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Economic impact of pharmaceutical interventions made in a renal transplant unit of a university hospital

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Abstract

Objective: To analyze the economic impact (EI) of pharmaceutical interventions (PI) made in a kidney transplant unit of a university hospital, through PI identification, EI classification and quantification of these. **Methods:** The observational cross-sectional study, descriptive study with retrospective data collection evaluated the PI records performed in a renal transplant infirmary in the period between June 2017 and June 2020, performed through the records on service-specific forms and database of the institution's clinical pharmacy unit. The economic impact was classified as: increase in effectiveness (IE); low cost (LC); avoided cost (AC), calculated through methodologies already developed and adapted to the reality of the study, were verified the costs of purchases of medicines in the hospital's own system and the values found adjusted to inflation of the years. The EI was classified according to the PI that had the potential to improve the medication use process and/or clinical effectiveness. In this classification, a real value of zero was assigned for the economic impact, even if the recommendation increased the value of the treatment. The RC was classified when the PI that included the cost was the one that felt the value of the treatment when compared with the previously administered therapeutic strategy without causing harm; and to classify as an AC the PI that was suggested to prevent or manage an Adverse Drug Event (ADE).**Results:** 873 PI were performed, of which 60.78% (n = 496) were of the type IE, 28.92% (n = 236) reduced cost and 10.30% (n = 84) avoided cost. The values found, were R$ 68,817.64 real (US$ 13.138,15 dollars) costs reduced, R$ 133,433.40 real (US$ 25.474,11 dollars) avoided, resulting in the final value of EI R$ 202,251.04 real (US$ 38.612,26 dollars). **Conclusion:** It is concluded that the implementation of Pharmaceutical interventions (IP) with Economic Impact (IE) and the use of pharmacoeconomic assessments function as an important strategy for optimizing resources and costs, combined with the search for ideal pharmacotherapy and improving clinical and economic.

Keywords: pharmacoeconomics, kidney transplantation, patient safety, drug-related side effects and adverse reactions, clinical pharmacists.

Impacto econômico das intervenções farmacêuticas realizadas em uma unidade de transplante renal de um hospital universitário

Resumo

Objetivo: Analisar o impacto econômico (IE) das intervenções farmacêuticas (IF) realizadas em uma unidade de transplante renal de um hospital universitário, através da identificação das IF, classificação do IE e quantificação destes. **Métodos:** O estudo de caráter transversal observacional, descritivo com coleta de dados retrospectiva que avaliou os registros das IF realizadas em uma enfermaria de transplante renal no período entre junho de 2017 e junho de 2020. A coleta de dados se deu entre janeiro a junho de 2022, realizada através dos registros em formulários específicos do serviço e banco de dados da unidade de farmácia clínica da instituição. O impacto econômico foi classificado como: aumento de efetividade (AE); custo reduzido (CR); custo evitado (CE), calculado através de metodologias já desenvolvidas e adaptadas a realidade do estudo. Foram verificados os custos de aquisições dos medicamentos no sistema próprio do hospital e os valores encontrados foram ajustados à inflação dos anos. O AE foi classificado quanto a IF que tinha o potencial de melhorar o processo de uso do medicamento e/ou a efetividade clínica. Nesta classificação foi atribuído o valor de zero real para o impacto econômico, mesmo que a recomendação tenha aumentado o valor do tratamento CR foi classificado quando a IF que reduziu custo foi a que diminuiu o valor do tratamento quando comparado com a estratégia terapêutica adotada anteriormente sem causar prejuízo; e para classificar como CE a IF que foi sugerida para prevenir ou manejar um Evento Adverso a Medicamento (EAM). **Resultados:** Foram realizadas 873 IF, das quais, 60,78% (n=496) foram do tipo aumento de efetividade, 28,92% (n=236) custo reduzido e 10,30% (n=84) custo evitado. Os valores encontrados, foram de R$ 68.817,64 reais (US$ 13.138,15 dólares) custos reduzidos, R$ 133.433,40 reais (US$ 25.474,11 dólares) evitados, resultando no valor final de IE R$ 202.251,04 reais (US$ 38.612,26 dólares). **Conclusão:** Conclui–se que, a implantação a implantação de Intervenções Farmacêuticas (IF) com Impacto Econômico (IE) e o uso de avaliações farmacoeconômicas funcionam como uma estratégia importante de otimização de recursos e custos, aliada à busca da farmacoterapia ideal e melhorando desfechos clínicos e econômicos.

