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OPEN

PHarmacist Avoidance or Reductions in Medical Costs in Patients Presenting the EMergency Department: PHARM-EM Study

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OBJECTIVES: To comprehensively classify interventions performed by emergency medicine clinical pharmacists and quantify cost avoidance generated through their accepted interventions.

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

SETTING: Community and academic hospitals in the United States.

PARTICIPANTS: Emergency medicine clinical pharmacists.

INTERVENTIONS: Recommendations classified into one of 38 intervention categories associated with cost avoidance.

MEASUREMENTS AND MAIN RESULTS: Eighty-eight emergency medicine pharmacists at 49 centers performed 13,984 interventions during 917 shifts that were accepted on 8,602 patients and generated $7,531,862 of cost avoidance. The quantity of accepted interventions and cost avoidance generated in six established categories were as follows: adverse drug event prevention (1,631 interventions; $2,225,049 cost avoidance), resource utilization (628; $310,582), individualization of patient care (6,122; $1,787,170), prophylaxis (24; $22,804), hands-on care (3,533; $2,836,811), and administrative/supportive tasks (2,046; $342,881). Mean cost avoidance was $538.61 per intervention, $875.60 per patient, and $8,213.59 per emergency medicine pharmacist shift. The annualized cost avoidance from an emergency medicine pharmacist was $1,971,262. The monetary cost avoidance to pharmacist salary ratio was between $1.4:1 and $10.6:1.

CONCLUSIONS: Pharmacist involvement in the care of patients presenting to the emergency department results in significant avoidance of healthcare costs, particularly in the areas of hands-on care and adverse drug event prevention. The potential monetary benefit-to-cost ratio for emergency medicine pharmacists is between $1.4:1 and $10.6:1.

KEY WORDS: cost; medical care; medication; pharmacist; safety; value

Patient visits to emergency departments (EDs) in the United States totaled almost 137 million in 2015 (1). Over the last few decades, emergency medicine (EM) teams that typically consisted of physicians and nurses have evolved to incorporate other professions, including pharmacists. Traditionally, pharmacists began their careers immediately after pharmacy school or 1 year of postgraduate residency training, whereas current EM pharmacists frequently have completed specialty residency or fellowship training and are board certified. Subsequently, the role of pharmacists in the care of

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ED patients has shifted from verifying, preparing, and dispensing medications in a remote location to performing direct, bedside patient care as a member of the EM multidisciplinary team (2). EM pharmacists are required to call upon knowledge pertaining to pharmacology ranging from pediatrics to geriatrics and critical care to primary care, which has resulted in improved outcomes in numerous populations and hospital structures (2–11). Consequently, multiple professional healthcare organizations, including the American College of Emergency Physicians and American College of Medical Toxicology, consider EM pharmacists to be essential healthcare providers (10–12). Despite these endorsements, a 2016 survey of characterizing EM pharmacist services found that over half of EDs employed EM pharmacists 12 hours per day or less, suggesting that EM pharmacists remain widely underutilized (13).

Previous studies of interventions performed by EM pharmacists have focused on adverse drug event (ADE) prevention and reductions in medication use and costs (3, 8, 9, 14). While these studies have made important steps toward establishing the value an EM pharmacist brings to patient care, they are limited in size and scope and document interventions in a heterogeneous manner not based on a rigorous framework. The only contemporary study to use a framework for cost avoidance (CA) from pharmacist interventions evaluated a medical ICU pharmacist's clinical activities over a 12-month period and determined the CA of those activities exceeded $3 million with a benefit-cost ratio of 24.5:1 (15). However, these findings may not be generalizable to the ED as the composition of interventions and practice culture differ greatly. The purposes of this study were to comprehensively classify interventions performed by EM pharmacists and quantify CA generated through accepted interventions.

