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Pharmacist Avoidance or Reductions in Medical Costs in Critically and Emergently Ill Pediatrics: PHARM-PEDS Study

Amy L. Kiskaddon, PharmD, MBA[1,2]

Michelle M. Smith, MD[3]

Frankie Gilliland, DNP, CPNP, AC/PC[3]

Megan A. Rech, PharmD, MS, FCCM[4,5]

Pharmacist Avoidance or Reductions in Medical Costs in Critically and Emergently Ill Pediatrics (PHARM-PEDS) Investigators

OBJECTIVES: To comprehensively classify interventions performed by pediatric critical care clinical pharmacists and quantify cost avoidance (CA) generated through their accepted interventions.

DESIGN: A multicenter, prospective, observational study performed between August 2018 and January 2019.

SETTING: Academic and community hospitals in the United States with pediatric critical care units.

SUBJECTS: Pediatric clinical pharmacists.

INTERVENTIONS: Pharmacist recommendations were classified into one of 38 total intervention categories associated with CA.

MEASUREMENTS AND MAIN RESULTS: Nineteen pediatric pharmacists at five centers documented 1,458 accepted interventions during 112 shifts on 861 critically ill pediatric patients. This calculated to an associated CA of $450,590. The accepted interventions and associated CA in the six established categories included as follows: adverse drug event prevention (155 interventions, $118,901 CA), resource utilization (267 interventions; $59,020), individualization of patient care (898 interventions, $217,949 CA), prophylaxis (8 interventions, $453 CA), hands-on care (30 interventions, $35,509 CA), and administrative/supportive tasks (108 interventions, $18,758 CA). The average associated CA was $309 per accepted intervention, $523 per patient day, and $4,023.13 per pediatric clinical pharmacist shift. The calculated potential annualized CA of accepted interventions from a pediatric pharmacist was $965,550, resulting in a potential monetary-associated CA-to-pharmacist salary ratio between $1.5:1 and $5.2:1.

CONCLUSIONS: There is potential for significant avoidance of healthcare costs when pediatric pharmacists are involved in the care of critically and emergently ill pediatric patients, with a monetary potential CA-to-pediatric pharmacist salary ratio to be between $1.5:1 and $5.2:1.

KEYWORDS: cost; medication; pediatric critical care; pharmacist; safety

Critically and emergently ill neonates, infants, and children require intensive care and emergency services. Neonatal ICU (NICU) admission rates were reported as 77.9 for every 1,000 live births in 2012 (1), costing an estimated 26.2 billion U.S. dollars (USD) per year (2). A study evaluating United States PICU resources noted admission rates to be almost 170,000 in 2012–2013, with associated cumulative total hospitalization costs accounting for more than USD 9.1 billion (3). There were 30 million pediatric emergency department (ED) visits in 2015, at a rate of 382.9 per 1,000 population (4). Pediatric patients provide a unique set of challenges because of limited communication ability, differences in pharmacokinetics, vulnerability to medical errors, and need for individualized care (5). Healthcare teams in pediatric

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KEY POINTS

Question: What is the impact of pediatric pharmacy services in the pediatric critical care setting?

Findings: Nineteen pediatric pharmacists documented 1,458 accepted interventions on 861 critically ill pediatric patients. The potential annualized cost avoidance (CA) of accepted interventions was $965,550, resulting in a potential monetary-associated CA-to-pharmacist salary ratio between $1.5:1 and $5.2:1.

Meaning: Emerging evidence indicates that pediatric critical care pharmacists play an integral role in the prevention of medical errors.

ED and ICUs that once consisted of physicians and nurses have evolved to include pediatric trained pharmacists, who apply physiologic and pharmacology knowledge to patient care (6, 7). The shift from a distribution role to participation in direct patient care activities as members of the multidisciplinary team has improved outcomes and decreased hospital costs (8–19). Professional healthcare organizations, such as the American Academy of Pediatrics, have also endorsed pharmacists as members of the medical team (20). However, there are limited data reporting the impact of pediatric pharmacist services.

