Nadia H.Ismail, Hadeel AL-Harbi. Clinical and cost avoidance benefits of integrating pharmacist in intensive care unit. Pharmacy Practice. 2024 Jul-Sep;22(3):2999.

https://doi.org/10.18549/PharmPract.2024.3.2999

Original Research

Clinical and cost avoidance benefits of integrating pharmacist in intensive care unit

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Received (first version): 19-Oct-2023 Accepted: 05-Dec-2023 Published online: 02-Aug-2024

Abstract

Introduction: Critical care pharmacists as integral members of multidisciplinary teams, play a crucial role in enhancing clinical, economic, and humanistic outcomes for all critically ill patients. In this region, however, the economic impact of critical care pharmacist has not been well investigated. **Objectives:** The purpose of this study was to classify and estimate critical care pharmacist interventions that are associated with cost avoidance in the intensive care units. **Methods:** This was a single-center, prospective, observational study conducted at a 30-bed adult medical and surgical intensive care unit for over 12 months. Interventions performed by the critical care pharmacist and accepted by the multidisciplinary intensive care teams were documented weekly. Interventions were retrieved monthly to be categorized and quantified for cost estimation using a systematic framework. Total cost avoidance was calculated by aggregating the cost avoidance values for each intervention. The average rates of cost avoidance per month were computed by dividing the total cost avoidance by the number of months the critical care pharmacist provided care. For the net benefit, we subtracted the cost of the clinical pharmacist service from the total cost savings. **Results:** For a cohort of 239 critically ill patients, a total of 912 interventions were recommended. Forty percent of critical care pharmacist interventions were related to the optimization of antibiotics. Cost avoidances were mainly observed in adverse event prevention (n = 170; 18%), which resulted in a cost savings of $336,189.2 and individualized patient care accounted for (n = 486; 53%) and resulted in cost savings of $304,905.46 The total cost avoidance was $697,254.1 with a benefit–cost ratio of 5.7:1. **Conclusion:** The presence of pharmacists in the intensive care unit has resulted in significant cost avoidance, mainly in adverse event prevention and individualized patient care, with a substantial return on investment.

Keywords: intensive care unit, cost, pharmacist, intervention

INTRODUCTION

To implement optimal care for critically ill patients, an interdisciplinary approach is imperative, whereby distinctive specialized expertise and knowledge are employed. In this context, pharmacists hold a crucial position as fundamental members of the intensive care unit team, making significant contributions towards the overall enhancement of clinical, economic, and humanistic outcomes for critically ill patients.[1] Critical care pharmacist interventions are diverse and include a range of activities, such as the correction and clarification of orders, provision of drug information, identification of drug interactions, target drug monitoring, and the suggestion of alternative therapies. Significantly, pharmacist involvement in the delivery of care to critically ill patients is linked to optimal fluid management and substantial reductions in the rates of preventable drug events and medication errors.[2,3] Furthermore, economic evaluations of clinical pharmacy services in intensive care units consistently reveal the potential for considerable cost savings.[4–6] In recent years, there has been a notable transformation in the role of critical care pharmacists. In Saudi Arabia, a significant number of critical care pharmacist have pursued specialized residency or fellowship training and have obtained board certification in critical care.[7] Rather than solely focusing on the preparation and dispensing of medications, critical care pharmacist are now actively engaged in direct patient care as integral members of multidisciplinary teams. This shift in responsibilities has been shown to yield positive results in terms of both clinical and financial outcomes across different patient subgroups and hospital settings.[8,9]The majority of published studies in the region have mainly focused on evaluating cost-saving interventions related to adverse event prevention, medication optimization, and drug cost.[10–12] But have not identified critical care pharmacists (CCP) intervention that are most associated with cost avoidance. Critical pharmacy services are available in major hospitals across the Kingdom of Saudi Arabia, the clinical and economic impact of critical care pharmacist are not well investigated. At present, there has not been a systematic examination of the types of critical care pharmacist interventions that are most attributed to cost savings in critically ill patients. The purpose of this study is to categorize and estimate critical care pharmacist interventions that are associated with potential cost avoidance in critically ill patients.