METHODS

Study Design

The PHarmacist Avoidance or Reductions in Medical costs in patients presenting the EMergency Department study was a multicenter, prospective, observational study performed across the United States in community and academic hospitals between August 2018 and January 2019. Recruitment was conducted via direct electronic mail with invitations sent to the Society of Critical Care Medicine's (SCCM) Clinical Pharmacy and Pharmacology section listserv. From this listserv, which includes multiple healthcare professionals in addition to pharmacists, clinical pharmacists who provided direct (at the bedside) or decentralized (not directly within the ED) patient care for ED patients were invited to participate. Pharmacists currently completing residency or fellowship training were not eligible for study participation. Multiple pharmacists from the same institution were eligible to participate. No minimum or maximum duration of study participation by each pharmacist was required so as to maximize data capture for pharmacist interventions; however, participants were encouraged to document interventions for 20 shifts. Only interventions made by a pharmacist for patients residing in an ED were eligible for study inclusion.

Data Collection

In preparation for this study, a comprehensive, evidence-based framework for categorizing and monetizing CA interventions by critical care and EM pharmacists was developed by our group a priori and previously published (16). This framework contained 38 interventions associated with CA that pharmacists can perform in the ICU and ED settings. Each intervention category was grouped into one of six intervention sections: ADE prevention, resource utilization, individualization of patient care, prophylaxis, hands-on care, and administrative and supportive tasks (**Supplemental Table 1**, http://links.lww.com/CCX/A595). All clinical interventions made by participating pharmacists, regardless of their acceptance by the healthcare team, were recorded in Research Electronic Data Capture (Version 6.18.1, 2019; Vanderbilt University, Nashville, TN) (17). All participants received training on appropriate documentation of interventions using the CA framework. Interventions were entered at the patient level by each individual pharmacist. Each intervention could only be documented in one intervention category; however, if multiple interventions were conducted in a given patient, pharmacists were encouraged log each intervention. Pharmacists were encouraged to enter these data in real time to provide the most accurate accounting of interventions. Although all interventions (accepted and not accepted) were captured, only interventions accepted and implemented by the medical team were included in the CA analysis. Any intervention unable to be classified was not recorded or available for study inclusion. Rush University Medical Center,

the central and coordinating institutional review board (IRB), reviewed and approved this study (IRB number 18021508-IRB01). This study was endorsed by the SCCM Discovery Network and was a work product of the SCCM Clinical Pharmacy and Pharmacology Section.

Study Outcomes and Statistical Analysis

The primary outcomes were the quantity, type, and acceptance of interventions provided by and the potential CA generated from clinical pharmacists practicing in ED settings. CA values overall and per patient were calculated by summing the CA for each intervention based on values from our previously published systematic framework and expressed in 2019 U.S. dollars (16). This framework, developed through a scoping review of the literature for interventions that could be performed by ICU and/or ED pharmacists, standardizes the capture of pharmacist interventions in this setting and includes CA data for each type of intervention based on controlled and observational studies, as well as expert opinion. A sensitivity analysis was conducted to evaluate CA from those interventions we previously identified with the highest quality of evidence (evidence from well-designed controlled trials with or without randomization) according to the Grading of Recommendations, Assessment, Development, and Evaluation evidence-to-decision framework (18). These interventions included the following: 1) medication route: IV to oral conversion (resource utilization section), 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) (16). Demographic data were collected on each pharmacist and institution. Patients were categorized according to Emergency Severity Index (ESI).

Data were characterized using descriptive statistics. The CA per pharmacist shift value was annualized using 240 shifts, corresponding to five shifts per week for 48 weeks, allowing for personal time off and holidays. This annualized CA for a pharmacist was compared with the average pharmacist salary and benefits not including overhead ($185,470) to calculate a monetary CA to pharmacist salary ratio (19). Analyses were performed in Stata (Version 16; StataCorp LLC, College Station, TX).

RESULTS

One-hundred twenty-four pharmacists responded to our invitation to participate, with 88 pharmacists subsequently participating in the study. During the study period, these 88 pharmacists at 49 centers across the United States completed 917 shifts. The mean ED visits per year at participating hospitals was 75,226 (SD 32,399). Pharmacists most frequently had been in practice for 1–3 years (40.9%) and were board certified (72.7%). EM pharmacists spent the majority of their shift providing direct patient care (median, 6 hr; interquartile range [IQR], 4–8 hr) incorporating prospective order verification into their shifts for a median of 5.5 hours (IQR, 1–9 hr). Most shift lengths were 8 hours (43.1%) or 10 hours (36.8%). EM pharmacists infrequently rounded with a multidisciplinary clinical service (17.4%) but rather spent a majority of time providing bedside services in the ED. The median number of shifts was 17 (IQR, 6–20), with significant variability in the number of patients each EM pharmacist-provided care for per shift (median, 55; IQR, 30–100). Patient acuity was most commonly ESI levels 2 or 3 (**Table 1**).