Palavras-chave: farmacoeconomia, transplante de rim, segurança do paciente, evento adverso, farmacêuticos clínicos.

Introduction

Transplantation is an alternative treatment that involves a surgical procedure to transfer an organ (heart, lung, kidney, pancreas, liver) or tissue (bone marrow, bones, corneas) between two individuals. This procedure aims to improve the outlook and quality of life of patients affected by diseases that compromise the functioning and homeostasis of some organ or tissue [1,2,3].

Kidney transplantation is a surgical procedure that aims to restore the kidney's organic function by replacing the dysfunctional kidney with a functional one from a compatible donor. This type of surgery is usually indicated for the treatment of advanced kidney disease, when there is severe damage to the kidney that impairs its function of filtering and eliminating toxins from the body, as well as maintaining the balance of water and minerals in the body[1,2,3].

Brazil is in second place in the ranking of countries that perform kidney transplants[1,2,3]. However, kidney transplant patients are subject to adverse events, either because of the complexity of the surgical procedure or because of the polypharmacotherapy. It is therefore extremely important to study the culture of patient safety in kidney transplantation, since the health team is challenged to guarantee quality care and patient safety during their stay in the hospital environment for transplantation[4,5].

The clinical pharmacist offers services within hospital institutions with the aim of increasing patient safety in the medications use, through pharmaceutical care, dealing with direct patient care, promoting the rational use of medications and other health technologies, redefining their practice based on the needs of patients, families, caregivers, and society. In addition to working to promote health and improve the experience within hospital institutions, through the use of therapeutic guidelines based on scientific evidence, intervening and contributing to medical prescription, not only in technical aspects, but also economically, in order to obtain better clinical results for the patient[6,7,8.].

Adverse reactions and side effects are part of pharmacoeconomic evaluations when their occurrence generates additional costs for prophylaxis, control or palliative care and when their intensity can interfere with the clinical benefits of treatment, so there are clinical aspects to be considered[9].

There are different strategies used by pharmacists to promote safe practices in the medication use, which can contribute directly to improving care processes and managing the costs involved in these processes. These include health education, medication reconciliation, prescription review and pharmaceutical recommendations[10].

In light of this, pharmacoeconomic evaluations can be understood as the best cost-effectiveness ratio and should always look for interventions that rule out the worst clinical results and the highest costs. Therefore, clinical evaluation seeks to achieve greater effectiveness, safety, and quality of health treatments, while pharmacoeconomic evaluations seek to determine which of them has the greatest health benefits and the lowest cost by comparing two or more medications or health treatments[9].

There are various types of pharmacoeconomic analysis, but cost-effectiveness analysis indicates the therapeutic option that achieves the best clinical result per monetary unit applied. Reduced-cost or cost-utility analysis is an analysis of treatments that prolong life by eliminating only side effects or that produce a reduction in morbidity, while in cost-utility or reduced-cost analysis a monetary value is assigned in order to make them measurable and compare them[9].

Studies conducted in Brazil have shown that pharmaceutical recommendations result in cost savings for health services, which is why pharmacoeconomics should be considered an important strategy for rationalization, allowing different variables to be assessed, such as the cost, effectiveness, benefit, usefulness, and efficiency of different treatments. It is understood that pharmacoeconomics is the application of economics to the study of medications by optimizing the use of financial resources without affecting the quality of treatment, providing improvements in clinical parameters related to the disease and pharmacotherapy[11,12].

The review of pharmacotherapy throughout the hospital by clinical pharmacists has a positive cost-benefit ratio and contributes to the detection and resolution of Drug-Related Problems (DRPs), mainly by reducing over-treatment[13].

