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# Transitional care in home care for older adults patients on antimicrobial therapy: patient profile and cost analysis

Alessandra SANCHES<sup>1</sup> , Ronara Camila GROIA-VELOSO<sup>1</sup> , Juliana ÁLVARES-TEODORO<sup>2</sup> , Adriano Max REIS<sup>2</sup> , Renata Rezende MENEZES<sup>1</sup> , Caryne Margotto BERTOLLO<sup>2</sup> 

<sup>1</sup>Hospital das Clínicas da Universidade Federal de Minas Gerais, Belo Horizonte, Brasil;

<sup>2</sup>Faculdade de Farmácia da Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.

Corresponding author: Sanches A, lelesanchess@outlook.com

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## Abstract

**Objective:** To describe the clinical and pharmacotherapeutic profile of patients discharged from hospital using Outpatient Parenteral Antimicrobial Therapy (OPAT) and oral sequential therapy (OST) in a hospital in Belo Horizonte. The study also aimed to analyze the costs related to these transitional care models. **Methods:** Cross-sectional study characterized as a partial economic evaluation of antimicrobial (ATM) treatment initiated during hospitalization and continued after discharge with ATM dispensation through OST or OPAT. The study was conducted in a public university hospital in Belo Horizonte, Minas Gerais. The study population included patients aged 60 years or older, hospitalized between January 2022 and December 2023. Demographic, clinical, pharmacotherapeutic, and pharmacoeconomic variables were described. The cost analysis was performed based on the difference between the cost of hospitalization required to complete in-hospital antimicrobial administration and the cost of hospitalization with home-based continuation of treatment through OST or OPAT. **Results:** During the study period, 67 elderly patients on ATM were discharged. The median age was 68 years (Min. 61; Max. 89) and the median length of stay was 14 days (Min. 1; Max. 138). Most patients were followed by the internal medicine team (56.7%), followed by the ophthalmology team (17.9%). The antimicrobial with the longest duration of use (92 days) and the most frequently dispensed (50.7%) was voriconazole. Regarding the costs analyzed for maintaining hospitalization of patients using ATM, teicoplanin showed the highest median (R\$123,157.86), followed by vancomycin (R\$52,645.80). For hospital discharge costs, the highest medians were observed for ertapenem (R\$2,019.79) and teicoplanin (R\$1,483.55). **Conclusion:** Hospital discharge with ATM dispensation for OPAT or OST showed potential for economic feasibility. The antimicrobials whose treatment by OPAT or OST contributed most to reducing hospital length of stay were voriconazole and teicoplanin. Care models involving OST or OPAT contribute to continued care for the elderly.

**Keywords:** cost analysis, elderly, antimicrobials; length of hospitalization.

## Cuidados transitórios em atenção domiciliar de idosos em terapia antimicrobiana: perfil de pacientes e análise de custos

## Resumo

**Objetivo:** Descrever o perfil clínico e farmacoterápico dos pacientes com alta hospitalar em uso de Terapia Antimicrobiana Parenteral Ambulatorial (*Outpatient Parenteral Antimicrobial Therapy* - OPAT) e terapia sequencial oral (TSO) em um hospital de Belo Horizonte. O estudo visou também analisar os custos relacionados a esses modelos de cuidado transicional. **Métodos:** Estudo transversal caracterizado como uma avaliação econômica parcial do tratamento com antimicrobiano (ATM) iniciado na internação hospitalar e continuado após alta com dispensação de ATM por meio de TSO ou OPAT. Estudo conduzido em um hospital universitário da rede pública de Belo Horizonte, Minas Gerais. A população incluída foi composta por pacientes com 60 anos ou mais, internados no período de janeiro de 2022 a dezembro de 2023. Foram descritas variáveis demográficas, clínicas, farmacoterápicas e farmacoeconômicas. A análise de custo foi realizada a partir da diferença entre o custo da internação com permanência para finalização da administração hospitalar do ATM e o custo da internação com continuidade de tratamento domiciliar com TSO ou OPAT. **Resultados:** No período avaliado, foram desospitalizados 67 idosos em uso de ATM. A mediana de idade foi de 68 anos (Mín. 61; Máx. 89) e a mediana de tempo de internação foi de 14 dias (Mín. 1; Máx. 138). A maioria dos pacientes foi acompanhada pela equipe de clínica médica (56,7%), seguido da equipe de oftalmologia (17,9%). O ATM com maior tempo de uso (92 dias) e mais dispensado (50,7%) foi o voriconazol. Em relação aos custos analisados para manter a internação do paciente em uso do ATM, a teicoplanina apresentou a maior mediana (R\$123.157,86), seguida pela vancomicina (R\$52.645,80). No custo da alta hospitalar, as maiores medianas encontradas foram do ertapenem (R\$2.019,79) e da teicoplanina (R\$1.483,55).



**Conclusão:** A alta hospitalar com dispensação de ATM para OPAT ou TSO apresentou potencial de viabilidade econômica. Os ATMs cujo tratamento por OPAT ou TSO que mais contribuíram para redução do tempo de internação foram voriconazol e teicoplanina. Modelos de atenção abrangendo TSO ou OPAT contribuem para um cuidado continuado ao idoso.

