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Costs of pharmaceutical interventions in the intensive care unit of a public urgency and emergency hospital

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Abstract

Objective: Describe the costs of pharmaceutical interventions in the ICU of a public urgent and emergency hospital and evaluate the impact on the length of hospital stay of diseases that required additional medication after pharmaceutical intervention. **Method:** Pharmacotherapeutic follow-up data were collected from May to July 2022 and the prices of medications, diluents and materials were used to calculate three types of costs: maximum intervention, accepted intervention and rejected intervention costs. For the evaluation of the impact on the length of hospital stay of diseases that required additional medication, a panel of specialists was carried out. **Results:** A total of 163 patients were monitored, and 5,770 medications were evaluated. The most frequent pharmaceutical intervention was the suggestion of changing pharmacotherapy (93.37%). The estimated saving of resources was US$ 2,092.91, a mean of US$ 1.83/patient-day. The maximum intervention and rejected intervention costs were US$ 2,462.56 and US$ 3.85, respectively. Infectious conditions required more interventions, resulting in more than 85% of total savings. Items A on the ABC curve corresponded to 77.00% of interventions, with savings of US$ 2,408.47. The expert panel agreed that the absence of medication for stress ulcer prophylaxis, combination therapy for ventilator-associated pneumonia, and septic shock could increase the patient's ICU stay at five, seven, and seven days, respectively. **Conclusion:** The clinical pharmacist, in the care of critical patients, provided savings in the use of medications. Infectious conditions and medications A of ABC curve are strategic points for professional action. Improving communication and building clinical protocols are important for greater clinical and financial return.

Keywords: Clinical Pharmacy Service; Hospital Pharmaceutical Service; Pharmaceutical Care; Critical Care; Pharmacoeconomics; Treatment Costs.

Custos das intervenções farmacêuticas na unidade de terapia intensiva de um hospital público de urgência e emergência

Resumo

Objetivo: Estimar os custos das intervenções farmacêuticas na UTI de um hospital público de urgência e emergência e analisar possíveis alterações no tempo de internação das doenças que necessitaram medicamentos adicionais após intervenção farmacêutica. **Método:** Foram coletados dados do acompanhamento farmacoterapêutico de maio a julho de 2022 e utilizados os preços dos medicamentos, diluentes e materiais médico-hospitalares para cálculos de três tipos de custos: custo máximo da intervenção, custo da intervenção aceita e custo da intervenção rejeitada. Para a avaliação do impacto no tempo de internação das doenças que necessitaram medicamentos adicionais foi realizado um painel de especialistas. **Resultados:** Foram acompanhados 163 pacientes e avaliados 5.770 medicamentos prescritos. A intervenção farmacêutica mais frequente foi a sugestão de alteração de farmacoterapia (93,37%). A economia de recursos estimada foi R$ 10.858,87 (US$ 2,092.91), uma média de R$ 9,50/paciente-dia (US$ 1.83/paciente-dia). O custo máximo da intervenção e o custo da intervenção rejeitada foram de R$ 12.776,76 (US$ 2,462.56) e R$ 18,93 (US$ 3.65), respectivamente. As condições infecciosas necessitaram de mais intervenções, resultando em mais de 85% da economia total. Os itens A da curva ABC corresponderam a 77,00% das intervenções, com economia de R$ 12.496,11 (US$ 2,408.47). O painel de especialistas concordou que a ausência de medicamentos para a profilaxia de úlcera de estresse, terapia combinada para pneumonia associada a ventilação mecânica e choque séptico poderia aumentar em cinco, sete e sete dias de internação do paciente na UTI, respectivamente. **Conclusão:** O farmacêutico clínico, no cuidado ao paciente crítico, proporcionou economia no uso de medicamentos. Condições infecciosas e medicamentos A da curva ABC são pontos estratégicos para atuação do profissional. A melhoria da comunicação e construção de protocolos clínicos são importantes para maior retorno clínico e financeiro.