Previous studies of interventions performed by pharmacists practicing in pediatric or critical care areas have focused on adverse drug event (ADE) prevention, incorrect dosing (under- and overdosing), drug monitoring, drug interaction/incompatibility, therapy changes, and dosage form modifications (21, 22). Pediatric pharmacists have been reported to perform 21 interventions per day, preventing nearly all medication order errors from reaching patients (9, 23). Given pharmacists are typically not revenue-generating, cost-to-benefit ratios may be useful in describing potential benefits (24). Although recent data in the adult critical care and emergency medicine setting have noted an annualized monetary benefit-to-cost ratio to be upward of 10.6:1, data specific to pediatric pharmacists in the ICU and ED settings are lacking (13–16). The purpose of this study was to classify interventions performed by pediatric pharmacists and quantify potential cost avoidance (CA) generated by accepted interventions.

METHODS

Study Design

The Pharmacist Avoidance or Reductions in Medical Costs in Critically and Emergently Ill Pediatrics (PHARM-PEDS) study was a multicenter, prospective, observational study conducted in academic and community hospitals in the United States caring for critically ill children between August 2018 and January 2019. PHARM-PEDS was part of two larger adult studies, PHARM-CRIT (PHarmacist Avoidance or Reductions in Medical Costs in CRITically Ill Adults) study and PHARM-EM (PHarmacist Avoidance or Reductions in Medical Costs in Patients Presenting the EMergency Department) study (15, 16). Pediatric pharmacist recruitment occurred through invitation to participate emails sent to members of the Society of Critical Care Medicine (SCCM) Clinical Pharmacy and Pharmacology section listserv as part of the PHARM-CRIT and PHARM-EM studies. Inclusion criteria included: pediatric clinical pharmacists providing direct or decentralized care to pediatric patients in the NICU, PICU, or ED. Pharmacists completing postgraduate training (e.g., residency or fellowship training) were not eligible for participation. Pediatric pharmacists were recommended to document interventions for at least 20 shifts according to a typical institutional schedule. The Rush University Medical Center's institutional review board (IRB) served as coordinating IRB (18021508-IRB01, March 2018). Ethical procedures were followed in accordance with institutional standards and the Helsinki Declaration of 1975. The SCCM Discovery Research Network, SCCM Clinical Pharmacy and Pharmacology Section, endorsed this study.

Data Collection

An evidenced-based framework based on a scoping review of more than 150 studies that categorized and monetized pharmacist interventions in the critical care and ED setting was used to organize and provide CA associated with pharmacist interventions (**Supplement Table 1**, http://links.lww.com/CCX/B256) (17). The published framework consists of 38 interventions grouped into six different categories: ADE prevention, resource utilization, individualization of patient care, prophylaxis, hands-on care, and administrative and supportive tasks (Supplement Table 1, http://links.lww.com/CCX/B256) (17). Pediatric clinical pharmacists documented all clinical interventions, whether accepted or not, into the Research Electronic Data Capture (version 6.18.1, 2019; Vanderbilt University, Nashville, TN) (25). Training on accurate documentation using established criteria was required prior to participation. Although both unaccepted and accepted interventions were documented, only accepted interventions were included in the final analysis.

Definitions

The intervention categories were defined as follows: 1) ADE prevention: intervention preventing a major or minor adverse event; 2) resource utilization: intervention to minimize unnecessary costs; 3) individualization of patient care: intervention tailored to patient-specific clinical status; 4) intervention resulting in the initiation of a prophylaxis strategy; 5) hands-on care: active participation in bedside care, such as a medical emergency event, medication education, or medication preparation bedside; and 6) administrative and supportive tasks: intervention that provides drug information, adherence to an established hospital protocol, or action secondary to collaborative practice. An accepted intervention was defined as the adoption of a pharmacist's recommendation.

