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PHarmacist Avoidance or Reductions in Medical Costs in CRITically Ill Adults: PHARM-CRIT Study

OBJECTIVES: To comprehensively classify interventions performed by ICU 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 hospitals and academic medical centers in the United States.

PARTICIPANTS: ICU clinical pharmacists.

INTERVENTIONS: Recommendations classified into one of 38 intervention categories (divided into six unique sections) associated with cost avoidance.

MEASUREMENTS AND MAIN RESULTS: Two-hundred fifteen ICU pharmacists at 85 centers performed 55,926 interventions during 3,148 shifts that were accepted on 27,681 adult patient days and generated $23,404,089 of cost avoidance. The quantity of accepted interventions and cost avoidance generated in six established sections was adverse drug event prevention (5,777 interventions; $5,822,539 CA), resource utilization (12,630 interventions; $4,491,318), individualization of patient care (29,284 interventions; $9,680,036 cost avoidance), prophylaxis (1,639 interventions; $1,414,465 cost avoidance), hands-on care (1,828 interventions; $1,339,621 cost avoidance), and administrative/supportive tasks (4,768 interventions; $656,110 cost avoidance). Mean cost avoidance was $418 per intervention, $845 per patient day, and $7,435 per ICU pharmacist shift. The annualized cost avoidance from an ICU pharmacist is $1,784,302. The potential monetary cost avoidance to pharmacist salary ratio was between $3.3:1 and $9.6:1.

CONCLUSIONS: Pharmacist involvement in the care of critically ill patients results in significant avoidance of healthcare costs, particularly in the areas of individualization of patient care, adverse drug event prevention, and resource utilization. The potential monetary cost avoidance to pharmacist salary ratio employing an ICU clinical pharmacist is between $3.3:1 and $9.6:1.

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

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For PHARM-CRIT Investigators, on behalf of the Society of Critical Care Medicine Clinical Pharmacy and Pharmacology Section and endorsed by the Discovery Network

Almost 1.5 million patients were admitted to ICUs in the United States in 2015 (1). The costs associated with providing critical care services in ICUs represented approximately 1% of the U.S. gross domestic product (2). Healthcare teams in ICUs have evolved to incorporate practitioners in other professions, including pharmacists (3). Many ICU pharmacists complete specialty residency or fellowship training and are board certified in critical care. The role of pharmacists has shifted from preparing and dispensing medications to performing direct patient care as a member of multidisciplinary teams. These activities have demonstrated improved clinical and financial outcomes across various patient subpopulations and hospital structures (4–9). Consequently, many

professional healthcare organizations consider pharmacists practicing in the ICU to be essential healthcare providers, yet the participation of pharmacists in critical care units is not universal (10–13).

Previous studies of interventions performed by ICU pharmacists have more commonly focused on adverse drug event (ADE) prevention and reductions in medication use and costs (4–6). Although two multicenter studies performed at the institution level and using insurance claims data evaluated a broader scope of clinical and economic outcomes, the pharmacists' specific interventions and roles in patient care were unknown (7, 8). A single contemporary study at an academic medical center evaluated a medical ICU pharmacist's clinical activities over a 12-month period and determined the cost avoidance (CA) of those activities exceeded $3 million with a monetary benefit-to-cost ratio of 24.5:1 (9). However, these findings may not be generalizable to other ICUs and hospital settings because of the patient population, pharmacist's training and relationships with providers, and rounding structure. The purposes of this study were to comprehensively classify interventions performed by pharmacists in the ICU and quantify CA generated through accepted interventions.

METHODS

Study Design

The PHarmacist Avoidance or Reductions in Medical costs in CRITically ill adults (PHARM-CRIT) study was a multicenter, prospective, observational study that was performed in community hospitals and academic medical centers in the United States between August 2018 and January 2019. Recruitment was performed using electronic mail. Invitations were sent to the Society of Critical Care Medicine's (SCCM's) Clinical Pharmacy and Pharmacology section listserv. From this listserv, which includes multiple healthcare professionals, in addition to pharmacists, clinical pharmacists who provided direct (rounding with the ICU team) or decentralized (not directly rounding with the ICU team) patient care for critically ill adults were eligible for study participation. Pharmacists completing residency or fellowship were ineligible. Only interventions made by a pharmacist for patients residing in an ICU were eligible for study inclusion. Multiple pharmacists from the same institution were eligible to participate. In order to maximize data capture for pharmacist interventions, no minimum or maximum duration of study participation by each pharmacist was required; however, participants were encouraged to document interventions for 20 shifts. All clinical interventions made by participating pharmacists during study participation were recorded in REDCap© (Version 6.18.1, 2019; Vanderbilt University, Nashville, TN) in accordance with best practices (14–16). Only interventions for adults 18 years old or older that were accepted were included in the analyses.