Of the 14,345 interventions made by EM pharmacists, 13,984 (97.4%) were accepted and implemented by the medical team. These 13,984 interventions were performed on 8,602 patients in six sections: ADE prevention (accepted interventions: 1,631; percentage of total accepted interventions: 11.7%), resource utilization (628; 4.5%), individualization of patient care (6,122; 43.8%), prophylaxis (24; 0.2%), hands-on care (3,533; 25.3%), and administrative/supportive tasks (2,046; 14.6%). The most frequent interventions were dosage adjustments in patients not receiving continuous renal replacement therapy (CRRT; accepted interventions 2,207; percentage of accepted interventions: 15.8%), initiation of nonantimicrobial therapy (1,705; 12.2%), antimicrobial therapy initiation and streamlining (1,375; 9.8%), and bedside monitoring (1,207; 8.6%). The least frequently accepted interventions were rejection of a restricted medication (percentage accepted: 84.6%), antivenin stewardship (87.5%), and medication reconciliation resulting in minor ADE prevention (88.7%). Interventions from the five intervention categories with the highest quality of evidence totaled 1,564 (11.2% of accepted interventions) (**Table 2**).

The potential CA generated from pharmacist recommendations totaled $7,531,862 in six sections: ADE

TABLE 1.
Emergency Medicine Pharmacist Characteristics

Characteristic	EM Pharmacist ($n = 88$)
Years in practice, *n* (%)	
≤ 1	11 (12.5)
> 1–3	36 (40.9)
> 3–6	24 (27.3)
> 6–12	13 (14.8)
≥ 12	4 (4.6)
ED visits per year, mean (SD)	75,226 (32,399)
Institution type, *n* (%)	
Academic medical center	44 (45.4)
Community teaching	34 (35.1)
Community nonteaching	18 (18.6)
Government	1 (1)
Special populations seen by EM pharmacists, *n* (%)	
Burn	21 (23.9)
Pediatrics	49 (55.7)
Trauma	68 (77.3)
Stroke	77 (87.5)
Shift duration (hr), *n* (%)	
8	3,272 (43.1)
10	2,793 (36.8)
12	1,117 (14.7)
Other	412 (5.4)
Shifts worked, median (IQR)	17 (6–20)
Direct patient care duration per shift (hr), median (IQR)	6 (4–8)
Prospective order verification duration per shift (hr), median (IQR)	5.5 (1–9)
Multidisciplinary clinical services rounded with each shift, *n* (%)	
0	4,948 (82.6)
1	569 (9.5)
2	37 (0.6)
3	367 (6.1)
4 or more	68 (1.1)
Patients cared for per shift (*n*), median (IQR)	55 (30–100)
Emergency Severity Index, patients with accepted interventions, *n* (%)	
1	419 (9.2)
2	1,631 (35.7)
3	1,841 (40.3)
4	507 (11.1)
5	168 (3.7)

ED = emergency department, IQR = interquartile range.

prevention ($2,225,049; percentage of CA: 29.5%), resource utilization ($310,582; 4.1%), individualization of patient care ($1,787,170; 23.7%), prophylaxis ($22,804; 0.3%), hands-on care ($2,836,811; 37.7%), and administrative/supportive ($342,881; 4.6%). The areas of greatest CA were major ADE prevention ($1,232,561; 16.4%), antimicrobial therapy initiation and streamlining ($846,244; 11.2%), and blood factor stewardship ($683,590; 9.1%). CA from the five intervention categories with the highest quality of evidence totaled $959,351 (12.7% of CA from all accepted interventions) (Table 2).