Palavras-chave: Cuidados Críticos; Custos de Tratamento; Serviço de Farmácia Clínica; Cuidados Farmacêuticos; Farmacoeconomia; Terapia Medicamentosa

Introduction

Clinical pharmacy is an area that promotes the rational use of medications and optimizes pharmacotherapy in order to increase its effectiveness and safety, reduce adverse events, prevent diseases and promote health, building and conducting a patient-centered care relationship[1-3]. Pharmaceutical interventions are actions planned, documented and carried out during multiprofessional care that aim to solve or prevent problems related to the use of medications (MRPs) and guarantee the achievement of therapeutic goals[4].

Participation in the intensive care unit (ICU) multi-professional team is regulated and encouraged by the Federal Pharmacy Council[5]. Brazilian studies have shown positive results related to clinical pharmacy in ICUs. In a teaching hospital in Mato Grosso do Sul, 97% of the pharmaceutical interventions were accepted, and the most frequently addressed points were the withdrawal or addition of medication and adjusting the dosage[6]. Another study, carried out in the ICUs of a university hospital in Paraná, showed that 14.6% of prescriptions had some problem related to medication[7].

In addition to improving positive clinical outcomes and the quality of care, clinical pharmacy consequently promotes the optimization of financial resources[8], since medications are a significant part of hospital costs. Aguiar *et al.* showed that the resolution of MRPs led to savings of R$54,081.01 and expenses of R$20,863.36, resulting in a positive balance of R$33,217.65[9]. In another study, carried out in the pediatric ICU at HCFMRP-USP, a total of 197 interventions were carried out during pharmacotherapeutic monitoring, saving R$15,118.73[10].

Studies on the costs of pharmacotherapeutic follow-up for critically ill patients in emergency hospitals are scarce. In addition, only the prices of medications are usually taken into account for calculations. Finally, it is of the utmost importance to investigate the impact of pharmaceutical interventions in the various hospital specialties, as well as to evaluate in detail and completely the different financial outcomes, whether direct or indirect, in order to optimize the distribution and planning of resources. Therefore, this study aimed to estimate the costs of pharmaceutical interventions in the pharmacotherapeutic monitoring of patients admitted to the adult ICU of a public urgent and emergency care hospital and to analyze possible changes in the length of stay for health conditions that required additional medication.

Methods

This is a descriptive and cost-evaluation study of pharmaceutical intervention carried out in the 48-bed adult ICU of the João XXIII Hospital, a reference in polytrauma, major burns, poisoning and life-threatening situations. The study was approved by FHEMIG's Ethics Committee, according to CAAE 58920722.6.0000.5119.

Pharmacotherapeutic follow-up data collection

Data was collected from May to July 2022 from the pharmacotherapeutic follow-up service. This service is staffed by clinical pharmacists and uses protocols, databases, and other references to assess patients' health conditions and prophylaxis, resulting in interventions with the multi-professional team and records in medical charts.

The criteria used to analyze the data were the sex and age (mean ± standard deviation) of the patients, information about their health conditions and the medications prescribed, the MRPs, according to Cipolle *et al*[3], the resolvability of the MRPs, the pharmaceutical interventions and acceptability. All recorded interventions were included and those with incomplete information were excluded. Medicines were also classified according to the ATC (Anatomical Therapeutic Chemical) and the ABC[11] curve, drawn up by the hospital's Costs Department.

Cost calculation

The perspective adopted was that of an autonomously run public hospital. The cost calculation was based on the sum of the purchase prices of medications, diluents and medical-hospital materials used for preparation and administration, according to the prescription and good practices established at the institution. The values used were those found in the current price registration minutes or in the hospital's electronic system, in Brazilian reais (R$). The values were also presented in dollars (US$), considering the value on 29/07/2022: R$5.19 (US$1.00).

The length of time the medication was to be used was determined according to the prescription, clinical protocols, or other references. Medications without a pre-defined time were considered to be in continuous use and their costs were calculated until the patient left the ICU. To calculate costs, interventions in which the patient remained in the ICU for less than 48 hours after the intervention and in which there was no response from the prescribers were excluded. The operating costs of healthcare professionals were not estimated and are not included in the costs of the study.

Three types of costs were calculated:

- Maximum cost of the intervention: value calculated from the day of the pharmaceutical intervention until the end of the medication's use or the patient's discharge from the ICU, representing the total intervention cost;

- Cost of the accepted intervention: value calculated from the date of acceptance of the intervention by the prescribing team until the end of the medication's use or the patient's discharge from the ICU;

- Cost of the rejected intervention: value calculated from the date of the intervention's rejection, with clinical justification, until the end of the medication's use or the patient's discharge from the ICU.

