. The number of verbal drug information requests also increased in all groups during Quarter 3, although this was not statistically significant.

Eighteen of 32 resident physicians completed the survey at the end of their monthly rotation during Quarter 3. Most resident physicians found the *Quality 101* program to be helpful and informative (mean, 4.83; 95% CI, 4.65 to 5.01). They agreed that a reduction in medical errors should be a priority and that current demands for

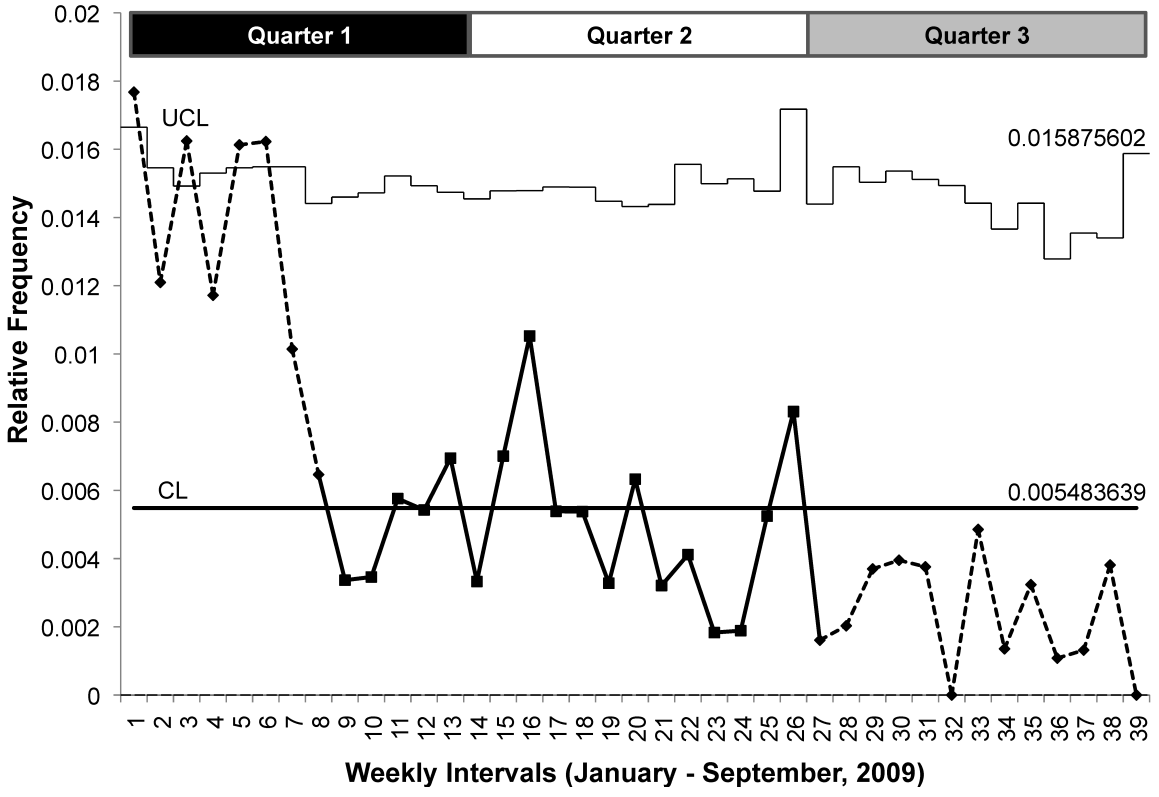

Figure 3. U-chart analysis of order clarifications (OC) over the 9 month period. The areas of statistical significance are shown by a dotted line.

increased quality in health care will affect the way they practice medicine. Survey results showed the program helped to improve their understanding of unapproved pharmacy abbreviations and incomplete medication orders and prescriptions (mean, 4.72; 95% CI, 4.51 to 4.93). Most residents agreed the educational program should become a permanent part of their curriculum (mean, 4.61; 95% CI, 4.33 to 4.89). No significant differences in answers were observed based on year of residency training (PGY1 to PGY3).