Study Outcomes and Statistical Analysis

The primary outcomes were the number, category, and associated CA from pediatric clinical pharmacists in the ICU and ED settings. To calculate CA, a summation of the CA for each accepted intervention was performed. Monetary values for each intervention were based on the published evidenced-based framework developed and expressed in 2019 USD (Supplement Table 1, http://links.lww.com/CCX/B256) (17, 26, 27). The framework used was developed from a scoping literature review of critical care and emergency medicine pharmacist recommendations from expert opinion, observational, and controlled studies.

To evaluate intervention-associated CA with high-quality evidence (evidence from well-designed controlled trials without/with randomization), a sensitivity analysis was subsequently conducted in accordance with the Grading of Recommendations, Assessment, Development, and Evaluation evidence-to-decision structure (28). The interventions include the following: 1) medication route: intravenous-to-oral conversion (resource utilization); 2) medication route: hypertensive crisis management (resource utilization); 3) antimicrobial therapy initiation and streamlining (individualization of patient care); 4) change venous thromboembolism prophylaxis to most appropriate agent (prophylaxis); and 5) initiation of venous thromboembolism prophylaxis (prophylaxis) (17).

To account for the possibility that not all interventions would have resulted in direct cost savings, a sensitivity analysis estimating CA across 25%, 50%, and 75% of accepted interventions was performed. This provided a CA range of anticipated benefits gained from each intervention across a range of outcomes.

Descriptive statistics were used. Associated CA with interventions was annualized based on 240 shifts or five shifts per week for 48 weeks. To determine a monetary CA-to-pharmacist salary ratio, the calculated annualized CA for a pharmacist was evaluated in context of the average pharmacist's earnings and benefits ($185,470) (26, 27). All data analyses were conducted using Stata (version 16; StataCorp, College Station, TX).

RESULTS

During the study period, 19 pharmacists at five centers completed 112 shifts (**Table 1**). Most pharmacists worked in the PICU (73.7%) and NICU (63.2%), and 52.6% provided care in more than one unit at a time. Nearly all pharmacists (89.5%) interacted with advanced practice providers, intensivists, and medical residents. Pharmacists spent approximately half the shift providing direct patient care (mean 4.1 hr, SD 9 hr). Pharmacists provided care for multiple services, with 25.9% providing coverage for one team, 48.2% covering two teams, 17% covering three teams, and 8.9% covering four or more teams. The median number of pharmacist shifts was 7 (interquartile range 4–12). The number of patients each pharmacist provided care for per shift had significant variability (mean 23 [SD 17] patients). Years in practice were well distributed among pharmacists and 52.6% were board-certified (Table 1).

In total, 97.8% of pediatric pharmacists' interventions were accepted. There were 19 pharmacists at five centers who performed 1,458 accepted interventions on 861 patients in six categories: ADE prevention

TABLE 1.
Pediatric Pharmacist Characteristics

Characteristic	Pediatric Pharmacists (*n* = 19)
Practice area[a]	
Emergency department	4 (21.0)
Pediatric ICU	14 (73.7)
Neonatal ICU	12 (63.2)
Practice model	
Open ICU practice model	4 (21.0)
ICU rounding 5–7 d/wk[b]	17 (100)
Beds in ICU practice area, mean (SD)	30.2 (23.1)
Nonpharmacist providers in practice area[c]	
Advanced practice provider	17 (89.5)
Emergency medicine attending	4 (21.0)
Hospitalist	6 (31.3)
Intensivist	17 (89.5)
Fellow	11 (57.9)
Resident	17 (89.5)
Institution type	
Academic medical center	4 (80)
Community teaching hospital	1 (20)
Pharmacist shifts	
Shift duration, 8 hr	93 (83.8)
Shift duration, 10 hr	17 (15.3)
Shift duration, 12 hr	1 (0.9)
Shifts worked, median (IQR)	7 (4-12)
Direct patient care duration per shift (hr), mean (SD)	4.1 (2.9)
Services rounded with each shift	
1	29 (25.9)
2	54 (48.2)
3	19 (17.0)
4 or more	10 (8.9)
Patients cared for per shift (*n*), mean (SD)	23 (17)
Total time in practice (yr)[d]	
≤ 1	2 (11.8)
> 1–3	6 (35.3)
> 3–6	3 (17.6)
> 6–12	3 (17.6)
≥ 12	3 (17.6)
Board certified, *n* (%)	10 (52.6)

[a]Cumulative percentage exceeds 100% because many pharmacists practice in multiple areas.
[b]Seventeen of 19 pharmacists practiced in at least one ICU.
[c]Cumulative percentage exceeds 100% because multiple providers in practice areas and many pharmacists practice in multiple practice areas.
[d]Seventeen of 19 pharmacists responded.