It is therefore necessary to measure and analyze the economic impact as a means of improving the quality of follow-up for transplant patients, as well as providing indicators for planning strategic actions to constantly improve the services provided by clinical pharmacists within hospital institutions.

Therefore, the purpose of this article is to analyze the economic impact of pharmaceutical recommendations made in a kidney transplant unit at a university hospital.

Methods

This is an observational, cross-sectional, descriptive study, with retrospective data collection, carried out in a university hospital in northeastern Brazil, based on the records of accepted pharmaceutical interventions (PI) carried out between June 2017 and June 2020, by clinical pharmacists of the service and resident pharmacists who work in the renal transplant ward. The hospital has 200 beds, 12 of which are wards for patients who have recently undergone kidney transplantation or who require hospitalization due to complications after transplantation. The unit is staffed by a medical, nursing, pharmacy, nutrition, physiotherapy, social work, and psychology team, in addition to medical and multi-professional residents, including pharmacists. The pharmacist's clinical practice in the renal transplant ward takes place through the provision of medication reconciliation on admission and discharge, and from Monday to Friday through the provision of a clinical pharmacotherapy review, where the pharmacist assesses the patient, the clinical records in the medical chart, discusses the patient in clinical rounds or individually with the attending physician and other team members, identifies opportunities to optimize pharmacotherapy and proposes interventions with the patient or team.

The data was collected from the clinical pharmacy unit's database (Microsoft Excel® 2016 model), and there was no need to access medical records or other electronic systems. The database in

question contains demographic, clinical and economic variables related to each of the pharmaceutical interventions carried out. The variables that make up the database are mainly: patient's initials, medical record, age, gender, PI date, hospitalization unit, pharmacist who performed the PI, description of the pharmacotherapeutic problem or clinical situation and its classification and its classification according to the standard adopted in the institutions, description of the pharmaceutical intervention and its classification according to the standard adopted in the institutions, PI acceptability, type of clinical impact, medications involved in the therapeutic strategy before and after PI, number of medications used or projected to be used before and after the PI, number of days of use or projected use of the medication before and after the PI, probability score for the occurrence of an adverse effect, financial value of the medication, financial value of the adverse effect, financial value of the therapeutic strategy before the PI, financial value of the strategy after the PI, difference in the financial value of the strategy before and after the PI (economic impact). The data recorded in the database comes from the pharmaceutical intervention registration form. The demographic and clinical variables on this form are filled in by the service pharmacist or resident pharmacist who assessed the patient and carried out the intervention. However, the economic variables are filled in by a group of pharmacists and trainees trained in the PI economic analysis, according to the methodology adopted at the institution. This group includes the coordinator of the clinical pharmacy unit. The data from this form is transcribed into the database by trainees under the supervision of the Clinical Pharmacy coordinator. Pharmaceutical interventions recorded in the database that did not have data for at least one of the database variables were excluded from the analysis.

Measuring economic impact

In order to classify and calculate the economic impact related to PIs, specific methodologies that have already been published and that work with projections were used to measure the PIs economic impact[14,15,16]. Some adaptations were necessary, mainly due to the difference in the health system. These adaptations are described in the methodology. The economic impact was classified as: increased effectiveness; reduced cost; avoided cost. In the study, an increase in effectiveness was defined as PI that had the potential to improve the process of using the medication and/or clinical effectiveness. In this classification, a real value of zero was assigned to the economic impact, even if the recommendation increased the treatment cost; the PI that reduced the cost was the one that reduced the treatment cost, without reducing its effectiveness, when compared to the therapeutic strategy adopted previously. For this calculation, unlike the original studies which used mean prices practiced on the market, we used the purchase price through a bidding process, at the time the PI was carried out, recorded in the specific system, and transcribed onto the PI form; the PI that was recommended to prevent or manage an Adverse Drug Event (ADE) was classified as an avoided cost. These PIs were classified by two clinical pharmacists trained in this methodology.