Data Collection

A comprehensive, evidence-based framework for categorizing and monetizing CA interventions by critical care and emergency medicine pharmacists including 38 unique interventions within six intervention sections was developed by our group a priori and previously published (17).These interventions included direct cost of medications (e.g., IV to oral conversions) as well as potential CA associated with initiating drug therapy (e.g., initiating venous thromboembolism prophylaxis [**Supplemental Table 1**, http://links.lww.com/CCX/A870]). Interventions were classified according to 38 different intervention categorizations organized into six different sections: ADE prevention, resource utilization, individualization of patient care, prophylaxis, hands-on care, and administrative and supportive tasks. Any intervention that could not be classified into one of the 38 intervention categories was not recorded or available for study inclusion. All participants received training on appropriate documentation of interventions using the CA framework. Interventions were entered at the patient level by each individual pharmacist. Pharmacists were encouraged to enter these data in real time. Although all interventions (accepted and not accepted) were captured, only interventions accepted and implemented by the medical team were included in the CA analysis. The Rush University Medical Center Institutional Review Board (IRB) served as the central and coordinating IRB (IRB number 18021508-IRB01). This study was endorsed by the SCCM's Discovery Research Network and was a work product of SCCM's Clinical Pharmacy and Pharmacology Section.

Study Outcomes and Statistical Analysis

The primary outcomes were the quantity and type of interventions provided and the potential CA generated

from clinical pharmacists practicing in ICU settings. The values for CA overall and per patient day 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. (17, 18) A sensitivity analysis was conducted to evaluate CA from just those interventions 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 (GRADE) evidence-to-decision framework (GRADE Ia-IIb interventions) (17). 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) (17).

Descriptive statistics were used to characterize the data. The Shapiro-Wilks test was used to determine normality of continuous data. Normally distributed data were expressed as mean (SD); nonnormally distributed data were expressed as median (interquartile range [IQR])The CA per pharmacist shift value was annualized using 240 shifts, which corresponds to five shifts per week for 48 weeks to allow for not providing care on personal time off and holidays. This annualized CA for a pharmacist was compared with the average pharmacist's salary and benefits ($185,470) to calculate a monetary CA to pharmacist salary ratio (18, 19). Analyses were performed in Stata (Version 16; StataCorp LLC, College Station, TX).

RESULTS

Overall, 302 pharmacists responded to our invitation to participate, of whom 215 participated in the study. These 215 pharmacists at 85 centers completed 3,148 shifts. Slightly greater than half of the participating pharmacists provided care in a medical ICU (58.6%) or surgical ICU (53.0%). More than one third of ICUs had an open practice model, and 87.4% of the ICUs had interdisciplinary patient care rounds at least 5 days per week. ICU pharmacists spent the majority of their shift providing direct patient care (median, 5.5 hr [IQR, 4–8 hr]).

Approximately half of each pharmacist's shift included prospective order verification (median, 4 hr [IQR, 0–6 hr]). ICU pharmacists most frequently rounded with a single service (62.8%) although almost one third of participants rounded with two or more services each shift. The median number of shifts for participating pharmacists was 17 (IQR, 6–20). ICU pharmacists cared for a median of 15 patients each day (IQR, 12–22). Most ICU pharmacists had been in practice for at least 1 year but less than 12 years and were board certified (**Table 1**).