A total of 104 of 150 staff members completed the second survey, including ED technicians, nurses, physicians, respiratory therapists, and child life specialists. ED nurses accounted for 51% of the response total, while attending and resident physicians comprised 28% of participants. The remaining responses came from other allied health professionals. Survey analysis revealed that 92% strongly agreed that medication safety had improved and error rates were decreased. Furthermore, 86% of respondents strongly agreed that the ED pharmacist was a valuable drug information resource. Open-ended comments were provided by 49% of respondents, all of which were favorable with regard to the ED pharmacist.

Limitations

The results of this study need to be viewed in the context of its limitations. This study occurred prior to the implementation of computerized physician order entry. The ED pharmacist did not have the technology to have all orders sent to one location for review and, thus, may not have been able to review all ED orders. The ED pharmacist was present only during the weekday evening shift for a total of 40 hours per week. Additionally, there was only one pharmacist present during that time, thus, medication errors could have been missed when multiple or higher-acuity patients required the attention of the single pharmacist. Thus, an underreporting in pharmacist interventions may have occurred due to the pharmacist to patient and staff ratio. The H1N1 influenza epidemic, which led to a doubling of the daily ED census during Quarter 3, may have had unforeseen effects on our final results. The H1N1 influenza season hit the re-

Table 2. Comparison of Interventions per Level of Training in Quarters 2 and 3

Intervention	RP	Attending	Other	Total
Quarter 2				
ADE	1	1	0	2
DA	29	23	2	54
OC	15	15	5	35
Drug information	106	243	391	740
Total	151	282	398	831
Quarter 3				
ADE	0	0	0	0
DA	26	23	0	49
OC	8	11	0	19
Drug information	128	310	419	857
Total	162	344	419	925

ADE, adverse drug effects; DA, dose adjustment; OC, order clarification; RP, resident physician.

gion 1 month earlier than normal, which placed unanticipated stress on the entire department. However, the number of actual or potential medication errors still decreased despite this surge in patient volume.

Additionally, resident physicians may have been coached by an attending physician during Quarters 2 and 3, who stressed that medication errors were being tightly monitored and tracked. For this reason, preobservational data (Quarter 1) were also included in the SPC charts, as during this quarter, the ED staff members and physicians were not aware of the upcoming educational program. The year of residency training was not recorded for each pharmacy intervention, thus comparisons between first, second, and third year residents could not be made. Finally, the effects of ED acuity and throughput times, especially when the ED was holding patients due to inpatient bed unavailability, were not examined.

DISCUSSION

Greater demands are being placed on health care institutions to decrease medical errors and improve health care quality. A single medical error can increase the patient's length of stay; the need for corrective, unplanned interventions; and the risk of adverse outcomes and potential morbidity. The Institute of Medicine estimates that any hospitalized patient is subject to at least one daily medication error.[2] Kaushal et al.[12,13] demonstrated that the prescription, dispensation, and administration of medications account for most of the preventable medical errors. Frush[14] asserted that the challenges that face institutions that deliver pediatric care with regard to the prevention of medical errors are the lack of available tools or instruments to identify such errors and the lack of national standards for pediatric dosing. Yamamoto and Kanemori[15] described 10 steps needed for error-free administration of a drug to a pediatric patient, and each step itself is potentially error prone. Our study demonstrates how the incorporation of a pediatric pharmacist into the ED environment and the residency training program helped to create a culture of medication safety, which led to a reduced number of ADEs, DAs, and OCs.

Pitts et al.[16] reported that more than three-fourths of ED visits are associated with medication administration or prescribing, representing 210 million events annually in the United States. The Harvard Medical Practice Study II found that ADEs were the most common type of hospital-wide adverse events and that the ED was responsible for 3% of the total number of ADEs.[17] Additionally, negligence was determined to be greatest for ED ADEs.[17] This study attempted to develop a method to address medication errors early in the residency training program and encourage use of the ED pharmacist in future resident educational activities.

Kozer et al.[18] described an estimated 100 prescribing errors and 39 administration errors per 1000 pediatric ED patients. Losek et al.[7] found a 22% error rate among ED orders for acetaminophen. Similarly, in an outpatient pediatric clinic setting, McPhillips et al.[19] discovered that 15% of discharge prescriptions had a potential dosing error. Rinke et al.[20] showed that prescribing errors occurred in their pediatric ED for both inpatient and discharge prescriptions: 12.5% and 4.3%, respectively. Medication errors can occur at all levels of training experience. Resident physicians are the most impressionable group and, thus, would most likely benefit from an educational program. However, practitioners at any level would benefit from increased awareness of medication errors in order to help prevent their occurrence.