The following formula was used to calculate the reduced cost[16]: (CM x DD x DT) BPI – (CM x DD x DT) API; Where BPI is before the pharmaceutical intervention; API is after the pharmaceutical intervention; CM is the medication cost in reais, considering the purchase price in the year of the PI; DD is the daily dose calculated in vials, ampoules or ml, when the medication is an oral solution; DT is the days of treatment. Only the direct amount spent on purchasing the medication was considered to be the medication cost as well as the unit value, for the year in which the PI was carried out. The days of treatment variable considered the effectively administered period for the BPI cost calculation, together with the projected use, taking into account the information provided by the prescriber; in the absence of this information, institutional protocols or the institution's clinical practice were taken into account. For the API cost, we considered what was agreed with the care team, care protocols or the institution's clinical practice. Some criteria were used to assess the economic impact resulting from the change in pharmacotherapy: 1- Duration protocols at the institution or the dose and treatment time provided for in the medical request for antimicrobial release; 2- Diluent for intravenous infusions, the type and volume of the diluent in its original commercialized packaging was taken into consideration; 3- Dosage variation, the cumulative dose of the treatment time was considered; 4 - Therapy with a duration determined by institutional protocol, the treatment time was based on the days established in the protocol; 5- Treatment time was not provided for in the protocol, therefore 30 days was adopted for the treatment of chronic health problems and seven days for acute problems or prophylaxis. As a practical example of cost-saving PI, we have: Patient started on daptomycin 1FA day, expected to last 28 days, due to suspicion of bloodstream infection (BSI) with endocarditis. Subsequent tests ruled out endocarditis and the diagnosis of BSI was maintained. On the fourth day of treatment with daptomycin, the pharmacist discussed the case with the attending physician and infectious disease specialist, recommending the replacement of daptomycin with vancomycin and projecting only 10 days of treatment to cover the isolated germ, where vancomycin would be administered for only 6 more days, considering the patient's clinical context. The intervention was accepted. Applying the methodology, filling in the formula recommended by the literature adopted we have: (R$ daptomycin x 1 FA x 28) BPI - (R$ x 4 FA x 10d) API. Since daptomycin treatment costs more than vancomycin, the pharmacist's intervention optimized pharmacotherapy, reducing costs.

The costs avoided with PI that prevented or managed adverse effects were assessed by multiplying the probability of the adverse effect occurring without the PI by the mean value of a hospitalization due to the adverse effect. To categorize the probability, a risk score was used, stratified into probability levels from 0 to 1.0 (zero chance until the occurrence of an ADE), with a final value of 1 when the actual occurrence of an ADE or the patient's exposure to a drug known to be related to a previous ADE was identified. The risk stratification for the probability of an adverse effect occurring was: 0 (0 chance of an ADE occurring); 0.01 (very low chance of an ADE occurring); 0.10 (low chance of an ADE occurring); 0.4 (medium chance of an ADE occurring); 0.6 (high chance of an ADE occurring); 1.0 (an ADE occurred)[17]. The Micromedex®, UpToDate® and Medscape® databases were used to identify the rate of occurrence of adverse effects in the clinical situation related to PI. When the sources were too divergent, the rate with the lowest value was considered. The value found

was listed in the closest stratification category. The mean value of R$3,195.42 was used, referring to the hospitalization of a patient who suffered an adverse effect, according to the Brazilian study[18]. Examples of avoided cost calculations include the following situations: 1- Patient with a history of periorbital edema due to dipyrone, prescribed dipyrone. The pharmacist identified the situation and intervened by requesting that it be discontinued. For the economic calculation we have: 1 (probability score because it is a re-exposure to a medication that has already caused an adverse effect) multiplied by R$3,195.42; 2 - Patient using thymoglobulin without a corticosteroid prescription to prevent infusional adverse effects (fever 63%, dyspnea 28%). The pharmacist intervenes and suggests prescribing methylprednisolone according to protocol. For the economic calculation we have: 0.6 (score closest to the rate of 63% for the occurrence of fever due to thymoglobulin) multiplied by R$3,195.42.