Of the 56,866 interventions performed by ICU pharmacists, 55,926 (99.4%) were accepted. These interventions were performed on 27,681 patients in six categories: ADE prevention (accepted interventions: 5,777; percentage of total accepted interventions: 10.3%), resource utilization (12,630; 22.5%), individualization of patient care (29,284; 52.4%), prophylaxis

TABLE 1.
ICU Pharmacist Characteristics

Characteristics	ICU Pharmacist (*N* = 215)
Practice area[a]	
Decentralized	42 (19.5)
Burn ICU	19 (8.8)
Cardiac ICU (medical)	79 (36.7)
Cardiac ICU (surgical)	87 (40.5)
Immunocompromised ICU	23 (10.7)
Medical ICU	126 (58.6)
Mixed ICU (medical/surgical)	60 (27.9)
Neuro ICU (medical/surgical)	80 (37.2)
Surgical ICU	114 (53.0)
Trauma ICU	75 (34.9)
Open ICU practice model, *n* (%)	82 (38.1)
ICU rounding 5–7 d per week, *n* (%)	188 (87.4)
Beds in ICU practice area, median (IQR)	22 (16–27)
Nonpharmacist providers in practice area[b]	
Advanced practice provider	162 (75.3)
Hospitalist	55 (25.6)
Intensivist	194 (90.2)
Fellow	129 (60.0)
Resident	165 (76.7)

(*Continued*)

TABLE 1. (*Continued*).
ICU Pharmacist Characteristics

Characteristics	ICU Pharmacist (*N* = 215)
Institution type, *n* (%)	
Academic medical center	38 (44.7)
Community teaching	30 (35.3)
Community nonteaching	16 (18.8)
Government	1 (1.2)
Shift duration (hr), *n* (%)	
8	2,452 (77.9)
10	552 (17.5)
12	51 (1.6)
Other	93 (3.0)
Shifts worked, median (IQR)	17 (6–20)
Direct patient care duration per shift (hr), median (IQR)	5.5 (4–8)
Prospective order verification duration per shift (hr), median (IQR)	4 (0–6)
Services rounded with each day, *n* (%)	
0	231 (7.4)
1	1,945 (62.8)
2	653 (21.1)
3	165 (5.3)
4 or more	105 (3.4)
Patients cared for per shift (*n*), median (IQR)	15 (12–22)
Years in practice (yr), *n* (%)	
≤ 1	27 (12.6)
> 1 to 3	74 (34.4)
> 3 to 6	50 (23.3)
> 6 to 12	40 (18.6)
≥ 12	24 (11.2)
Board certified, *n* (%)	174 (81.0)

IQR = interquartile range.

[a]Cumulative percentage exceeds 100% because many pharmacists practice in multiple areas.

[b]Cumulative percentage exceeds 100% because multiple providers in practice areas and many pharmacists practice in multiple practice areas.

(1,639; 2.9%), hands-on care (1,828; 3.3%), and administrative/supportive tasks (4,768; 8.5%). The most frequent interventions were discontinuation of clinically unwarranted therapy (8,842; 15.8%), renal dosage adjustments in patients not receiving continuous renal replacement therapy (CRRT) (8,557; 15.3%), initiation of nonantimicrobial therapy (7,764; 13.9%), and antimicrobial therapy initiation and streamlining (5,019; 9.0%). The least commonly accepted interventions were medication route for resolving shock management (percentage accepted: 60.5%) and prevention of unnecessary high-cost medication (93.7%). Interventions from the five most validated intervention categories used in our sensitivity analysis totaled 9,175 (16.4% of all accepted interventions) (**Table 2**).

The CA generated from ICU pharmacist recommendations totaled $23,404,089 in six sections: ADE prevention (CA: $5,822,539; percentage of total CA: 24.9%), resource utilization ($4,491,318; 19.2%), individualization of patient care ($9,680,036; 41.4%), prophylaxis ($1,414,465; 6.0%), hands-on care ($1,339,621; 5.7%), and administrative/supportive ($656,110; 2.8%). The areas of greatest CA were medication route for hypertensive crisis management ($3,436,598; 14.7%), major ADE prevention ($3,242,171; 13.9%), and antimicrobial therapy initiation and streamlining ($3,088,944; 13.2%). In our sensitivity analysis of interventions with the highest level of evidence, CA from the five most validated intervention categories totaled $7,961,681 (34.0% of CA from all accepted interventions) (Table 2).