**Palavras-chave:** análise de custo; idoso; antimicrobiano; tempo de internação.

## Introduction

The term “dehospitalization” refers to a planned hospital discharge process aimed at providing appropriate care to patients while preventing complications and readmissions<sup>1</sup>. This process becomes even more relevant in older adults, as prolonged hospitalizations can lead to functional decline<sup>2</sup>. To promote dehospitalization, it is essential to consider clinical, psychosocial, and logistical aspects to ensure that patients are not left without adequate support outside the hospital environment. For this reason, dehospitalization is also regarded as a factor that contributes to the humanization of healthcare practices<sup>3</sup>.

Home care services include innovative models of assistance, among which are transitional care programs. These programs aim to enable dehospitalization or early discharge through teams that continue medical interventions at the patient's home for a certain period, until definitive discharge, transition to family care, or follow-up in other healthcare services<sup>4</sup>. Among the models of transitional care in home settings is *Outpatient Parenteral Antimicrobial Therapy* (OPAT), which encompasses strategies that facilitate hospital discharge while ensuring the parenteral administration of antimicrobials (ATMs) at home or in an outpatient clinic, infusion center, or equivalent setting<sup>5</sup>. Another model is based on *Sequential Oral Therapy* (SOT), which involves antimicrobials available in oral dosage forms whose pharmacokinetic and pharmacodynamic profiles allow conversion from parenteral to oral administration in clinically stable patients<sup>6</sup>.

When implemented, dehospitalization offers economic benefits to the healthcare system, as the average cost of hospitalization increases with patient age and impacts the allocation of hospital resources<sup>7</sup>. Studies using data from DATASUS revealed that between 2002 and 2011, the Brazilian Unified Health System (SUS) spent approximately R\$21 billion on hospitalizations, with 36.47% of this amount spent on elderly patients alone<sup>8</sup>. Moreover, prolonged hospitalization also predisposes patients to healthcare-associated infections (HAIs)<sup>9</sup>.

In the case of elderly patients, care must be even more thorough, as the risk of developing infections increases with age<sup>10</sup>. One study found that 71% of HAIs occurred in individuals over 60 years old<sup>11</sup>. The prevalence of HAIs was 11% among older adults, compared with 7% in patients under 65 years<sup>10</sup>. Furthermore, up to 45% of hospitalized elderly patients with infections experience unfavorable outcomes within 30 days<sup>12</sup>. The Oswaldo Cruz Foundation highlights that heterogeneity is a hallmark of aging, manifesting as complex health needs due to the frequent coexistence of multiple chronic diseases, leading to polypharmacy. This contributes to increased dependence across multiple levels of care and heightens susceptibility to infections due to immunosenescence.

Evaluations of transitional care models that ensure access to antimicrobial therapy have reported reductions in the risk of HAIs, prevention of functional decline, and improvements in patients' quality of life<sup>5,13-14</sup>.

Conducting studies that assess costs associated with hospital discharge of elderly patients undergoing antimicrobial therapy can help quantify the economic impact of this strategy, identify potential cost differences linked to reduced hospital stays, and provide evidence for comparison with the costs of traditional care. Such studies therefore offer essential insights for healthcare managers to evaluate the feasibility and sustainability of transitional care programs.

Accordingly, the present study aimed to describe the profile of elderly patients and the costs associated with their hospitalizations compared to the costs of hospital discharge with antimicrobial therapy administered under OPAT or SOT regimens in a public university hospital in Belo Horizonte, Minas Gerais, Brazil.

## Methods

### Study Design

A cross-sectional study was conducted, characterized as a partial economic evaluation (cost analysis) of antimicrobial therapy (AMT) initiated during hospital admission and continued after discharge through *Sequential Oral Therapy* (SOT) or *Outpatient Parenteral Antimicrobial Therapy* (OPAT). The cost analysis was performed from the hospital's perspective. The present study was reported in accordance with the *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) guidelines.

### Population and Inclusion/Exclusion Criteria

The study population consisted of elderly patients, defined as individuals aged 60 years or older according to Law No. 10.741 of 2003, who were hospitalized between January 2022 and December 2023, initiated AMT during hospitalization, and were discharged with antimicrobial dispensing through SOT or OPAT.

Patients were excluded if their request for antimicrobial dispensing upon discharge was denied by the hospital administration or if they were discharged using medications other than antimicrobials.

All patients meeting the inclusion criteria and hospitalized during the study period were included; therefore, no sample size calculation was applied, and the data are not subject to sampling error.

### Study Setting

The study was conducted in a public university hospital in Belo Horizonte, Minas Gerais, Brazil. The hospital has approximately 500 beds and serves as a municipal and state reference center for the treatment of medium- and high-complexity diseases, benefiting about 450,000 people annually.



The institution implements transitional care models to ensure continuity of care at home or on an outpatient basis, developed in integration with the home care services of the Municipal Health Department of Belo Horizonte. Among these transitional models are OPAT and SOT.