For the final calculation of the economic impact, the sum of Reduced Costs and Avoided Costs were taken into account, with the values adjusted for the year June 2022, by the Broad National Consumer Price Index (IPCA), calculated directly from the Central Bank of Brazil's website[19].

The medications involved in the study's PI are arranged using the Anatomical Therapeutic Chemical (ATC) classification, guided by the 2nd level classification used by the World Health Organization (WHO), with the aim of grouping the types of drugs according to the organ or system of action and their chemical, pharmacological and therapeutic properties[20].

The data was analyzed using descriptive statistics. Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as percentages. The study was approved by the research ethics committee under CAAE (56178022.9.0000.5045) in accordance with resolution no. 466 of the National Health Council.

Results

A total of 873 accepted PIs were included in the analysis (95% acceptability). Of these, 6.5% (n=57) were not evaluated for clinical and economic impact due to missing data (missing medical record number=10; missing age=22; missing gender=25), so 816 PIs were included in the economic analysis. A total of 311 patients were involved in the 816 PIs, 61% (184) of whom were male, with a mean age of 48±16 years. The PI mean number per patient was 2.6 and 22.6 per month.

The most common pharmacotherapeutic problems involved in PI were non-prescribed necessary medication 12% (n=99), medication overdose 11% (n=89) and inadequate infusion time 10% (n=84). The other problems are listed in Table 1.

The main pharmaceutical interventions were dose adjustment 19% (n=161), medication inclusion 12% (n=100) and infusion time adjustment 11% (n=87). Table 2 shows the PI types identified in the study.

According to the ATC classification, the classes of medications most involved in PI were systemic antibacterials 31% (n=258), followed by immunosuppressants 13% (n=106) and anti-anemic medications 9% (n=72) (Figure 1).

As for the economic impact, 61% (n=496) of the PIs are of the increased effectiveness (IE) type, 29% (n=236) reduced cost (RC) and 10% (n=84) avoided cost (AC).

Table 1. Classification of pharmacotherapeutic problems identified during the study period in a Renal Transplant Unit at a University Hospital

Pharmaceutical recommendations	**n (%)**
Non-prescription of a necessary medication	99 (12.1%)
Overdose	89 (10.9%)
Inadequate/absent infusion time	84 (10.3%)
Unavailability of the medication (shortage)	72 8.80%)
Subdose	70 (8. 6%)
Prescription of non-necessary medication	53 (6.5%)
Missing documentation	52 (6.4%)
Inadequate or absent dilution/reconstitution	50 (6.1%)
Inadequate dosage	34 (4.2%)
Inadequate treatment time	25 (3.1%)
Inappropriate pharmaceutical form	24 (2.9%)
Medication unavailability (non-standard)	23(2.80%)
Inadequate selection	23 (2.57%)
Inappropriate administration route	21 (2.6%)
Low comfort	13 (1.6%))
Inadequate scheduling	12 (1.5%)
Others	72 (7.5%)