When considering all accepted interventions, average CA was $418 per intervention, $845 per patient each day, and $7,435 per ICU pharmacist shift. The annualized CA from an ICU pharmacist was $1,784,302. The potential monetary CA to pharmacist salary ratio was $9.6:1. When considering accepted interventions from the five most validated intervention categories, average CA was $868 per intervention, $288 per patient each day, and $2,529 per ICU pharmacist shift. Considering these categories only, the annualized CA from an ICU pharmacist was $606,990, and the potential monetary CA to pharmacist salary ratio was $3.3:1.

DISCUSSION

This is the first multicenter prospective study to comprehensively classify interventions performed by pharmacists in adult ICUs and quantify potential CA generated through these interventions. The CA generated from 215 pharmacists practicing in the ICU over the study period totaled over 23 million U.S. dollars. This CA resulted from pharmacists intervening almost 56,000 times over

TABLE 2.
Accepted Pharmacist Interventions and Potential Cost Avoidance

Intervention	Accepted, n (%)	Cost Avoidance, $
Section 1: **Adverse drug event prevention**	5,777 (97.9)	5,822,539
Major ADE prevention	968 (97.2)	3,242,171
Minor ADE prevention	1,894 (98.7)	772,766
Medication reconciliation resulting in major ADE prevention	170 (99.4)	569,390
Medication reconciliation resulting in minor ADE prevention	696 (96.8)	328,687
Recommend laboratory monitoring	2,049 (98.3)	909,525
Section 2: **Resource utilization**	12,630 (97.9)	4,491,318
Preventing unnecessary laboratories and/or tests	415 (98.3)	8,085
Prevention of inappropriate screening of heparin induced thrombocytopenia	40 (97.6)	31,843
Medication route: IV to oral conversion	2,908 (97.6)	159,419
Medication route: hypertensive crisis management	164 (97.6)	3,436,598
Medication route: resolving shock management	23 (60.5)	1,716
Discontinuation of clinically unwarranted therapy	8,842 (98.3)	604,881
Prevention of unnecessary high-cost medication	238 (93.7)	248,776
Section 3: **Individualization of patient care**	29,284 (98.3)	9,680,036
Dosage adjustment: continuous renal replacement therapy	712 (98.5)	1,813,357
Dosage adjustment: no continuous renal replacement therapy	8,557 (98.6)	1,398,814
Antimicrobial therapy initiation and streamlining	5,019 (97.0)	3,088,944
Anticoagulant therapy management	1,806 (98.7)	1,262,069
Initiation of nonantimicrobial therapy	7,764 (98.2)	1,307,535
Antimicrobial pharmacokinetic evaluation	4,398 (99.1)	740,667
Total parenteral nutrition management	1,028 (99.1)	68,650
Section 4: **Prophylaxis**	1,639 (99.5)	1,414,465
Change venous thromboembolism prophylaxis to most appropriate agent	329 (100)	27,610
Initiation of venous thromboembolism prophylaxis	755 (99.2)	1,249,110
Initiation of stress ulcer prophylaxis	375 (99.5)	21,251
Initiation of ventilator associated pneumonia prophylaxis with chlorhexidine	180 (99.5)	116,494
Section 5: **Hands-on care**	1,828 (98.6)	1,339,621
Bedside monitoring	1,150 (98.5)	446,798
Emergency code blue participation	213 (99.1)	327,498
Rapid response team participation	82 (97.6)	13,810
Emergency code stroke participation	43 (100)	29,311
Emergency code sepsis participation	23 (100)	36,453
Blood factor stewardship	36 (100)	346,609
Emergency procedural sedation or rapid sequence intubation participation	131 (99.2)	36,333
Medication teaching or discharge education	146 (97.3)	100,067
Culture follow-up after emergency department discharge	4 (100)	2,742
Antivenin stewardship	0	0

(*Continued*)

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

Intervention	Accepted, n (%)	Cost Avoidance, $
Section 6: **Administrative and supportive tasks**	4,768 (98.7)	656,110
Drug information consultation	2,174 (99.0)	245,836
Drug information consultation: toxicology specific	75 (100)	31,833
Patient own medication evaluation	335 (98.5)	130,154
Therapeutic interchange	290 (98.6)	15,350
Pharmacist provided drug protocol management pursuant to collaborative practice agreement	1,803 (98.4)	197,122
Rejection of a restricted medication	91 (100)	35,815
Total	55,926 (99.4)	23,404,089