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METHODOLOGY

Study Design and Setting

This is a prospective, observational study carried out at King Fhad Hospital of the University, which is one of the largest

https://doi.org/10.18549/PharmPract.2024.3.2999

academic medical Centres in the eastern region of Saudi Arabia with a capacity of 550 beds. The medical facility encompasses three intensive care units comprising a total of 30 beds and catering to medical, surgical, neurocritical care, and burn units. The adult critical care service is provided in closed intensive care units with an average daily census of 18-20 patients per day. Advanced technology is utilized for physician order entry, including medications and laboratory and diagnostic tests. In addition, over 90% of all medications are available throughout the intensive care units via automated dispensing machines.

The critical care pharmacist has been an integral member of intensive care units for the past 14 years. The critical care pharmacist actively engages in rounds with one of two multidisciplinary teams, dedicating five hours each day to pharmacotherapy assessment, as well as participation in the training and education of pharmacy students and residents. Furthermore, the critical care pharmacist participates in daily multidisciplinary rounds and performs pharmacotherapy consultations throughout the day, from Sunday to Thursday, between 8 am and 4 pm. Critical care pharmacist also has the privilege of adjusting medication orders with a narrow therapeutic index, as well as medications that require dose adjustment for renal dysfunction. It is important to note that during after hours and weekends, the on-call clinical pharmacy specialist assumes responsibility for covering the intensive care units and is available 24/7. However, the on-call pharmacist does not participate in weekend rounds. The human research ethics committee at Imam Abdulrahman bin Faisal University provided ethical approval for the study (ID: irb-2023-11-189).

Data Collection

All critical care pharmacist interventions that were endorsed by the multidisciplinary intensive care unit team from January 2022 to December 2022 were documented in the pharmacy intervention system, Quantifi® by Wolters Kluwer, daily. Subsequently, the recorded interventions were retrieved monthly for the purpose of categorization and cost approximation. The framework divided interventions into categories of six distinct sections, namely, adverse event prevention, individualized patient care, resource utilization, prophylaxis, hands-on care, and administrative and supportive tasks. Each section was then divided into subsections of interventions, and each had a cost in USD designated with it based on the framework.[13] The classification and cost estimation of the interventions were carried out independently by two investigators. The first investigator conducted the classification and cost estimation based on a previously published framework. The second investigator then conducted the verification of cost estimation and classification. Any interventions that could not be classified were not encompassed within the scope of the study.

Cost Estimation for Each Intervention and Benefit-to-Cost Ratio

Each intervention was categorized and assigned a cost avoidance estimate using a systematic framework . To account for inflation rates, all values associated with the interventions from 2018 based on the framework were adjusted to 2022 U.S. dollars (supplemental appendix), based on inflation rates from the U.S. Bureau of Labor Statistics.[14] The total cost avoidance was calculated by aggregating the cost avoidance values for each subsection. The average rates of cost avoidance per month were computed by dividing the total cost avoidance by the number of months that the critical care pharmacist provided care. The cost of interventions on weekends was not included since critical care pharmacist did not provide care on weekends. The net benefit was then determined by subtracting the cost of the clinical pharmacist service from the total cost savings. The salary of a senior clinical pharmacist was reported as USD 120,540 per year.

Study Outcomes

The study's main objective was to identify the class of interventions that yielded potential cost avoidance. In addition, the secondary outcomes included assessing the total cost avoidance in the medical and surgical ICUs, critical care pharmacist-related cost savings per month, and the benefit–cost ratio associated with clinical pharmacy services in the intensive care units. The cost avoidance per pharmacist shift value was annualized using 240 shifts, corresponding to five shifts per week for 48 weeks. This annualized cost avoidance was then compared to the average pharmacist's salary and benefits to determine the monetary cost avoidance to pharmacist salary ratio.

Statistical Methods

Descriptive statistics were employed in the study using Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corporation, Armonk, New York, United States). For categorical data, frequencies and percentages were utilized for reporting purposes. Conversely, medians accompanied by interquartile ranges (IQRs) were implemented for the presentation of continuous data.

RESULTS

Over the course of 12 months, a total of 912 interventions were carried out by the critical care pharmacist for a cohort of 239 patients with a median age of 59 years Table 1. Ninety-nine percent of critical care pharmacist interventions were accepted by the multidisciplinary intensive care team. critical care pharmacist performed recommendations for 958 types of medications, of which 40% were related to optimization of antibiotics, 12.1% were related to injectable anticoagulants and 6.1% were related to TPN formulations.