Expert panel

The five health conditions that had the highest additional medication therapy costs after the pharmaceutical intervention were evaluated by a panel of experts from the institution, using the modified Delphi method[12,13]. All the physicians on duty in the hospital's ICU on the days of the interview were invited, and the exclusion criterion was having worked in intensive care for less than three years.

In the first round, the experts reported their time working in intensive care, as well as their theoretical and practical knowledge of each health condition. They then asked how many days the absence of medication for the condition could increase each patient's length of stay in the ICU. Health conditions with less than 70% agreement on the increase in length of stay were disregarded.

In the second round, held 14 days after the first, the experts were asked whether they agreed that the absence of medication for each health condition could increase the mean value, in days, found in the previous round. The increase in hospitalization time was accepted if more than 70% of the experts agreed with the value of the mean.

All the data was collected and analyzed using Microsoft Excel (2016), taking absolute and relative frequency measurements. Costs were calculated as described above and the results presented in tables. The results of the expert panel were described according to the rounds carried out and the agreement between them.

Results

During the collection period, a total of 163 patients were monitored, totaling 1,143 patient-days (total time, in days, of pharmacotherapeutic monitoring of the monitored patients). Of these, 65.64% were male. The mean age was 55 ± 21 years, with the mean age for males being 49 ± 21 years.

A total of 5,770 prescription medications were analyzed, a mean of 35 medications per patient. Enoxaparin 40mg was the most prescribed medication (8.28%), followed by intravenous omeprazole 40mg (7.38%) and chlorhexidine solution 0.12% (6.67%). In relation to the health conditions found, thromboembolism prophylaxis was the most frequent (9.24%), followed by stress ulcer prophylaxis (7.34%) and oral hygiene (6.65%).

Of the total number of medications prescribed, 4.78% (n=276) required pharmaceutical intervention for 104 patients. Intravenous omeprazole was the medication with the highest number of interventions (13.04%), followed by vancomycin (9.42%) and tetanus vaccine (4.35%). The main therapeutic groups that required pharmaceutical intervention are listed in Table 1.

Table 1. Pharmaceutical interventions carried out in the ICU of an urgent and emergency hospital according to the ATC therapeutic groups, between May and July 2022.

Therapeutic Group	Frequency	
	Absolute	Relative (%)
J01 - Antibacterials for systemic use	66	19.35
A02 - Medications for acid disorders	45	13.20
N03 – Antiepileptics	29	8.50
B01 - Antithrombotic agentes	23	6.74
J07 – Vaccines	18	5.28
A11 – Vitamins	17	4.99
R03 - Drugs for respiratory obstructive diseases	15	4.40
Others	128	37.54

ICU - intensive care unit. ATC - Anatomical Therapeutic Chemical[14]. Elaborada pelos autores, 2022.

During the study period, 362 pharmaceutical interventions were carried out, with a mean of two interventions per patient. Most of the interventions were related to changes in pharmacotherapy (93.37%). Of the remainder, around 3.04% were related to general information and guidance and 0.83% to documenting special medications. 75.00% of the interventions were acceptable. Around 12% of the interventions were rejected without clinical justification, while approximately 4% were rejected with justification. The remainder corresponded to interventions carried out on patients who were discharged, transferred, or died less than 48 hours after the intervention.

A total of 361 MRPs were found, almost half of which were related to indication, either due to the need to include a new medication or the withdrawal one currently in use. Safety aspects were the reason for around 32% of the MRPs, while effectiveness and convenience accounted for around 10% and 8%, respectively. The resolution rate of the MRPs was 74.24%.

Intervention costs

The direct costs of the pharmaceutical interventions that suggested a change in pharmacotherapy were stratified according to acceptability (Table 2). As the costs involve the value of the prescribed therapy minus the value of the proposed therapy, a total saving of R$10,858.87 (US$2,092.91) was estimated, with a monthly mean of R$3,619.62 (US$697.64). The savings related to diluents and medical materials were R$635.21 (US$122.43) and R$237.29 (US$45.43), respectively.