### System for Providing OPAT and SOT to Patients at Hospital Discharge

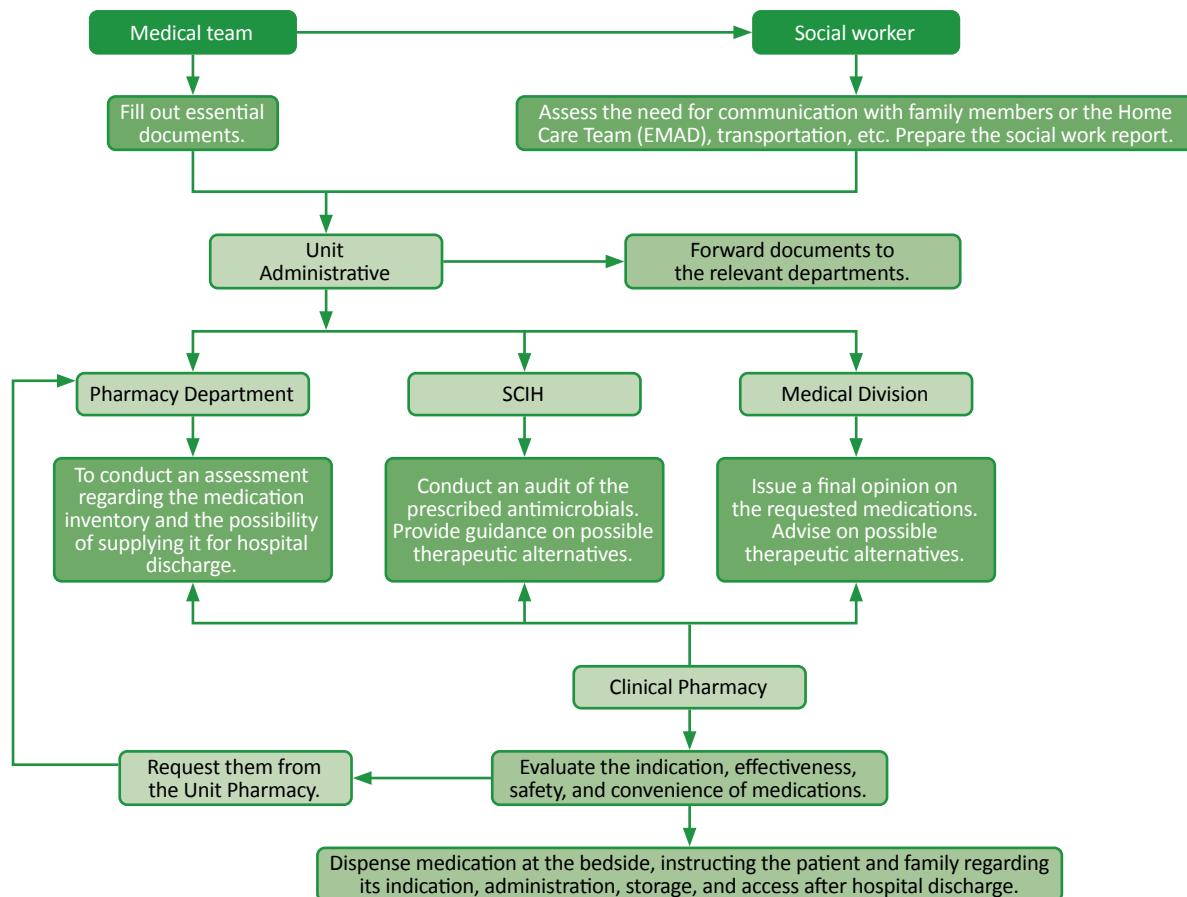
The feasibility of hospital discharge with OPAT or SOT is assessed by the *Clinical Pharmacy Unit* (UFCli) after authorization from the *Health Care Management Department* (GAS) and the *Hospital Infection Control Service* (SCIH). Initially, the attending physician verifies whether the patient is clinically stable and completes a medication discharge request form, which is then forwarded to the social worker for preparation of a social report. The social worker subsequently requests information from the Hospital Pharmacy regarding the cost and availability of the medication.

The Hospital Pharmacy, in turn, consults the Infectious Diseases team of the SCIH to assess the indication and duration of therapy. The GAS then reviews the budgetary availability for medication release. Once approved, dispensing is carried out by the clinical pharmacist at the patient's bedside (Figure 1).

During dispensing, the pharmacist provides counseling to the patient and their family regarding medication use, storage, and main adverse reactions, and delivers an instruction booklet. If the medication can be administered by the patient or a family member, the pharmacist provides training on the correct administration technique. For instance, some medications originally formulated for intravenous use, such as vancomycin, can be administered orally in specific situations, such as for the treatment of pseudomembranous colitis<sup>15</sup>. In such cases, the pharmacist provides guidance on proper dosage, administration techniques, and necessary precautions.