(accepted interventions: 155; percentage of all accepted interventions: 10.6%), resource utilization (267; 18.3%), individualization of patient care (898; 61.6%), prophylaxis (8; 0.5%), hands-on care (30; 2.1%), and administrative/supportive tasks (108; 7.4%). Most interventions (71%) were performed in the PICU, and the majority of interventions included the following: renal dosage adjustments in patients not receiving continuous renal replacement therapy (CRRT) (295; 20.2%), discontinuation of clinically unwarranted therapy (157; 10.8%), total parenteral nutrition (TPN) management (152; 10.4%), antimicrobial pharmacokinetic evaluation (149; 10.2%), antimicrobial therapy initiation and streamlining (134; 9.2%), and initiation of non-antimicrobial therapy (133; 9.1%). Interventions from the five most validated intervention categories totaled 225 (15.4% of all accepted interventions) (**Supplement Table 2**, http://links.lww.com/CCX/B256).

The potential CA associated with pharmacist recommendations totaled $450,590: ADE prevention (CA: $118,901; percentage of total CA: 26.4%), resource utilization ($59,020; 13.1%), individualization of patient care ($217,949; 48.4%), prophylaxis ($453; 0.1%), hands-on care ($35,509; 7.9%), and administrative/supportive ($18,758; 4.2%). Greatest CA included antimicrobial therapy initiation and streamlining ($82,470; 18.3%), major ADE prevention ($66,987; 14.9%), and dose adjustments in patients not receiving CRRT ($49,681; 11.0%). The CA from the five most validated intervention categories totaled $127,362 (28.3% of CA from all accepted interventions) (**Supplement Table 3**, http://links.lww.com/CCX/B256). The sensitivity analysis estimated CA across 25%, 50%, and 75% of accepted interventions (**Supplement Table 4**, http://links.lww.com/CCX/B256).

When considering all accepted interventions, the average potential CA was $309 per intervention, $523 per patient, and $4,023 per pharmacist shift. The annualized potential CA associated with interventions from a pediatric pharmacist was $965,550. The potential monetary CA-to-pharmacist salary ratio was 5.2:1. When applying the sensitivity analysis and considering accepted interventions from the five most validated intervention categories, the average potential CA was $566 per intervention, $148 per patient each day, and $1,137 per pharmacist shift, resulting in a potential annualized CA of $272,919 and CA-to-pharmacist salary ratio of 1.5:1. For the second sensitivity analysis, the annualized potential CA from a pediatric pharmacist was $241,387.50 (25%), $482,775 (50%), and $724,162.50 (75%) equating to an estimated CA-to-pharmacist salary ratio of 1.3:1 to 3.9:1.

DISCUSSION

This is the first multicenter, prospective study to categorize and quantify potential CA associated with pediatric ICU and ED pharmacist interventions. Of the documented interventions, 97.8% were accepted, resulting in $4,023 potential CA per pediatric pharmacist shift when all interventions were considered, or $1,137 potential CA with the most validated intervention categories. In the pediatric critical care setting, CA was predominantly generated from interventions that individualized patient care, prevented ADEs, and used resources more effectively. The potential monetary CA-to-pharmacist salary ratio for pediatric pharmacists was between 1.5:1 and 5.2:1.