Table 2. Costs of pharmaceutical interventions resulting from pharmacotherapeutic monitoring in the ICU of an urgent and emergency hospital in May and July 2022.

Cost Type	Month			Monthly mean	Total
	May	June	July		
Maximum intervention cost	9.183,32 R$ (1,769.97 US$)	1.488,84 R$ (286.96 US$)	2.104,60 R$ (405.64 US$)	4.258,92 R$ (820.85 US$)	12.776,76 R$ (2,462.56 US$)
Accepted intervention cost	8.123,63 R$ (1,565.73 US$)	935,60 R$ (180.33 US$)	1.799,64 R$ (346.86 US$)	3.619,62 R$ (697.64 US$)	10.858,87 R$ (2,092.91 US$)
Rejection intervention cost	79,37 R$ (15.30 US$)	48,41 R$ (9.33 US$)	-108,86 R$ (- 20.98 US$)	6,31 R$ (1.22 US$)	18,93 R$ (3.65 US$)

ICU- intensive care unit; R$- reais; US$- dollar. Positive values mean a reduction in costs in relation to the prescribed therapy and negative values mean an increase in costs. The dollar value (US$) on July 29, 2022 was R$ 5.19 (US$ 1.00). Prepared by the authors, 2022.

The maximum cost of the interventions was R$12,776.76 (US$2,462.56), while the cost of the interventions rejected with justification would have been R$18.93 (US$3.65) if they had been accepted. A mean saving of R$9.50/patient-day (US$1.83/patient-day) was estimated for pharmacotherapeutic follow-up. The difference between the maximum cost of the intervention and the cost of the accepted intervention was R$1,917.89 (US$369.65). The 39 interventions (15.79%) that were not accepted without justification amounted to a total cost of R$1,873.48 (US$361.09).

There were 101 interventions that generated savings, with the suggestion of downgrading from anidulafungin to fluconazole having the highest economic value, R$3,209.77 (US$618.64). On the other hand, 82 interventions increased costs, the highest being the downgrading of vancomycin to ampicillin+sulbactam, R$467.56 (US$90.12). Table 3 shows the main health conditions that saw savings after the intervention. A total of 46 infectious conditions were recorded, and the interventions on them led to savings of R$9,174.60 (US$1,768.29).

Among the prescribed medications that had pharmaceutical intervention accepted, around 78% were classified as A and 22% as B on the institution's ABC curve. These amounted to savings of R$12,496.11 (US$2,408.47) and R$541.23 (US$104.32) respectively. Table 4 shows the main medications, the therapeutic class, the classification on the ABC curve and the savings resulting from the pharmaceutical intervention.

Of the 361 MRPs, 54.57% had a financial impact. The need for additional medication (MRP 2) and a dose increase (MRP 4) corresponded to an additional cost of R$2,160.50 (US$416.41) and R$563.88 (US$108.68), respectively. On the other hand, MRPs involving unnecessary medications (MRP 1), adverse reactions (MRP 5), high doses (MRP 6) and convenience (MRP 7) led to savings of R$5,643.55 (US$1,087.72), R$3,674.64 (US$708.24), R$4,099.85 (US$790.20) and R$165.23 (US$31.85), respectively. It is worth noting that the classification in terms of convenience included factors such as the purchase of special medications and more rational dilutions, in addition to patient compliance.

Table 3. Health conditions that showed savings in resources after acceptance of pharmaceutical intervention in pharmacotherapeutic monitoring in the ICU of an urgent and emergency hospital, in the months of May and July 2022.

Health condition	Number of interventions	Economy
Intra-abdominal infection	1	3.209,77 R$ (618.64 US$)
Pleural empyema	3	2.878,66 R$ (554.83 US$)
Soft tissue infection	5	991,87 R$ (191.17 US$)
Infection without a defined focus	6	705,25 R$ (135.93 US$)
Wernicke's encephalopathy prophylaxis	12	467,11 R$ (90.03 US$)
Community-acquired pneumonia	4	434,91 R$ (83.82 US$)
Nosocomial pneumonia	3	419,31 R$ (80.81 US$)
Stress ulcer prophylaxis	23	271,40 R$ (52.31 US$)
Ventilator-associated pneumonia	8	191,42 R$ (36.89 US$)
Others	79	1.923,05 R$ (370.64 US$)

ICU- intensive care unit; R$- reais; US$- dollar. The dollar value (US$) on July 29, 2022 was R$ 5.19 (US$ 1.00). Prepared by the authors, 2022.