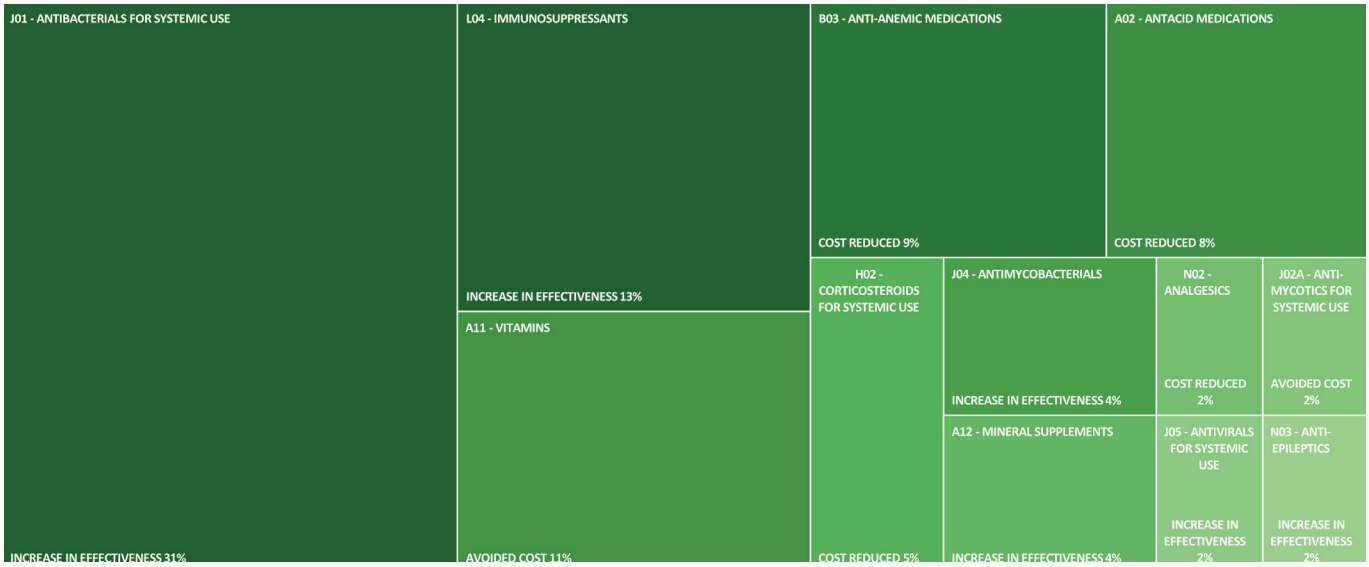
Source: Database of the institution's clinical pharmacy unit

Table 2. Classification of pharmaceutical recommendations made during the study period in a Renal Transplant Unit at a University Hospital

Pharmaceutical recommendations	n (%)
Dosage adequacy	161 (19.73%)
Medication inclusion	100 (12.25%)
Infusion time adecquacy	87 (10.66%)
Medication replacement	80 (9.80%)
Medication suspension	69 (8.46%)
Adaptation to the dispensing process	55 (6.74%)
Dilution/reconstitution adequacy	50 (6.13%)
Dosage adequacy	35 (4.29%)
Pharmaceutical form adequacy	32 (3.92%)
Administration route adequacy	23 (2.82%)
Essay correction	23 (2.82%)
Treatment time adequacy	22 (2.70%)
Medication availability	21 (2.57%)
Medication acquisition	19 (2.33%)
Scheduling adequacy	18 (2.21%)
Necessary tests request	11 (1.35%)
Education in the use of medications	4 (0.49%)
Technical information on medications	2 (0.25%)
Develop adherence strategies	2 (0.25%)
Medication inclusion	1 (0.12%)
Referral to other professionals	1 (0.12%)

Source: Database of the institution's clinical pharmacy unit

Figure 1. Anatomical Therapeutic Chemical (ATC) classification

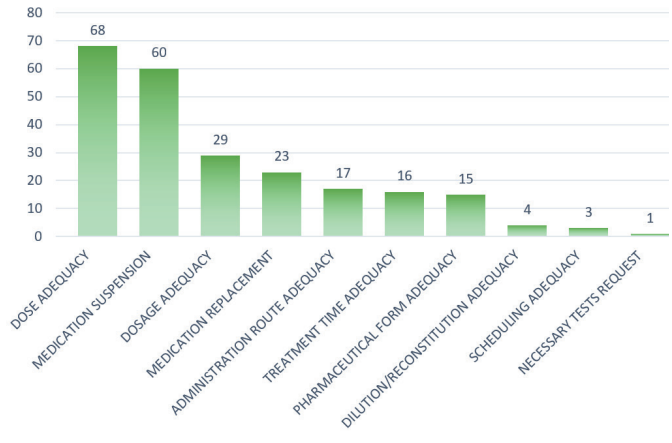


Source: Elaborated by the authors

For reduced-cost financial impact interventions, dose adjustment 28% (n=68) and medication discontinuation 25% (n=60) were the most prevalent pharmacotherapeutic interventions. For interventions with a financial impact of the avoided cost type, dose adequacy 20% (n=17) and infusion time adequacy 19% (n=16) were the most prevalent (Figures 2 and 3).