For patients discharged with OPAT, the medication is dispensed by the *Clinical Pharmacy Unit* (UFCli), and home administration instructions are provided by professionals from the *Multidisciplinary Home Care Team* (*Equipe Multiprofissional de Atenção Domiciliar*, EMAD), coordinated by the *Municipal Health Department of Belo Horizonte*. Furthermore, the hospital schedules follow-up visits with the EMAD and the *Support Multidisciplinary Home Care Team* (*Equipe Multiprofissional de Apoio*, EMAP) closest to the patient's residence. For patients residing in other municipalities, the institution contacts the local *Home Care Service* (*Serviço de Atenção Domiciliar*, SAD) at the destination.

**Figure 1.** Medication dispensing process for hospital discharge in a tertiary hospital. Belo Horizonte, 2024.



## Medications Provided through SOT or OPAT

The standardized antimicrobials that may be dispensed at discharge under SOT in the studied hospital are: Amoxicillin-clavulanate 500 mg + 125 mg tablets; Voriconazole 200 mg capsules; Vancomycin 500 mg vials; Sulfamethoxazole-trimethoprim 400 mg + 80 mg tablets. For patients discharged under OPAT, the following antimicrobials are available: Teicoplanin 500 mg vials; Amikacin 250 mg/mL ampoules; Gentamicin 40 mg ampoules; Piperacillin-tazobactam 400 mg + 500 mg vials; Ertapenem 1 g vials; Ceftriaxone 1 g vials.

## Data Collection

Data collection was retrospective, based on the review of management and clinical reports from the hospital for the study period. The hospital's electronic system (*Hospital Management Application for University Hospitals – AGHUX®*) was consulted to identify the purchase prices of antimicrobials dispensed for SOT and OPAT patients. These prices refer to acquisition costs obtained through public procurement processes. The data were recorded in an Excel® spreadsheet.

The cost per hospital bed-day was obtained from the cost centers of the inpatient units where patients discharged on SOT or OPAT were admitted. The bed-day cost was calculated using the *SUS Cost Management and Accounting System (APURASUS)*, developed by the *National Cost Management Program* of the *Department of Health Economics and Development (DESID)*, under the *Secretariat of Science, Technology, and Innovation and the Health Economic-Industrial Complex (SECTICS)*. In the studied hospital, cost calculations are performed by the accounting department by cost center.

## Variables Analyzed

The analyzed variables were divided into demographic, clinical, pharmacotherapeutic, and pharmaco-economic categories. Demographic variables: sex (female or male) and age (in years); clinical variables: length of stay, hospital unit during admission, previous hospitalization (within the past year), and readmission (within the past year); pharmacotherapeutic variables: antimicrobials used during hospitalization, antimicrobials dispensed at discharge, and duration of dispensed treatment (in days); pharmaco-economic variables: cost of hospitalization with in-hospital AMT administration and cost of antimicrobials and supplies dispensed for OPAT or SOT.

## Cost Calculation

For the cost of antimicrobials and supplies dispensed for OPAT or SOT, the 24-hour treatment cost with the antimicrobial was multiplied by the number of days required to complete therapy. For the cost of hospitalization with in-hospital antimicrobial administration, the bed-day cost for the patient's inpatient unit was multiplied by the number of days of hospitalization from admission to discharge following completion of therapy (based on the planned treatment duration). The difference between the cost of hospitalization required to complete in-hospital antimicrobial administration and the cost of hospitalization with continued home treatment through SOT or OPAT was then calculated.

## Data Analysis

Statistical analysis included calculating absolute (n) and relative (%) frequencies for categorical variables and measures of central tendency and dispersion for numerical variables. Normality was assessed using the Kolmogorov-Smirnov test, considering a significance level of  $p < 0.05$  and a 95% confidence interval (CI). Data were analyzed using SPSS® software, version 21.0.

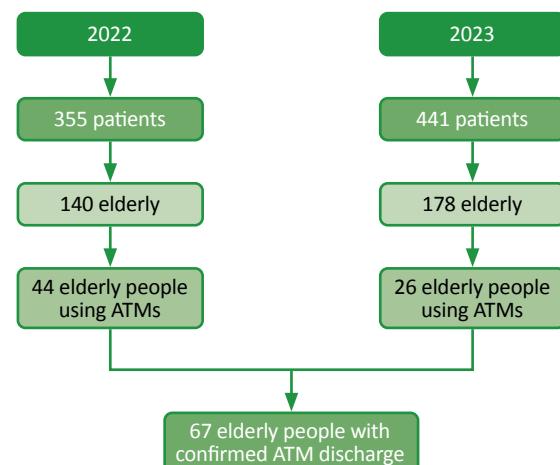
## Ethical Aspects

This study was conducted in accordance with Resolution No. 466/12 of the Brazilian National Health Council (CNS) and was approved by the Research Ethics Committee of the Federal University of Minas Gerais under protocol number 80169717.4.0000.5149.