Average potential CA from accepted interventions was $539 per intervention, $876 per patient, and $8,214 per EM pharmacist shift. The annualized potential CA from an EM pharmacist was $1,971,262. The potential monetary CA to pharmacist salary ratio was $10.6:1. When considering the sensitivity analysis of accepted interventions from the five most validated intervention categories, average potential CA was $613 per intervention, $112 per patient each day, and $1,046.18 per ED pharmacist shift. The annualized potential CA for an ED pharmacist was $251,084.23. The potential monetary CA to pharmacist salary ratio was $1.4:1.

DISCUSSION

This is the first multicenter, prospective study to comprehensively classify interventions performed by EM pharmacists and quantify potential CA generated through those interventions. The potential CA generated from 88 pharmacists over the study period totaled over $7.5 million U.S. dollars. This potential CA resulted from pharmacists intervening almost 14,000 times over the course of greater than 8,000 patients. In total, 97.2% of these interventions were accepted. EM pharmacists generated $8,214 in potential CA per shift when all interventions were considered and $1,046 in potential CA per shift when only the intervention categories with the highest quality of evidence were used. A significant portion of potential CA resulted from interventions that involved hands-on care and prevented ADE development. The monetary CA to pharmacist salary ratio for EM pharmacists appears to be between $1.4:1 and $10.6:1.

Previous studies focusing on the monetary benefit-to-cost ratio of an EM pharmacist have primarily focused on a single disease state and have not used a

TABLE 2.
Accepted Pharmacist Interventions and Potential Cost Avoidance

Intervention	Accepted Interventions, *n*	Percentage Acceptance	Potential Cost Avoidance, $
Section 1: Adverse drug event prevention	1,631	95.0	2,225,049
Major ADE prevention[c]	368	97.9	1,232,561
Minor ADE prevention[c]	398	96.6	154,631
Medication reconciliation resulting in major ADE prevention[c]	168	98.8	568,224
Medication reconciliation resulting in minor ADE prevention[c]	456	88.7	182,565
Recommend laboratory monitoring[d]	241	98.8	93,633
Section 2: Resource utilization	628	96.2	310,582
Preventing unnecessary labs and/or tests[d]	47	100	18,260
Prevention of inappropriate screening of heparin-induced thrombocytopenia[b]	0	–	0
Medication route: IV to oral conversion[b]	169	92.9	10,007
Medication route: hypertensive crisis management[b]	4	100	81,340
Medication route: resolving shock management[c]	2	100	149
Discontinuation of clinically unwarranted therapy[c]	317	97.2	21,686
Prevention of unnecessary high-cost medication[d]	89	96.7	179,140
Section 3: Individualization of patient care	6,122	98.1	1,787,170
Dosage adjustment: continuous renal replacement therapy[c]	4	100	10,187
Dosage adjustment: no continuous renal replacement therapy[c]	2,207	98.2	371,681
Antimicrobial therapy initiation and streamlining[a]	1,375	97.6	846,244
Anticoagulant therapy management[c]	249	97.3	174,006
Initiation of nonantimicrobial therapy[c]	1,705	98.3	287,139
Antimicrobial pharmacokinetic evaluation[c]	581	98.5	97,846
Total parenteral nutrition management[c]	1	100	67
Section 4: Prophylaxis	24	100	22,804
Change venous thromboembolism prophylaxis to most appropriate agent[b]	13	100	252
Initiation of venous thromboembolism prophylaxis[b]	3	100	21,508
Initiation of stress ulcer prophylaxis[c]	7	100	397

(*Continued*)

TABLE 2. (*Continued*).
Accepted Pharmacist Interventions and Potential Cost Avoidance