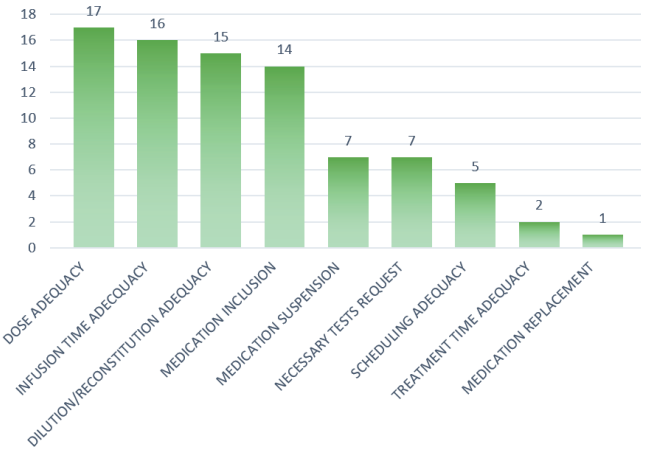
The figures for RC-type interventions were R$68,817.64 reais (US$13,138.15 dollars), which corresponds to savings of R$22,939.21 reais (US$4,379.38 dollars) per year. The economic impact interventions of the AC type resulted in savings of R$133,433.40 reais (US$25,474.11 dollars) over the 3 years. Therefore, the total value estimated in the study by adding reduced costs and avoided costs was R$202,251.04 reais (US$38,612.26 dollars), corresponding to R$67,417.01 reais (US$12,870.75 dollars) per year and R$5,618.08 (US$1,072.56) per month (Figure 4) without considering indirect costs.

Figure 2. Pharmaceutical Recommendations versus Reduced Cost



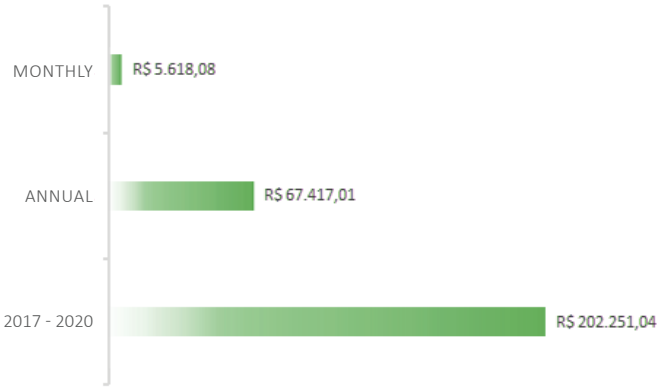
Source: Database of the institution's clinical pharmacy unit

Figure 3. Pharmaceutical Recommendations versus Avoided Cost



Source: Database of the institution's clinical pharmacy unit

Figure 4. Mean Economic Impact per Year and Month



Source: Elaborated by the authors

Discussion

The total of 873 PIs accepted in the period analyzed confirms the continued inclusion of clinical pharmacists in the institution where the study was carried out[21]. In an integrative review by Silva, 2022 it was found that pharmaceutical practice in the care of kidney transplant patients has been expanding continuously due to its growing recognition, appreciation, and clinical practice.[22].

Studies that report on the demographic profile of transplant patients undergoing pharmacotherapeutic follow-up, 63% (n=107) were male, with the most prevalent age group between 46-60 years[2]; similar to the present study where 61% (n=184) were male, with a mean age of 48 years, showing that the profile of transplant patients has not changed in relation to gender, which is consistent with the importance of these patients seeking medical follow-up as early as possible in order to avoid possible renal replacement therapy.