## Results

During the evaluated period, among the 796 patients discharged with dispensed medications, 318 were elderly, of whom 67 were using antimicrobials (Figure 2). There was a slightly higher number of female patients (50.7%). The median age was 68 years (Min. 61; Max. 89), and the median length of hospital stay was 14 days (Min. 1; Max. 138). Most patients were treated by the internal medicine team (56.7%), followed by ophthalmology (17.9%) and hematology (9%). Nearly half of the elderly patients required readmission after discharge (49.3%), and 44 patients (65.7%) had been hospitalized previously within the same year (Table 1).

**Figure 2.** Selection of older patients discharged while using antimicrobials included in the study.



A total of ten different antimicrobials were dispensed, with the same antimicrobial used during hospitalization in 68.5% of cases. Most patients were discharged with orally administered medications, that is, under Sequential Oral Therapy (SOT) (73.1%). The antimicrobial with the longest duration of use was voriconazole (92 days), which was also the most frequently dispensed (50.7%), followed by vancomycin (16.4%). Vancomycin also presented the greatest variability in treatment duration (maximum 81 days; minimum 4).

Teicoplanin had the second-highest median treatment duration (19.5 days), with a maximum duration similar to that of ertapenem (28 days). Gentamicin, piperacillin + tazobactam, and sulfamethoxazole + trimethoprim were each prescribed to only one patient (Table 2).

Regarding the analyzed costs of maintaining hospitalization for antimicrobial administration, teicoplanin had the highest median cost (R\$123,157.86), followed by vancomycin (R\$52,645.80) and amoxicillin + clavulanate (R\$46,407.90). Conversely, the lowest median costs were observed for amikacin (R\$18,141.23) and ertapenem (R\$26,368.12). For hospital discharge with SOT or OPAT, the highest median costs were associated with ertapenem (R\$2,019.79), teicoplanin (R\$1,483.55), and voriconazole (R\$1,274.40), while the lowest were observed for amoxicillin + clavulanate (R\$20.97) and vancomycin (R\$32.98).

**Table 1.** Demographic and clinical characteristics of older patients discharged while using antimicrobials in a tertiary hospital. Belo Horizonte, 2024.

Sociodemographic characteristics		Value	
Age in years [median (maximum; minimum)]	68	89; 61	
Female sex [n (%)]	34	50.7	
Male sex [n (%)]	33	49.3	
Clinical characteristics			
Length of hospital stay [median (maximum; minimum)]	14	138; 1	
Readmission [n (%)]	33	49.3	
Previous hospitalization [n (%)]	44	65.7	
Under medical clinic care [n (%)]	38	56.7	
Under ophthalmology care [n (%)]	12	17.9	
Under hematology care [n (%)]	6	9.0	
Under palliative care [n (%)]	2	3.0	
Under cardiology care [n (%)]	2	3.0	

Consequently, the greatest cost differences between in-hospital treatment and home-based continuation were found for teicoplanin (R\$121,674.31), vancomycin (R\$52,612.82), and amoxicillin + clavulanate (R\$46,386.93) (Table 3).

**Table 2.** Description of treatment duration with Sequential Oral Therapy (SOT) or Outpatient Parenteral Antimicrobial Therapy (OPAT) among older adults included in the study. Belo Horizonte, 2024.

ATC – Chemical level Drug used at hospital discharge <sup>1</sup>	Median (days)	Maximum (days)	Minimum (days)
Systemic antibacterials			
Aminoglycosides			
Amikacin (n = 4)	7.5	9	4
Penicillin combinations including $\beta$ -lactamase inhibitors			
Amoxicillin + clavulanate (n = 3)	7	10	4
Third-generation cephalosporins			
Ceftriaxone (n = 2)	12.5	15	10
Carbapenems			
Ertapenem (n = 6)	11	28	6
Glycopeptides			
Teicoplanin (n = 4)	19.5	28	7
Vancomycin (n = 11)	9	81	4
Antifungals			
Triazole and triazole derivatives			
Voriconazole (n = 34)	36	92	15

<sup>1</sup>Data for gentamicin (aminoglycosides), piperacillin + tazobactam (penicillin combinations including  $\beta$ -lactamase inhibitors), and sulfamethoxazole + trimethoprim (sulfamethoxazole + trimethoprim combinations) were omitted, as these medications were dispensed to only one patient each.

**Table 3.** Costs of continuing antimicrobial treatment at home through SOT or OPAT compared with in-hospital administration costs among older adults. Belo Horizonte, 2024.

Drug used at hospital discharge <sup>1</sup>	Maintain hospitalization			Hospital discharge			Difference (Median) (R\$)
	Median (R\$)	Maximum (R\$)	Minimum (R\$)	Median (R\$)	Maximum (R\$)	Minimum (R\$)	
Amikacin	18,141.23	77,877.14	8,437.80	78.84	105.12	70.08	18,062.39
Amoxicillin + clavulanate	46,407.90	78,356.23	41,482.71	20.97	29.95	11.98	46,386.93
Ceftriaxone	45,701.61	82,965.42	8,437.80	148.71	210.00	87.43	45,552.90
Ertapenem	26,368.12	118,129.20	15,718.43	2,019.79	3,141.25	162.68	24,348.33
Teicoplanin	123,157.86	193,034.60	92,183.80	1,483.55	3,025.51	504.25	121,674.31
Vancomycin	52,645.80	202,094.10	4,490.98	32.98	113.07	14.13	52,612.82
Voriconazole	41,837.11	284,287.32	8,437.80	1,274.40	3,256.80	531.00	40,562.71

<sup>1</sup>Data for gentamicin (aminoglycosides), piperacillin + tazobactam (penicillin combinations including  $\beta$ -lactamase inhibitors), and sulfamethoxazole + trimethoprim (sulfamethoxazole + trimethoprim combinations) were omitted, as these drugs were dispensed to only one patient each.