Table 4. Main medications, classification in the ABC curve and costs of pharmaceutical interventions accepted in the pharmacotherapeutic monitoring of the ICU of an urgent and emergency hospital, in the months of May and July 2022.

Medication	Therapeutic class	ABC curve	Number of interventions	Accepted intervention cost
meropenem 1g FA	Antimicrobial	A	6	3.341,33 R$ (644.00 US$)
anidulafungina 100mg FA	Antimicrobial	A	1	3.209,77 R$ (618.64 US$)
colistimetato 1.000.000UI FA	Antimicrobial	A	5	1.679,08 R$ (323.62 US$)
tiamina 100mg/mL amp 1mL	Vitamin	A	6	1.317,66 R$ (253.96 US$)
omeprazol 40mg FA	Antacid	A	19	1.040,46 R$ (200.54 US$)
amoxicilina 1g + clavulanato 200mg FA	Antimicrobial	A	4	505,20 R$ (97.37 US$)
enoxaparina 60mg/0,6mL ser	Anticoagulant	A	2	368,17 R$ (70.96 US$)
fenitoína 50mg/mL amp 5mL	Anticonvulsant	A	8	313,55 R$ (60.43 US$)
vancomicina 500mg FA	Antimicrobial	A	18	288,17 R$ (55.54 US$)
Others	-	-	55	1.301,32 R$ (250.81 US$)

ICU- intensive care unit; R$- reais; US$- dollar; g- gram; FA- vial; mg- milligram; IU- international units; mL- milliliter; amp- vial; ser- syringe. The ABC curve classification was provided by the institution's Costs Department. The dollar value (US$) on July 29, 2022 was R$5.19 (US$1.00). Prepared by the authors, 2022.

Expert panel

Table 5 shows the five main health conditions that were the reason for pharmaceutical intervention, with the need to introduce medication and, consequently, an increase in cost, totaling R$1,860.49 (US$358.59) in 19 interventions carried out. In the first round of questions from the experts panel, the conditions were assessed by eight professionals, who had worked in the ICU for 9.1 ± 4.6 years, finding the mean possible increase in a patient's length of stay in the sector for each health condition. Hypocalcemia was disregarded due to the agreement of only half of the specialists.

In the second round, the means of the health conditions were validated by nine specialists, who had worked in ICUs for 8.4 ± 4.7 years. There was agreement that the absence of medication for stress ulcer prophylaxis could increase the length of stay by five days, while the absence of antimicrobial synergism for the treatment of ventilator-associated pneumonia (VAP) and the absence of corticosteroids for the management of adrenal insufficiency in septic shock could each increase the length of stay by seven days. Wernicke's encephalopathy prophylaxis was disregarded due to only 67.00% of the experts agreeing with the mean found in the first round.

Table 5. Increased length of stay in the ICU of an urgent and emergency hospital due to lack of medication for health conditions, according to an Expert Panel.

	Condição de saúde				
	Stress ulcer prof.	**Prof. of Wernicke's encephalopathy**	**ATM synergism for VAP**	**Hypokalemia**	**Adrenal insufficiency**
Intervention (n)	2	7	2	7	1
Total added cost (R$)	780,35	717,18	215,80	73,83	73,33
Total added cost (US$)	150.40	138.23	41.59	14.23	14.13
First round of the Experts Panel					
Concordance	100,0%	87,0%	100,0%	50,0%	100,0%
Additional length of stay	5 dias	5 dias	7 dias	-	7 dias
Second round of the Experts Panel					
Concordance	89,0%	67,0%	100,0%	-	78,0%
Confirmation of addition	5 dias	-	7 dias	-	7 dias

Total added cost

Discussion

This study estimated the costs of pharmaceutical intervention in an urgent and emergency hospital, based on data collected from the pharmacotherapeutic monitoring service in the ICU. Positive results were expected, given that the role of clinical pharmacists in the care of critically ill patients has been described as a strategy for optimizing and reducing hospital costs[15,16].