Values presented as number of accepted interventions (percentage of interventions accepted in section or subsection).

the course of greater than 27,000 patient days. In total, 99.4% of these interventions were accepted. ICU pharmacists generated $7,435 in CA per shift when all interventions were considered and $2,529 in CA per shift when only the most validated intervention categories were used. A significant portion of CA resulted from interventions that individualized patient care, prevented ADEs, and used resources more effectively. The potential monetary CA to pharmacist salary ratio for ICU pharmacists appears to be between $3.3:1 and $9.6:1.

Major ADE prevention provided the second largest amount of CA among the six intervention categories. The use of multiple agents with a narrow therapeutic index in critically ill patients with altered pharmacokinetics and pharmacodynamics places these patients at great risk for complications (20). The significant impact pharmacists have on ADE prevention aligns with results from a landmark trial, which described a 66% relative risk reduction in ADEs following inclusion of a clinical pharmacist (5). In addition to preventing almost 3,000 ADEs during direct and decentralized patient care activities, 866 additional ADEs were prevented as a result of interventions made following medication reconciliation. For critically ill 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 (21, 22).

Approximately one fifth of ICU pharmacist interventions supported more efficient utilization of healthcare resources. Pharmacists in the ICU commonly converted more expensive IV medications to oral dosage forms with similar efficacy or discontinue certain prophylactic medications when they are no longer indicated. These are common practices that often are performed pursuant to a protocol or collaborative practice agreement and can reduce ADEs and decrease prescription costs at hospital discharge (23, 24). Improved management of hypertensive crises was the intervention associated with the greatest CA in this study. Additionally, antimicrobial agents were frequently discontinued because their empirical use was no longer necessary or a shorter duration of use that still would adequately treat a presumed or confirmed infection was deemed appropriate (25). Finally, interventions that improved resource utilization also frequently reduced the use of medications that are on shortage in the United States. These stewardship activities are imperative and challenging in an era of medication shortages but are necessary to maintain a medication's stock for treating the most critical and compelling indications and patients (26). ICU pharmacists are well positioned to incorporate the costs and availability of medications into the clinical decision-making process and patient care (27).

Individualizing therapies for specific patients was the most common classification of intervention performed by ICU pharmacists, representing 52.4% of all included interventions. These interventions represented approximately 41% of the CA generated from ICU pharmacist recommendations. The pharmacists' ability to individualize antimicrobial dosing initially and in response to pharmacokinetic and pharmacodynamic monitoring variables in

patients with renal dysfunction, especially those receiving CRRT, significantly impact patient care (28). Additionally, ICU pharmacists were active in determining the most appropriate empirical antimicrobial therapies and de-escalating to definitive therapy or discontinuing treatment in these complex patients. Pharmacists are best positioned to ensure patient care is individualized with regard to the "five rights" of medication use: the right patient, the right drug, the right time, the right dose, and the right route (29).

A pharmacist intervention to ensure prophylaxis was provided for patients at risk for preventable complications of critical illness was performed infrequently, totaling less than 3% of interventions and approximately 6% of CA. Although these interventions are not often viewed as highly impactful, they do result in a reduced rate of complications in high-risk patients and are processes that can be protocolized at many institutions (23, 24). ICU pharmacists also were involved in the infrequent but highly complex activities that represent hands-on care, which accounted for approximately 3% of interventions and almost 6% of CA. They commonly participated in emergency code blue (i.e., cardiac arrest) response, which has been shown to improve compliance with advanced cardiac life support guidelines (30, 31). Additionally, ICU pharmacists were active in acute stroke management, which frequently reduces door-to-needle times and increases the proportion of patients who are eligible to receive thrombolytics (32, 33). Finally, blood factor stewardship represented a significant portion of CA for this category of intervention. In these activities, pharmacists ensure appropriate use of blood factor products and dosages is achieved (34, 35). In critical and emergent situations, pharmacists bring expertise that complement other team members and elevate the clinical and safety outcomes for patients (36).