## Discussion

Aging is closely associated with the process of frailty, as pathological aging more profoundly compromises an individual's vitality and is related to functional decline<sup>16</sup>. The median patient age of 68 years, along with the finding that nearly 50% of elderly individuals required readmission, indicates a characteristic frailty within this age group, particularly given that the hospital is a tertiary-care facility providing high-complexity services<sup>17</sup>. The high rate of previous hospitalizations (65.3%) further reinforces the concept of frailty among these patients, possibly due to chronic conditions or the recurrent nature of certain infections. Moreover, the observed readmission rate may be underestimated, as the analysis considered only those readmissions that occurred in the same hospital. Consequently, patients who were readmitted to other public or private institutions were not included, which may result in a partial view of the recurrence of hospitalizations in this population.

A literature review identified a variation between 1% and 26% in readmission rates among patients receiving OPAT. Although elderly patients were more prone to readmissions and OPAT-related complications, the methodologies employed in these studies do not allow for definitive conclusions regarding its applicability in this group. Evidence suggests that appropriate patient selection is the most effective strategy to minimize unfavorable outcomes associated with OPAT in any setting<sup>18</sup>. Despite the greater clinical complexity typically seen in elderly patients, available evidence demonstrates the benefits of OPAT. Age alone does not increase the likelihood of adverse outcomes; however, cognitive factors and patient skills must be carefully evaluated to ensure treatment continuity after hospital discharge<sup>19</sup>.

Data from a national cohort study identified that the presence of three or more chronic diseases is strongly associated with higher rates of hospitalization, readmission, and longer hospital stays among Brazilian adults and elderly individuals<sup>20</sup>. Consistently, other studies have shown that multimorbidity significantly increases the risk of hospitalization and readmission in older adults, regardless of sex, advanced age, or socioeconomic level, highlighting the clinical complexity of this population and the need for integrated and personalized care strategies<sup>21</sup>.

The *Home Care Service* (*Serviço de Atenção Domiciliar – SAD*), implemented in Brazilian municipalities through the *Better at Home* (*Melhor em Casa*) program of the Ministry of Health, supports elderly care aligned with this theoretical model, as described in the *Home Care Handbook* (*Caderno de Atenção Domiciliar*). The program provides care directly connected to the patient's family structure and home environment. Consequently, it helps prevent unnecessary hospitalizations, reduces infection risk, improves hospital bed management and resource utilization, and alleviates overcrowding in emergency and urgent care services.

In Brazil, research on OPAT services as a strategy to support home care programs remains incipient. In line with the findings of the present study, investigations conducted in public hospitals in Curitiba, São Paulo, and Fortaleza reported financial savings and reductions in hospital length of stay<sup>13,22-23</sup>.

A large proportion of elderly patients under OPAT or SOT occupied beds in ophthalmology wards. This finding aligns with the high rate of voriconazole dispensing, as *Fusarium spp.* infection is a possible outcome following ophthalmic surgery. Fusariosis, an invasive infection caused by *Fusarium spp.*, is the second most common invasive fungal infection and is resistant to most available antifungal agents<sup>24</sup>.

Voriconazole, one of the few antifungals available for oral use and the drug of choice for such cases, is not provided through the *Strategic Component of Pharmaceutical Assistance* (CESAF) and has a high cost, which may limit access for patients in need. It is worth noting that the *State Health Secretariat of Minas Gerais* (SES/MG) offers reimbursement for antifungal treatments provided to SUS users. According to CIB SUS/MG Resolution from July 2019, reimbursement applies to antifungal treatments for onco-hematologic conditions and clinical complications following bone marrow or solid organ transplantation. Nonetheless, hospitalization costs remain high, further emphasizing the importance of discharge with SOT, particularly for these patients.

Continuation of OPAT/SOT with the same antimicrobial agent used during hospitalization was observed in most patients. This approach provides several benefits, as it prevents treatment interruption and reduces the risk of post-discharge complications, contributing to safer and more effective recovery. It is important to note that such benefits occur when the general principles of antimicrobial stewardship are observed during hospitalization, including minimizing unnecessarily prolonged intravenous therapy, optimizing doses according to individual patient characteristics (e.g., age, renal function, and weight), promoting intravenous-to-oral switch therapy, and, whenever possible, de-escalating to the narrowest effective spectrum of antimicrobial agents<sup>25-26</sup>.