Most of the patients were male and aged between 40 and 60, a profile corresponding to that found by Rosa *et al.* in a Brazilian university emergency hospital. [17].

The prescription of medications from therapeutic groups J01 (systemic antibacterials), B01 (antithrombotic medications) and A02 (medications for acid disorders) was predominant. A similar result was seen in the study carried out by Cardinal *et al.* in the adult ICU of a university hospital in Brazil, in which these therapeutic groups accounted for 10.90%, 4.77% and 5.50% respectively, with a greater difference in the use of antithrombotics[18]. There was a correspondence between the most prescribed medications and the most common health conditions, which are related to the clinical characteristics of critically ill patients, given the risks of infection and severity[19].

Pharmaceutical interventions were more frequent in groups J01, A02 and N03 (antiepileptics), similar to the profile of interventions carried out in cardiology and general practice ICUs in a public hospital in Brazil[15]. Suggesting changes to pharmacotherapy was the most frequent type of intervention and corroborates the assiduous participation of pharmaceutical professionals in the rational use of medications.

In 2016, in the same ICU as this study, Magalhães *et al.* showed that only 8.27% of MRPs were related to indication, while effectiveness and safety accounted for 51.44% and 40.29%, respectively[20]. The results showed a change in the profile of MRPs, which can be explained by the greater number of professionals and participation in the multi-professional team, as well as the education of prescribing professionals that has been taking place since the service was implemented. The acceptability of the interventions and the resolution of the MRPs were similar to other studies evaluating pharmaceutical interventions.[7,15].

Intervention costs

Unlike most studies of pharmaceutical intervention costs, this study used the prices of medications, diluents and medical-hospital materials used in the preparation and administration of medication therapy, thus approximating the hospital's expenditure on medication. In addition, the stratification of the three types of costs allowed for a broader analysis of the hospital routine.

A reduction of R$10,858.87 (US$2,092.91) in spending on pharmacotherapy was estimated, obtained with the accepted pharmaceutical interventions. Arantes *et al.*, in a study carried out in a university hospital in Brazil, obtained a saving close to the one found (R$10,521.20), with 296 interventions carried out over 6 months in clinical ICUs[21].

Savings on diluents amounted to 5.85% of the total value, while savings on medical materials amounted to 2.18%. The month of May had the greatest financial impact, due to the higher number of active residents and the significantly economical intervention of anidulafungin decalonization.

The calculation of the maximum cost of the intervention and the difference of R$1,917.89 (US$369.65) in the cost of the accepted intervention highlight a saving that could have been made if, above all, communication between the care team had been more effective.

Reis *et al*. estimated only 6.75% of refusals without justification in an analysis of pharmaceutical interventions[7], unlike the 15.79% found in this study, which had a potential saving of R$1,873.48 (US$361.09). On the other hand, a saving of R$18.93 (US$3.65) would have been made, inadequately, if the pharmaceutical interventions had not been rejected, given the existence of a clinical justification for each rejection. As such, efforts should be made to improve team communication and interaction, especially between pharmacists and prescribers[22], to encourage evidence-based practices and the construction of clinical protocols, in order to enable discussions with a better scientific basis, more effective pharmacotherapy changes and greater clinical and financial effectiveness.

The mean saving of R$9.50/patient-day (US$1.83/patient-day) would make it possible to estimate the financial impact of expanding the clinical pharmacy service. This estimated value could be even higher (R$11.18/patient-day - US$2.15) with improvements in communication, multidisciplinary interaction and the creation of clinical protocols. Although this figure is small compared to the cost of a bed per patient-day (unpublished data), it does not take into account the indirect costs related to the rational use of medications, promoting patient safety, reducing hospitalization time and other contributions made by pharmacists to multi-professional care. Furthermore, extrapolating to the 48 ICU beds, this saving could reach up to R$13,680.00 (US$2,636.65) per month, an amount that could help to hire clinical pharmacists.