Intervention	Accepted Interventions, *n*	Percentage Acceptance	Potential Cost Avoidance, $
Initiation of ventilator associated pneumonia prophylaxis with chlorhexidine[c]	1	100	647
Section 5: Hands-on care	3,533	97.4	2,836,811
Bedside monitoring[d]	1,207	97.7	468,944
Emergency code blue participation[c]	313	96.9	481,253
Rapid response team participation[c]	408	96.2	68,711
Emergency code stroke participation[c]	343	95.8	233,809
Emergency code sepsis participation[c]	129	98.5	204,453
Blood factor stewardship[c]	71	97.3	683,590
Emergency procedural sedation or rapid sequence intubation participation[c]	389	98.7	107,889
Medication teaching or discharge education[c]	373	98.9	255,650
Culture follow-up after emergency department discharge[d]	330	97.1	226,179
Antivenin stewardship[c]	7	87.5	106,333
Section 6: Administrative and supportive tasks	2,046	98.6	342,881
Drug information consultation[c]	1,154	97.8	130,494
Drug information consultation: toxicology specific[c]	142	98.6	60,270
Patient own medication evaluation[d]	239	100	92,856
Therapeutic interchange[c]	221	98.7	12,058
Pharmacist provided drug protocol management pursuant to collaborative practice agreement[c]	262	99.6	28,644
Rejection of a restricted medication[c]	22	84.6	18,559
Total	13,984	97.2	7,531,862

ADE = adverse drug event.
[a]Level of evidence IB.
[b]Level of evidence IIA.
[c]Level of evidence III.
[d]Level of evidence IV.
Values presented as cost avoidance in 2019 U.S. dollars (percentage of interventions accepted in section or subsection).

comprehensive framework of interventions to capture CA (8, 9, 20–23). These studies were limited by their single center nature, focused on a relatively limited number of interventions, and were not based on an evidence-based framework. As such, this current study adds substantially to the literature to support the role of the EM pharmacist as a member of the multidisciplinary team.

The most common types of intervention made by EM pharmacists were in the individualization of patient care category, accounting for nearly 44% of interventions and 24% of CA. The most frequent interventions were dosage adjustments in patients not receiving CRRT, initiation of nonantimicrobial therapy, and antimicrobial therapy initiation and streamlining. Pharmacists are able to intervene on a wide array of interventions, including dosing of medications based on a number of patient-specific factors such as age, weight, route of administration, and renal function (4). Pharmacists also play an important role in antimicrobial stewardship, demonstrating improved guideline adherence and antimicrobial selection, and decreasing the need for follow-up to change or prescribe antimicrobials (24, 25). Specifically, EM pharmacists have demonstrated an improvement in prescribing practices for community-acquired pneumonia and intra-abdominal infections (26). EM pharmacists likely had less frequent exposure to patients at high risk of medications being under- or over-dosed than the ICU but more than other inpatient areas because initial doses provided in the ED are less likely to exceed a toxic threshold and very few patients are provided CRRT in the ED (27).

EM pharmacists were very involved in the provision of hands-on care to emergently ill patients. Almost 25% of interventions and approximately 38% of CA resulted from these activities. Pharmacists participated in emergency code blue (i.e., cardiac arrest) response, which has been shown to improve compliance with advanced cardiac life support guidelines (23, 28). Additionally, EM pharmacists were highly active in acute stroke management, which frequently reduces door-to-needle times and increases the proportion of patients who are eligible to receive a thrombolytic if other criteria are met (22, 29). Finally, blood factor stewardship was the third-largest category of CA for EM pharmacists, ensuring appropriate use of blood factor products and dosages are achieved (30, 31). These activities have demonstrated a reduction in time to hemostasis and subsequent reduction in length of stay (21).

Almost one-third (30%) of interventions performed by EM pharmacists prevented or mitigated ADE development. Major ADE prevention provided the largest amount of CA of all interventions. Many of the ADEs prevented by EM pharmacists were likely because of the lack of available data and velocity at which new data are being generated and available for acting on in the ED (32, 33). These results build on previous findings from a landmark study in which a 66% relative risk reduction in ADEs was generated from adding pharmacists to interdisciplinary healthcare teams (34). In our study, in addition to preventing over 1,600 ADEs during patient care activities, over 600 additional ADEs were prevented following medication reconciliation. For ED patients, determining appropriate medication dosages, time of last dose, presence of medications that may result in withdrawal symptoms, and duplicative therapies are the most common interventions that prevent an ADE (35, 36).