The second most dispensed antimicrobial agent at hospital discharge was oral vancomycin, which also showed the greatest variability in treatment duration. This finding can be explained by its role as the first-line therapy for *Clostridioides difficile* infection, whose treatment duration depends on recurrence and disease severity. Several studies have emphasized the superiority of oral vancomycin compared to metronidazole. Oral vancomycin achieves high fecal concentrations, well above the minimum inhibitory concentration (MIC) required for its action, maintains elevated levels in the colon throughout treatment, and is not systemically absorbed<sup>27</sup>. Moreover, as it is a parenteral formulation administered orally, vancomycin is available exclusively for hospital procurement, meaning that patients cannot obtain it in community pharmacies. Therefore, access to adequate treatment for pseudomembranous colitis must be ensured by the hospital institution, and, as observed in this study, treatment may be prolonged. In this context, hospital discharge with antimicrobial therapy contributes to reducing treatment costs. Given that an intravenous formulation is being administered orally, the clinical pharmacist plays a key role in instructing the patient on the correct administration technique at the time of discharge<sup>15</sup>.

In the present study, teicoplanin showed the second-highest median dispensing duration, in addition to the highest median cost per hospital discharge. This drug was dispensed to three patients with osteomyelitis and one with endocarditis—both complex infections that require prolonged treatment and have strong evidence supporting the benefits of OPAT in terms of patient outcomes and healthcare system sustainability<sup>23,28</sup>.

Similarly, ertapenem presented a maximum dispensing duration of 28 days. This antimicrobial belongs to one of the classes most frequently used in antimicrobial stewardship programs, being essential for treating infections caused by extended-spectrum  $\beta$ -lactamase-producing organisms. Furthermore, ertapenem is highly relevant for hospital discharge under OPAT due to its convenient dosing regimen (once daily), which offers a practical advantage compared to other carbapenems<sup>29</sup>.



Significantly higher costs were observed for maintaining hospitalizations compared to discharge under OPAT or SOT, indicating a reduction in institutional expenditures. Hospital discharge with dispensed antimicrobials for SOT or OPAT has a substantial impact on resource allocation, as the cost savings generated and the resulting bed availability enable the admission and treatment of new patients. Bed occupancy rate is a key indicator of a hospital's ability to efficiently meet patient demand, as the lack of available beds may lead to canceled elective surgeries, delayed admissions, inappropriate bed assignments, and difficulties in transferring patients between departments<sup>7</sup>.

Several authors highlight pharmacists as key providers of interventions during care transitions<sup>30</sup>. Their activities may include medication reconciliation, patient education on drugs and diseases, monitoring for adverse drug reactions, and assessing the feasibility of SOT and OPAT. Such interventions may occur at the time of discharge or post-discharge. A systematic review analyzing studies on hospital discharge optimization and readmission prevention identified the following as the most effective strategies: integrated systems between hospital and primary care, multidisciplinary service provision, individualized care, discharge planning, and specialized follow-up<sup>31</sup>.

These findings reinforce the importance of having a clinical pharmacist available to participate in the patient discharge planning process, as well as the need for a more streamlined, well-defined discharge process supported by appropriate training and institutional awareness. When such activities are conducted in a coordinated manner, following established antimicrobial stewardship guidelines, patient care can be significantly improved, and the use of antimicrobial agents can be optimized<sup>26</sup>.

As a limitation of this study, the economic evaluation did not use standardized cost values. However, since the study period covered only two years and medications were purchased through public bidding, price variation is expected to be minimal, thereby reducing the risk of bias. Nevertheless, potential distortions may exist in the calculated cost differences associated with hospital discharge and antimicrobial dispensing.

For future research perspectives, to broaden understanding of the economic impact of implementing transitional care models from the perspective of Brazil's Unified Health System (SUS), future studies should consider the costs associated with drug administration by home-care teams, comparing hospital costs with the direct and indirect costs of municipal home-care services.

Assuming that the effectiveness of antimicrobial therapy in hospital settings is equivalent to that of OPAT delivered under various home-care models, future evaluations should employ cost-minimization analysis to better assess the impact of such services on the healthcare system<sup>32</sup>.

As a strength, this study is innovative in its use of a bed-day cost measurement methodology adopted by the Brazilian Ministry of Health, emphasizing key differences between care costs across hospital departments. This approach facilitates reproducibility in other healthcare settings and enables a more accurate comparison of hospital discharge costs associated with antimicrobial dispensing.

## Conclusion

Hospital discharge with antimicrobial dispensing through OPAT or SOT in the investigated hospital demonstrated economic feasibility and contributed to reducing hospital stay among older patients. The antimicrobials that most contributed to reduced hospitalization time were voriconazole and teicoplanin. Care models incorporating SOT or OPAT promote continuity of care for older adults, enhance bed turnover, and optimize hospital resource utilization.

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## Contributors

AS and RCGV collected the data. AS, RCGV, and CMB contributed to the study conception and design, data analysis and interpretation, and manuscript drafting. CMB, RCGV, AMR, JAT, and RRM performed critical revision of the manuscript for important intellectual content. All authors approved the final version of the article.