Cost avoidance was mainly observed in adverse events prevention and individualized patient care. In addition, more than half of the critical care pharmacist interventions were attributed to individualized patient care, accounting for 53.3% of the overall interventions, followed by adverse event prevention at 18.6% and prevention of venous thromboembolism at 10%. Table 2. The critical care pharmacists administered an average of 76 interventions each month and 17 interventions per week. These interventions resulted in a monthly cost avoidance of

https://doi.org/10.18549/PharmPract.2024.3.2999

$58,104.5 and an annual cost avoidance of $697,254.1 with a benefit–cost ratio of 5.7:1 (697,254.1/120,540). The highest number of drug-related problems associated with critical care pharmacist interventions were mainly seen in renal dosing (13.8%), deep vein thrombosis prophylaxes (11.1%), targeted drug monitoring (8.5%), safety dose evaluation (8.5%), discontinuation of drug therapy (6.9%), and antibiotics (7.5%) Table 3.

Table 1. Baseline Characteristics	
Characteristics	
Patient N=239	
Age, years median (IQR)	59 (39-73)
Sex, male-no. (%)	143 (60%)
ICU LOS , days median (IQR)	7 (5.3-9.6)
Number of intervention based on type of ICU, Cost Avoidance per month and Net benefit	
Medical ICU, no. of interventions	600 (65.7%)
Surgical ICU, no. of intervetions	292 (32%)
Burn Unit, no.of interventions	20 (2.2%)
No. of interventions per patient	3.81
Monthly cost avoidance	58,104.5
Net benefit in USD	576,714.1

Abbreviation: LOS: length of stay, ICU: intensive care unit, USD= dollars in US

Table 2. Section and subsection of CCPI with cost avoidance			
Category 1: Adverse drug event prevention			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Major ADE prevention	3,717.29	80	2,97,383.20
Minor ADE prevention	431.2	80	34,496
Medication reconciliation resulting in minor ADE prevention	431.2	10	4,310
Category 2: Resource utilization			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Medication route: intravenous to oral conversion	Medication cos	9	Medication cos
Discontinuation of clinically unwarranted therapy	76.93	76	5,847
Category 3: Individualized patient care			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Dosage adjustment: continuous renal replacement therapy	2,826.63	57	1,61,117
Dosage adjustment: No continuous renal replacement therapy	186.9	101	18,876.90
Antimicrobial therapy initiation and streamlining	683.42	117	79,960.14
Anticoagulant therapy management	807.79	18	14,540.22
Initiation of non-antimicrobial therapy	186.9	65	12,148
Antimicrobial pharmacokinetic evaluation	186.9	78	14,578.20
Total parenteral nutrition management	74.11	50	3,705

https://doi.org/10.18549/PharmPract.2024.3.2999

Category 4: Prophylaxis			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Change venous thromboembolism prophylaxis to most appropriate agent	93.13	78	7,264.14
Initiation of venous thromboembolism prophylaxis	1,836.20	8	14,689.60
Initiation of stress ulcer prophylaxis	62.9	1	62.9
Category 5: Hands- on care			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Bedside monitoring	431.2	48	20,697.60
Category 6: Administrative and supportive tasks			
Intervention class	**Cost of intervention in (USD) (Year,2022)**	**Number of interventions**	**Total Cost Avoidance In (USD) (Year,2022)**
Drug information consultation	125.51	22	2,761.22
Drug information consultation: toxicology specific	471.06	1	471.06
Patient own medication evaluation.	431.2	9	3,880.80
Pharmacist provided drug protocol. management pursuant to collaborative practice agreement	121.34	4	485.36

CCPI= critical care pharmacist intervention; ADE= adverse drug events

DISCUSSION

To the best of our knowledge, this is the first prospective observational study in this region that aims to categorize and estimate CCP interventions that are associated with potential cost avoidance in critically ill patients using a systematic framework. Our results indicate that CCP inclusion as a member of the multidisciplinary intensive care team has yielded positive clinical and economic benefits. The presence of CCP in the ICU resulted in a cost avoidance of over $697,088 during a 12-month period, and almost all these interventions were accepted by the multidisciplinary ICU team. For each dollar spent on one full-time pharmacist salary, approximately $5.7 was avoided. This suggests that the cost of incorporating a critical care pharmacist is outweighed by the financial benefits achieved through individualized patient care and prevention of adverse events.