Interventions targeting infectious conditions provided savings of R$9,174.60 (US$1,768.29), more than 85% of the total saved. Antimicrobials were the medications that had the greatest financial impact from the interventions, making them a potential therapeutic group for prioritization. Studies show that the role of clinical pharmacists in the use of antimicrobials also helps to reduce antimicrobial resistance and hospital-acquired infections, as well as optimizing treatment, advocating the importance of this professional in stewardship programs and hospital infection control committees, among others[23-25].

The differentiation between the items on the ABC curve showed the need for greater monitoring of the A items, given the savings of R$12,496.11 (US$2,408.47). Antimicrobials are five of the main medications with intervention and significant cost reductions, corroborating the impact of this therapeutic group. Along with them, the medications used for prophylaxis are also part of the A items on the ABC curve. In this way, using the A items on the ABC curve as a tool for prioritizing pharmaceutical activity can have a significant clinical and financial impact in the hospital environment[26,27].

The breakdown by MRP showed that the increase in costs was inevitable, given the need for additional medications (MRP 2) or an increase in the dose of the ones in use (MRP 4). The other MRPs promoted savings with the acceptance of pharmaceutical intervention. In addition to patient convenience, MRP 7 may also have greater savings, given the impossibility of the methodology used to measure the impacts of reducing the dispensing, handling and administration of medications by the pharmacy and nursing staff. No other studies with an economic approach were found for each of the MRPs.

Experts panel

The health conditions in the experts panel were the focus of pharmaceutical interventions aimed at introducing a medication (MRP 2), thus increasing costs. Despite the lower level of evidence, the construction of the expert panel using the modified Delphi method was a more specific inference of the clinical pharmacist's contribution to reducing the length of stay in the hospital's ICU. In addition, the definition of 70% agreement between the opinions of the interviewees allowed for greater reliability in the values found[12,28].

The estimate of an increase of five days of hospitalization due to the absence of medication for stress ulcer prophylaxis was similar to that found by Cook *et al.* who saw an increase of four to eight days of hospitalization for mechanically ventilated patients without stress ulcer prophylaxis[29]. Abdelsalam *et al*. showed that the use of two antimicrobials to treat ventilator-associated pneumonia reduced the length of stay of patients in intensive care by around four days[30], unlike the seven days found from the data in this study. Despite experts' agreement with the seven-day increase in hospitalization due to the absence of medications for adrenal insufficiency, a recent meta-analysis found no impact on hospitalization time associated with their use[31]. The frequent updating of the literature and the lower evidence level of an expert panel may explain the differences found, although this method allows for a more specific analysis of the hospital's reality.

Despite the cost increase of R$1,860.49 (US$358.59) with pharmaceutical interventions, the reduction in the possibility of negative outcomes of these health conditions has an impact on the clinical picture and indirect costs. Considering the mean value of an ICU bed/day, each pharmaceutical intervention could have avoided an additional cost of between R$20,000.00 (US$3,854.75) and R$28,000.00 (US$5,396.65) per negative outcome caused by the absence of medication.

Due to the possible lack of recording of interventions by patients being monitored, the absence of data on patients not being monitored and the suggestions and guidance given to the multi-professional team, the savings found in this study may be underestimated. In addition, the indirect costs of reducing the workload of other professionals (pharmacy technicians, nursing technicians, nurses, among others) were not measured in the study. The values of the medications, medical and hospital materials and diluents used to calculate the costs can change depending on the availability of the items on the market and the various purchasing processes. The experts panel, despite using the Delphi method, may be influenced by the profile of each interviewee and variations in response may occur according to the studies and experience of each expert. Finally, despite the reduction in costs in terms of hospitalization time with the expert panel, the financial outcomes were not assessed in terms of clinical improvement and the completeness of the patient's medication care, both inside and outside the intensive care unit.

Conclusion

The participation of the clinical pharmacist proved to be important for patient care and made it possible to save R$10,858.87 (US$2,092.91), as well as promoting the rational use of medications. The stratification of costs according to the variables evaluated (types of intervention, acceptability, medications, health

conditions and ABC curve) was relevant for a detailed analysis, while the experts panel made it possible to evaluate the reduction in hospitalization time. As mentioned, there are still variables that have not been fully covered, making future studies possible. Finally, this economic investigation could help pharmaceutical care management and improve the allocation of financial and human resources in the ICU of the institution and other hospitals.

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Conflict of interest declaration

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