Fundamentally, our analysis provides estimates of CA, but such estimates are sensitive to underlying assumptions. We used an evidence-based framework for the types of interventions and associated CA from published literature to classify interventions and quantify their CA; however, these CA values are imperfect and may result in both over- or underestimation of the true CA, depending on the patient, pharmacist institution, and situation (17). We used fixed costs per intervention documented, although we acknowledge that the costs may vary by center, participant, and other conditions including medication costs. Specifically for categories such as ADE avoidance, our approach assumed that pharmacist interventions consistently lead to avoidance of an adverse event that was destined to occur (i.e. 100% probability of harm), which we recognize may not always be a valid assumption and risk overinflating CA estimates given that an adverse event would not have occurred or the intervention may have ultimately been detected by another member of the healthcare team. A recent scoping review of CA from pharmacist interventions demonstrated high risk of inflation and limited assessment of probability of harm (38). We attempted to mitigate this risk with the incorporation of a sensitivity analysis using only the CA categories with the highest levels of evidence, although 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 CA from ICU pharmacists. Although the rate and type of preventable ADEs were determined in a similar manner to past studies, the counterfactual or true extent of ADE development cannot be known. Participating pharmacists were encouraged to err on the side of underemphasizing the extent of an ADE, which may have resulted in an underappreciation of the true CA from ADE prevention. In studies of this nature, the reduction in potential harm and associated CA from an intervention is difficult to precisely determine. In addition to a probabilistic factor that an identified scenario actually leads to harm, the CA of an intervention likely varies per patient, and again we used fixed estimates for these categorizations. Nevertheless, a substantial decrease in the quantity of accepted interventions or actual CA from these interventions would need to occur to cause the return on investment for ICU pharmacists demonstrated in this study to approach unacceptable values. Even for the cost estimates that were directly quantifiable such as direct pharmaceutical costs of agents, we recognize that costs may vary significantly per center. Furthermore, the evidence-based framework only included categorized interventions for which there were pre-existing data (17). Although this framework is based on published literature, it has not been prospectively validated with probabilistic CA considerations included. This also implies that if an intervention was not included as a category, we were unable to capture activities not quantified in the framework that may still generate CA for critically ill patients. Although categorizing CA in healthcare is a difficult task, particularly

in critically ill patients, proposed guidance has recently been published for CA studies in pharmacy practice, including a probabilistic framework (39).

There are several ways in which CA may be overestimated. In addition to the aforementioned challenges of fixed CA values, participants may have documented accepted interventions more frequently than accepted or inflated interventions performed, although attempts to reduce this Hawthorne effect were instituted (37). Although selection bias was mitigated by the diversity of pharmacists with regard to training, experience, and hospital, we cannot rule out the possibility that pharmacists electing to participate in the study are more likely to either make interventions and/or document those interventions compared with pharmacists not participating. Conversely, CA may have been underestimated as well through a host of factors. Additionally, the quantity and type of interventions were likely incomplete because data collection was performed in real time. A greater quantity of interventions may have been performed than were documented. Furthermore, sustained interaction between an ICU pharmacist and healthcare team may alter the potential CA of a pharmacist over time. When first incorporating an ICU pharmacist, potential CA may be much larger as pharmacists likely have a larger impact given protocol develop, education, implementation of best practice, and other initial benefits. This time-varying CA of ICU pharmacists is hypothesis generating only as we were not able to evaluate in our study. Although many ICU clinical pharmacists were included, these results may not be generalizable to all ICU pharmacists and hospitals. Additionally, there was substantial variability in the number of shifts contributed by ICU pharmacists (IQR, 6—20); it is unclear how this affected our findings. Finally, many other factors may have impacted the quantity and types of interventions as well as their acceptance, including interpersonal traits, professional relationships with other healthcare providers, and patient volume and complexity during the study period.

CONCLUSIONS

ICU pharmacists resulted in significant avoidance of healthcare costs, particularly in the areas of individualization of patient care, ADE prevention, and resource utilization. The potential monetary CA to pharmacist salary ratio for ICU pharmacists appears to be between $3.3:1 and $9.6:1.

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