Few studies evaluating pediatric pharmacist interventions report financial implications (8–13, 19, 20). Recent studies evaluating adult ICU and ED pharmacist impact found monetary benefit-to-cost ratios of 9.62:1 and 10.63:1, respectively (14–17). In these studies, acceptance rates for some interventions were below 90%, whereas in PHARM-PEDS were accepted at least 91.7% of the time. At the most conservative estimate of CA associated with pediatric pharmacist interventions

WHAT THIS STUDY MEANS

- Nineteen pediatric pharmacists at five centers documented 1,458 accepted interventions during 112 shifts on 861 critically ill pediatric patients.
- The calculated potential annualized cost avoidance (CA) of accepted interventions from a pediatric pharmacist was $965,550, resulting in a potential monetary-associated CA-to-pharmacist salary ratio between $1.5:1 and $5.2:1.
- There is potential for avoidance of healthcare costs when pediatric pharmacists are involved in the care of critically and emergently ill pediatric patients.

(25% in our second sensitivity estimate), the benefit added by a pharmacist still exceeded the pharmacist's salary. To date, there are no other multicenter studies evaluating pediatric pharmacists' potential return on investment.

Pediatric patients are at an increased risk for medication errors, which is further heightened in the critical care setting given pharmacokinetic changes, use of high-risk medications, and drug–drug interactions (11–13, 23, 29–31). Over 10% of interventions performed by pediatric pharmacists prevented or minimized ADEs. The impact that pediatric pharmacists may have on ADE prevention aligns with the findings by Kaushal et al, which noted a 79% absolute reduction in serious error when pediatric pharmacists were directly involved in patient care (29). In addition to preventing 62 ADEs through patient care, 12 additional ADEs were prevented through medication reconciliation.

Pediatric pharmacists are well positioned to support integration of medication availability and cost management into patient care decisions. Approximately one-fifth of interventions improved resource utilization, such as converting more costly intravenous medications to enteral dosage forms or discontinuing unnecessary medications. Such practices may be part of a hospital-approved protocol or collaborative practice agreement, which may minimize hospital costs while improving patient outcomes (30–34). Although activities specific to medications on shortage were performed less frequently by pediatric ICU pharmacists compared with adult ICU pharmacists, such stewardship activities are vital to ensure medications are available when needed in critically ill children (32).

Individualizing care for pediatric patients was the most common intervention performed by pediatric pharmacists, representing over two-thirds of all accepted interventions, accounting for nearly half of the CA generated. Of note, this was greater than the 41% and 24% CA generated by adult ICU and ED pharmacists, respectively (15, 16). The pediatric pharmacist's ability to individualize therapy selection and dosing given developmental pharmacokinetic and pharmacodynamic principles is widely recognized as an important contribution of pediatric pharmacist activities (9–13). When compared with physician-led efforts, shorter hospital lengths of stay have been described with pharmacist-driven antimicrobial stewardship efforts, TPN modifications, dose adjustments, and medication tapering protocols (32–35).

There were fewer interventions related to prophylaxis when compared with the adult population. This may be because interventions were largely based around venous thromboembolism prophylaxis, which is not routinely used in pediatric patients younger than 12 years. However, prophylaxis strategies represent a value-added intervention that minimizes ADEs and high-risk complications in critically ill patients or at transitions of care if prophylactic agents are continued (35–37).

Pediatric pharmacists also participated in hands-on care activities, namely emergency code blue response, an activity highly encouraged by the Pediatric Pharmacy Association (37). In critical and emergent situations, pediatric pharmacists complement other healthcare team members to facilitate accurate and timely care that is compliant with evidenced-based guidelines (38, 39).

With regard to administrative and supportive tasks, pediatric pharmacists were most involved with drug information consultation and patient own medication evaluation. These interventions highlight the reliable and invaluable uses of a pharmacist's specialty knowledge and minimize concerns related to nuanced aspects of patient care plans (6–13). Pharmacists are a vital contribution to a safety culture, and although these interventions are valued by hospital and regulatory bodies, it remains difficult to quantify these types of services provided by pharmacists from a potential CA perspective.