Several studies that employed the same framework have observed that the acceptance of critical care pharmacists' interventions during multidisciplinary rounds was correlated with significantly higher cost avoidance outcomes, mainly in the domains of individualized patient care and adverse event prevention. Notably, a recent single-center observational study, which focused on cost avoidance attributed to critical care pharmacist presence in the medical intensive care unit, revealed that such presence generated over three million US dollars annually, with a benefit–cost ratio of 24.5:1. The study further reported that critical care pharmacists implemented 8,866 accepted interventions, with the four most accepted interventions being minor ADEs (45%), dose adjustment for non-renal replacement therapy (non-RRT; 13%), antimicrobial initiation and streamlining (11%), and antimicrobial pharmacokinetic evaluation (9%).[15]

Likewise, a study conducted in southern Chile examined the cost avoidance and benefit-cost ratio of critical care pharmacist interventions, with comparable results. The approved CCP interventions yielded a total of USD 263,500, resulting in a benefit-cost ratio of 24.2:1 over a 12-month period. The majority of cost avoidance was generated from three sections: individualized patient care (36%), resulting in $ 56,089 in savings; hands-on care (23%), resulting in $ 57,864 in savings; and adverse event prevention, resulting in $50,525 in savings.[16]

Last, in a comprehensive multicenter study that sought to classify and quantitate interventions carried out by critical care pharmacists from 85 intensive care units, it was ascertained that the presence of critical care pharmacists in the intensive care unit was linked to an estimated annual cost avoidance of more than $23 million. This estimation was derived from 55,926 interventions for over 27,681 adult patients, with an estimated benefit-cost ratio ranging from 3.3:1 to 9.6:1. The most significant number of accepted interventions were essentially attributed to the prevention of adverse events, which yielded over $ 5,822,539 in savings, and individualized patient care, which resulted in $ 9,680,036 in savings.[8]

In our study, the interventions that resulted in the highest cost savings were those related to adverse event avoidance. The notable inclusion of pharmacists as members of the multidisciplinary intensive care team had a significant impact on reducing adverse events and prescribing errors. The landmark study by Leape et al. over two decades ago substantiated that

https://doi.org/10.18549/PharmPract.2024.3.2999

CCP rounding with the ICU team was significantly associated with a reduction in adverse events that were attributed to prescribing errors by 66%[3]. Furthermore, the results from a systematic review and a meta-analysis also showed that the presence of critical care pharmacists in intensive care units was associated with a decreased incidence of preventable adverse drug events and prescribing errors[17].Findings from systematic analysis demonstrated that the integration of a pharmacist as part of the multidisciplinary intensive care unit team yielded a reduction in preventable and nonpreventable adverse drug events (ADEs), as well as mortality[18]. It should be noted, however, that none of the studies reported any cost-saving outcomes.

The class of interventions that accounted for the second highest number of interventions and cost savings was attributed to individualized patient care, which contributed to 53% of overall CCP interventions, with most savings related to renal replacement (RRT and non-RRT combined). Critically ill patients are typically subjected to a considerable number of drugs and treatment modalities that can impact renal function and alter the pharmacokinetic and pharmacodynamic properties of prescribed medications, thereby leading to suboptimal and unsafe treatment outcomes.

In a comparative study conducted to assess the effectiveness of pharmacist interventions in critically ill patients undergoing continuous renal replacement therapy, pharmacist dose adjustments significantly led to a reduction in ICU costs, amounting to $2,345.9, as well as an increase in therapeutic benefits and a decrease in harm[19]. At our institution, critical care pharmacists have the privilege of modifying medication dosage based on a preestablished pharmacist-driven renal dosing protocol, which ensures ongoing medication safety and effectiveness, following prescriber entry of initial orders into the hospital information system. The implementation of a similar protocol has been shown to have a significant association with positive clinical and cost-saving outcomes. In a single center study conducted in an academic medical center, which evaluated the impact of pharmacist-driven renal dosing protocol, medication dose reduction was necessary in 73.5% of medication orders, while dose increase was needed in 24.4% of medication orders. Furthermore, the adjustment of drug dosing by pharmacists in critically ill patients resulted in a cost savings of $3,919.87 for each medication's duration of therapy[20].