Smith et al.[21] described how pharmacists clearly have a place in the medical home, as they can perform comprehensive reviews of patient therapies, identify or resolve medication-related complaints, optimize treatment, and prevent or

identify drug-drug interactions. Pharmacists can also assist resident and attending physicians in designing patient-acceptable medication adherence techniques and advocate for cost-effective drug therapy regimens. This is particularly important in the acute care setting, where drug costs and patient compliance are often troublesome issues for the patient and the physician. With incorporation of the pharmacist into the resident educational curriculum, physicians can learn earlier in their career how pharmacists can assist with optimization of individualized patient care and medication-related issues.

Resident physicians are responsible for writing the majority of hospital admission orders for patients, and they used the pharmacist to assist in medication reconciliation, which in turn ensured patient safety and continuity of care upon admission. The pharmacist was also involved in reviewing ED discharge prescriptions. McPhillips et al.[19] showed that a computerized prescription writer without dosing logic provided no prescription error prevention advantage over manually written prescriptions. Therefore, education on how to write a complete and accurate prescription has a place in the residency curriculum and was discussed in the educational program and on an individual basis.

We believe the resident physician-focused program was responsible for improvements in pharmacy-related metrics, specifically ADE, DAs, and OCs. The program made a difference based on the timing of the decline in ADEs, DAs, and OCs with the start of the educational interventional phase (Figures 2 and 3). In addition, even though ED patient volumes increased in Quarter 3, the number of medication errors still decreased with program implementation. The program also increased staff awareness and utilization of the ED pharmacist, as indicated by the overall increase in the total number of pharmacy interventions, particularly verbal requests for drug information. This is likely to have contributed to the decreased frequency of ADEs, DAs, and OCs.

The cost avoidance associated with each ADE reported during the study period was estimated. Lada and Delgado[10] reported the potential cost avoidance of medication errors and ADEs to be $1375 and $1098 per event, respectively, in the Veterans' Health Administration hospital system. Direct cost savings and decreased length of stay associated with ADE detection or prevention by a clinical pharmacist have also been demonstrated.[21] The estimated cost avoidance for ADEs in our study ranged from $3580 to $10,585 per event. Although most of our analysis was based on direct health care costs related to the ADE and treatment, nursing and pharmacist employment costs were included, along with a detailed description of the interventions performed, which previously published cost analyses tend to exclude.[22] Limitations of this cost analysis include lack of a societal perspective or inclusion of patients' health benefits towards treatment and hospital costs.[22] We also did not include physician costs, costs related to any complaints or potential litigation, or the costs of patient suffering and morbidity.

In conclusion, the resident physician educational program *Quality 101* and incorporation of the ED pharmacist into the residency curriculum were well received by the physicians and the ED staff. Future goals include continuing to expand the role of the ED pharmacist and permanent implementation of *Quality 101* into the residency curriculum. Although the educational program focused on the residents, it increased ED staff awareness of medication safety and the importance of health care quality, which in turn created a culture of patient safety. Successful resident physician training programs should incorporate a multidisciplinary team of health care professionals to ensure a complete approach to patient care and medication safety.

DISCLOSURE The authors declare no conflicts or financial interest in any product or service mentioned in the manuscript, including grants, equipment, medications, employment, gifts, and honoraria.

ACKNOWLEDGMENTS This work was presented in poster form at the 2010 Annual Meeting of the Pediatric Academic Societies, Vancouver, BC, Canada, May 4, 2010; the 2010 Annual Meeting of the Pediatric Pharmacy Advocacy Group, St. Charles, MO, Oct 7, 2010; and the 2010 Annual Meeting of the American College of Clinical Pharmacy, Austin, TX, Oct 20, 2010.

ABBREVIATIONS ADE, adverse drug event; CI, confidence interval; CL, control limits; DA, dosage adjustment; ED, emergency department; NP, nurse practitioner; OC, order clarification; PA, physician assistant; SPC, statistical process control.

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