In relation to medication-related problems, studies have highlighted the following as prevalent: medication needed not prescribed (26%), underdose (14%) and overdose (13%)[2], while in the present study, medication needed not prescribed (12.1%), medication overdose (10.9%), infusion time (10.3%). The MRPs prevalence in the two studies of the necessary medication type and dose-related indicated that pharmaceutical recommendations result in processes to improve the clinical management of patients, contributing to the multi-professional team in the search for the best clinical outcome.

Research has shown that the pharmacist has been able to make recommendations with a significant clinical impact that have generated a very important increase in the effectiveness or quality of therapy through the follow-up of kidney transplant patients[23], therefore a study that reports the detection of drug-related problems by the pharmacist generates pharmaceutical recommendations that can promote the optimization of medication therapies, increase patient compliance and safety, as well as contributing to the reduction of institutional costs, length of hospital stay and negative outcomes of pharmacotherapy[21].

Based on the ATC classification, according to studies carried out at the second level, the predominant therapeutic classes were antibacterials for systemic use (31.2%), immunosuppressants (25.1%) and blood substitutes and perfusion solutions (7.8%)[22], corroborating this study, where the prevalent classes were antibacterials for systemic use (31%), immunosuppressants (13%) and anti-anemic medications (9%).

Although cost-saving interventions may comprise a small percentage of clinical pharmacy interventions, a cost minimization analysis has shown that such interventions can generate substantial savings without compromising patient outcomes[24]. However, the savings generated in direct and indirect costs, in another research, amounted to R$72,648.39 (US$13. 869.49) over seven months, including a Prescription Evaluation Center (Central de Avaliação de Prescrições, CAP), in the ten Intensive Care Units (ICUs) and seven wards where prescriptions are evaluated, confirming the performance of clinical pharmacists, and the ICU is considered a highly complex unit, with more diverse pharmacotherapies and more critical patients, which made it possible to have a higher reduced cost, in addition to being a high number of beds[26]. The amount of R$68,817.64 (US$13,138.15) found in this study for the RC during the clinical pharmacists' recommendations when evaluating patients and their pharmacotherapy is considerable, given that this is a unit with only 13 beds, compared to the hospital structure of ten ICUs and seven wards[25].

A Brazilian study found that 80 adverse medication events had a financial impact of R$96,877.90 (US$18,495.20) on the research institution, SUS (acronym for Unified Health System, in Portuguese) and society, 25 of which could have been avoided[4]. The data from this study related to the cost avoided (R$133,433.40) (US$25,474.11), referring to 84 pharmaceutical recommendations made, demonstrated the positive financial impact that PIs can have on avoiding and/or minimizing adverse effects, in addition to the clinical and humanistic impact. On a mean, each PI avoided a cost related to adverse effects of R$1,588.49 (US$303.26), by proposing pharmacotherapeutic conducts to prevent or manage an adverse drug effect.

This study has limitations, including being retrospective, using the value of an adverse effect from a study carried out in 2010, when practices and costs were different from those of today, and using a methodology based on conduct projections.

However, this article breaks new ground by presenting the economic impact of the role of clinical pharmacists in the care of kidney transplant patients and presents a methodology for the PI economic analysis that can be reproduced in other centers with any patient profile, for retrospective data.

Conclusion

The results estimate that the pharmaceutical interventions carried out achieved cost savings in the pharmacotherapy of kidney transplant patients (R$202,251.04 reais or US$38,612.26 dollars), the largest percentage of which was due to the avoided costs of adverse drug effects. Antimicrobials were the medications most involved in PIs with an impact on cost reduction.

Finally, the relevance of the economic evaluation of the pharmacist's clinical work should be highlighted, as this is an important strategy for optimizing resources and costs in scenarios of limited resources, with a view to the sustainability of health systems.

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Collaborators

The authors DTM, JAN and ABO took part in drawing up the project, critically reviewing the intellectual content, DTM, JAN contributed to the analysis and interpretation of the data, GAS, DTM, LMO took part in writing the article, and AML and CAC took part as reviewers of the article.

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Conflict Of Interest Declaration

The authors declare no conflict of interest in relation to this article.

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