EM pharmacists were infrequently reporting interventions supporting more efficient utilization of healthcare resources, ensuring prophylaxis was provided for patients at risk for preventable complications of critical illness, and performing administrative and supportive tasks. These findings are not surprising given these opportunities occur less frequently in ED patients, who are commonly being stabilized prior to admission than in already hospitalized patients (27). Many of the interventions in these sections may not occur until day 2 or 3 of hospitalization, including eliminating therapies, changing from IV to oral dosage forms, or resolving shock (20, 37, 38).

Major strengths of our study include the prospective design and data collection, multicenter nature, large sample size, and use of an evidence-based and previously published framework to categorize and monetize CA associated with interventions ED and ICU pharmacists could perform. Based on our design, there are important limitations to note that have the potential to both over- and under-estimate the CA. First, while 88 EM pharmacists were included, these results may not be generalizable to all EM or non-EM pharmacists and EDs due to possible selection bias due to the method of recruitment, characteristics of pharmacists likely to participate, and the voluntary nature of documenting interventions during each shift. The impact this may have had on documentation of interventions is uncertain. Second, documentation of the exact number and types of interventions were likely incomplete as prospective, real time data collection was performed and the ED is a dynamic environment that requires

a pharmacist's attention to move between multiple patients and activities. Additionally, interventions not included in the published framework were not included in this study. However, interventions that may not have been documented are likely offset by interventions that might otherwise have been implemented at a later point in time by another member of the healthcare team. Downstream clinical decisions that reversed a previous pharmacist intervention, appropriateness of initial interventions, and reasons for interventions not being accepted were not collected. In contrast, a potential bias for more frequently documenting accepted interventions or inflating interventions performed theoretically exists. Pharmacists could record interventions in a nonconsecutive manner at their discretion, which may have bias the study results. Although the study group lacked nonpharmacist collaborators, attempts to reduce this bias using the Hawthorne effect were instituted (39). Participating pharmacists were aware that all data analysis would be performed without the use of identifying information and were educated on proper identification and documentation of interventions prior to study participation. Third, while a comprehensive, evidence-based framework was used to classify interventions and quantify CA, these CA values are imperfect. While some are more tangible costs such as medication costs when changing from IV to oral, other costs such as ADE prevention, are more difficult to assign specific values given the unknown probability of the ADE occurring without pharmacists intervention. The interventions in our framework mostly pertain to critically ill patients in the ICU and may not capture activities of EM pharmacists with patients of lower acuity (16). The framework is also limited in that several studies date back several years and practice has evolved significantly since then. Additionally, data collection for this study was undertaken before the evidence-based framework was published; however, we did conduct a pilot to use this framework before the multicenter study (15). Because only five intervention categories have CA values that come from controlled studies, the results from the sensitivity analysis that used only these intervention categories was used to anchor the lowest suspected potential CA from EM pharmacists, resulting in a substantial decrease in benefit-to-cost ratio; this highlights the need for high-quality studies of EM pharmacists' contribution to CA. Furthermore, we were unable to assess the impact of indirect CA and benefits, such as protocol or order set implementation that drives practice changes and may have 'trickle down' effects on practice beyond an individual pharmacist-patient care scenario. Additional factors may have affected the quantity, types of interventions and acceptance, including interpersonal and professional relationships, patient volume, and complexity during the study period. Finally, the impact of the EM pharmacist on patient-specific outcomes remains to be determined and future research should correlate pharmacist interventions with patient outcomes like mortality and length of stay. Although it is difficult to ascertain the exact monetary benefit that any healthcare professional adds to the multidisciplinary team, our study suggests that EM pharmacists make a significant number of clinical interventions and that the potential CA is greater than the salary and benefits of an individual pharmacist.

CONCLUSIONS

Pharmacist involvement in the care of patients presenting to the ED results in significant avoidance of healthcare costs, particularly in the areas of hands-on patient care and ADE prevention. The potential monetary CA to pharmacist salary ratio for EM pharmacists is between $1.4:1 and $10.6:1.

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PHARM-EM Investigators provided in **Supplemental Table 2** *(http://links.lww.com/CCX/A615).*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccejournal).

The authors have disclosed that they do not have any potential conflicts of interest.

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