This is the first multicenter study evaluating specific interventions made by pharmacists in the pediatric ICU and ED settings to categorize and associate potential CA. Given the nature of this study, there are limitations to note. First, because of the small number of pediatric pharmacists who participated, findings may not be generalizable. Second, variables that may affect study outcomes were not evaluated (e.g., patient volume/complexity, pharmacist coverage of multiple units, professional relations, and interpersonal traits). Furthermore, the actual quantity and type of intervention could be incomplete, a greater number of interventions than were documented may have been performed and accepted, and it is difficult to account for differences in contributions across the groups. There is also the theoretical potential risk of double counting CA interventions or bias that self-reported interventions were inflated or more frequently documented. However, to minimize this, all pharmacists were trained on appropriate intervention documentation prior to starting the study, reviewed for accuracy, and CA interventions were linked to a specific medication to minimize the potential of double counting CA activities. Third, in determining the potential CA, a published framework of more than 150 studies was used for categorizing an associated CA with interventions (Supplement Table 1 and **Supplement Table 5**, http://links.lww.com/CCX/B256) (17). Given the lack of pediatric CA data, this framework was derived largely from adult critical care studies, and therefore, requires extrapolation to the pediatric population, which may limit the ability to generalize CA data to the pediatric patient population in this study (Supplement Table 1 and Supplement Table 5, http://links.lww.com/CCX/B256). Additionally, the authors developed a table noting the specifics of each study reference, it is worth noting the Consolidated Health Economic Evaluation Reporting Standards Guidelines were developed after the completion of this study, and given limited data in pediatrics, it is not uncommon to extrapolate from adult data in efforts to facilitate future pediatric studies (Supplement Table 5, http://links.lww.com/CCX/B256) (40). Critically ill pediatric patients have unique challenges in medication management, and it is unclear how this might influence our findings. Counterfactual arguments for CA also assume that the potential ADE would reach the patient, resulting in excess cost. Efforts to mitigate this confounding factor include using an established scoring for major/minor ADE prevention and associated costs. It is also worth noting that some categories, such as costs associated with ADE might be more challenging to assign values as baseline data regarding ADE occurrence without a pharmacist may be lacking. Because five intervention categories had a greater level of evidence than the others, a separate analysis was conducted to serve as an anchor for the lowest suspected CA from a pediatric ICU or ED pharmacist. Specifically, a sensitivity analysis estimating 25%, 50%, and 75% of the total CA across interventions was conducted to provide estimates that are more conservative and account for situations where there is variation in the monetary benefits derived from each intervention. However, there still would need to be a substantial decrease in accepted interventions for the monetary benefit-to-cost ratio to become unacceptable. Although the types of preventable ADEs are similar to those found in other studies, the actual cost or full extent of ADE implications still remains unknown. Thus, participating pharmacists were educated prior to study participation to conservatively classify ADEs, which may have resulted in an overall underappreciation of actual CA. The need for research on the impact of pediatric pharmacists' interventions on clinical outcomes remains.

CONCLUSIONS

In the pediatric critically and emergently ill patient populations, pharmacist participation leads to reductions in healthcare costs, particularly in the areas of individualization of patient care, ADE prevention, and resource utilization. This study found a potential monetary CA-to-pharmacist salary ratio for pediatric pharmacists caring for critically and emergently ill pediatric patients to be between 1.5:1 and 5.2:1.

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1 *Department of Pharmacy, Johns Hopkins All Children's Hospital, St. Petersburg, FL.*

2 *Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, MD.*

3 *Division of Critical Care Medicine, Johns Hopkins All Children's Hospital, St. Petersburg, FL.*

4 *Department of Veterans Affairs, Center of Innovation for Complex Chronic Healthcare, Edward Hines, Jr. VA Hospital, Hines, IL.*

5 *Department of Emergency Medicine, Loyola University Medical Center, Maywood, IL.*

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For information regarding this article, E-mail: akiskad1@jhmi.edu

Pharmacist Avoidance or Reductions in Medical Costs in Critically and Emergently Ill Pediatrics (PHARM-PEDS) Investigators provided in ***Supplemental Appendix*** *(http://links.lww.com/CCX/B256).*

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