Currently, there is a scarcity of critical care pharmacists in Saudi Arabia. Despite the extensive literature supporting the indispensability of critical care pharmacists as integral members of the multidisciplinary ICU team and their consequential influence on enhanced patient outcomes, numerous critically ill patients in Saudi Arabia lack the access of care from a critical care pharmacists. Based on a cross-sectional study conducted on 94 hospitals situated in the western region of the Kingdom, it was observed that only 43% of the surveyed hospitals provided critical care pharmacy services[21]. Currently, it is noteworthy to mention that Saudi Arabia only has a mere three critical care pharmacy residency programs, in stark contrast to the United States of America, which has approximately 171 accredited critical care pharmacy residency programs[22,23]. This study possesses potential limitations. First, it is a single-center study. Second, the interventions were recorded in real time on a weekly basis, which could have resulted in an underestimation of the overall interventions monthly. Third, our estimation of cost avoidance for the majority of CCP interventions was based on Hammond's scoping review[13], in which cost of CCP intervention was extrapolated for the most part from studies on non-critically ill patients who were carried out in different regions, some of which were of low quality of evidence. Therefore, this estimation may not accurately reflect the actual cost of service in Saudi Arabia's healthcare system and could lead to an underestimation or overestimation of the cost related to the presence of critical care pharmacy specialists in the intensive care unit. Nonetheless, future studies can employ these findings as a starting point to re-examine the clinical and economic benefits of critical care pharmacy specialists as members of the intensive care multidisciplinary ICU team.

CONCLUSION

Critical care pharmacists play a pivotal role in medication optimization, prevention of adverse events, and provision of individualized patient care. The integration of critical care pharmacists into the multidisciplinary ICU team can lead to the avoidance of high-cost expenditures, a positive return on investment, and improved patient outcomes. The results of this study can aid institutions and pharmacy services in justifying the inclusion of additional clinical pharmacists in intensive care units.

DECLARATIONS OF INTEREST

All author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

ACKNOWLEDGEMENT

None

FUNDING

This research did not receive any funding from agencies in the public, commercial, or nonprofit sectors.

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https://doi.org/10.18549/PharmPract.2024.3.2999

Supplemental Appendix

Table 1. Section and subsection of CCPI with cost avoidance

Category 1: Adverse drug event prevention

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	Number of interventions	Cost Avoidance In (USD)
Major ADE prevention	3,277.25	3,717.29	80	297,383.2
Minor ADE prevention	380.16	431.2	80	34,496
Medication reconciliation resulting in minor ADE prevention	380.16	431.2	10	4,310

Category 2: Resource utilization

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	No. of interventions	Estimated Avoidance In (USD) 2022
Medication route: intravenous to oral conversion	Medication cost	Medication cost	9	Medication cost
Discontinuation of clinically unwarranted therapy	66.94	76.93	76	5,847

Table 2. Section and subsection of CCPI with cost avoidance

Category 3: Individualized patient care

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	Number of interventions	Cost Avoidance In (USD)
Dosage adjustment: continuous renal replacement therapy	2,492	2,826.63	57	161,117
Dosage adjustment: No continuous renal replacement therapy	164.78	186.9	101	18,876.9
Antimicrobial therapy initiation and streamlining	602.52	683.42	117	79,960.14
Anticoagulant therapy management	683.78	807.79	18	14,540.22
Initiation of non-antimicrobial therapy	164.78	186.9	65	12,148
Antimicrobial pharmacokinetic evaluation	164.78	186.9	78	**14,578.2**
Total parenteral nutrition management	65.34	74.11	50	3,705

Category 4: Prophylaxis

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	Number of interventions	Cost Avoidance In (USD)
Change venous thromboembolism prophylaxis to most appropriate agent	82.11	93.13	78	7,264.14
Initiation of venous thromboembolism prophylaxis	1,618.84	1,836.2	8	14,689.6
Initiation of stress ulcer prophylaxis	55.45	62.9	1	62.9

CCPI= critical care pharmacist intervention

Category 5: Hands- on care

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	Number of interventions	Cost Avoidance In (USD)
Bedside monitoring	380.16	431.2	48	20,697.6

Category 6: Administrative and supportive tasks

Intervention	Cost of intervention in (USD) (year,2018)	Cost in (USD) 2022	Number of interventions	Cost Avoidance In (USD)
Drug information consultation	110.65	125.51	22	2,761.22
Drug information consultation: toxicology specific	415.30	471.06	1	471.06
Patient own medication evaluation	380.16	431.2	9	3,880.8
Pharmacist provided drug protocol. management pursuant to collaborative practice agreement	106.98	121.34	4	485.36

www.pharmacypractice.org (eISSN: 1886-3655 ISSN: 1885-642X)