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## Conflict of Interest Statement

The authors declare no conflicts of interest related to this article.

## References

1. Rangel MLSV. Processo de desospitalização e atenção domiciliar no Brasil e seus fatores associados. Res Soc Dev. 2023;12(4):e0612440793. doi: 10.33448/rsd-v12i4.40793
2. Simão ESM, Pacca JBCP, Hungria IC, et al. Dehospitalization: A Humanized Perspective on the Elderly. Braz J Dev. 2022;8(1):8002–18. doi: 10.34117/bjdv8n1-53
3. Silva RC, Queiroz MG, Grego Maia L. As perspectivas da desospitalização no Brasil e a assistência humanizada como coadjuvante neste processo: uma revisão de literatura. Bol Téc Senac. 2022;47(2):114–26. doi: 10.26849/bts.v47i2.882
4. Castro EAB, Lina van Keulen MS, Vieira CS, et al. Efetividade e custos de modelos de cuidados transitórios em atenção domiciliar: revisão integrativa. Rev Enferm Cent Oeste Min. 2024;v(14). doi:10.19175/recom.v14i0.5114

5. Reidy P, Breslin T, Muldoon E. Outpatient parenteral antimicrobial therapy (OPAT) across the world: a comparative analysis-what lessons can we learn? *JAC Antimicrob Resist.* 2024;6(4):dlae111. doi:10.1093/jacamr/dlae111
6. Rodriguez-Pardo D, Pigrau C, Campany D, et al. Effectiveness of sequential intravenous-to-oral antibiotic switch therapy in hospitalized patients with gram-positive infection: the SEQUENCE cohort study. *Eur J Clin Microbiol Infect Dis.* 2016;35(8):1269-1276. doi:10.1007/s10096-016-2661-5
7. Souza DM, Vasconcelos BF, Viana DMS, et al. Gestão de leitos em um hospital polo da região ampliada de saúde Jequitinhonha: aspectos organizacionais e operacionais do processo de trabalho. *J Health Biol Sci.* 2020;8(1):1-5. doi: 10.12662/2317-3076jhbs.v8i1.2819.p1-5.2020
8. Silveira RE, Santos S, Sousa MC, et al. Gastos relacionados a hospitalizações de idosos no Brasil: perspectivas de uma década. *Einstein* 2014;11(4):514-20. doi: 10.1590/S1679-45082013000400019
9. Ortiz-Mayorga JL, Pineda-Rodríguez IG, Dennis RJ, et al. Costos atribuidos a las infecciones asociadas con la atención en salud en un hospital de Colombia. *Biomedica.* 2019;39(1):102-12. doi:10.7705/biomedica.v39i1.4061
10. Katz MJ, Roghmann MC. Healthcare-associated infections in the elderly: what's new. *Curr Opin Infect Dis.* 2016;29(4):388-393. doi:10.1097/QCO.0000000000000283
11. Stewart S, Robertson C, Pan J, et al. Epidemiology of healthcare-associated infection reported from a hospital-wide incidence study: considerations for infection prevention and control planning. *J Hosp Infect.* 2021;114:10-22. doi:10.1016/j.jhin.2021.03.031
12. Mohammed SA, Alharthi A, Alharthy A, et al. A systematic review and meta-analysis of the cost-effectiveness of outpatient parenteral antimicrobial therapy. *Helijon.* 2024;10(6):e31560. doi:10.1016/j.helijon.2024.e31560
13. Morosini S, Marques APO, Leal MCC, et al. Costs and length of hospitalization for elderly residents in Recife-PE. *Geriatr Gerontol Aging.* 2011;5(2):91-98.
14. Freitas TC, Lima ACC, Andrade AGA, et al. Use of the step-down strategy for dehospitalization and performance of outpatient parenteral antimicrobial therapy (OPAT) in transplanted patients. *Braz J Health Rev.* 2022;5(1):3134-47. doi:10.34119/bjhrv5n1-274
15. Johnson S, Lavergne V, Skinner AM, et al. Clinical Practice Guideline by the Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA): 2021 Focused Update Guidelines on Management of *Clostridioides difficile* Infection in Adults. *Clin Infect Dis.* 2021;73(5):e1029-e1044. doi:10.1093/cid/ciab549
16. Moraes EN, Reis AMM, Moraes FL. Manual de terapêutica segura no idoso. Belo Horizonte: Folium;2019.
17. Bourriuen M, Couderc AL, Bretelle F, et al. Effect of frailty on unplanned readmission in older adults: A systematic review. *J Epidemiol Popul Health.* 2024;72(5):202774. doi:10.1016/j.jeph.2024.202774
18. Sriskandarajah S, Hobbs J, Roughead E, Ryan M, Reynolds K. Safety and effectiveness of 'hospital in the home' and 'outpatient parenteral antimicrobial therapy' in different age groups: A systematic review of observational studies. *Int J Clin Pract.* 2018 [Ahead of print]. doi:10.1111/ijcp.13216
19. Norris AH, Shrestha NK, Allison GM, et al. 2018 Infectious Diseases Society of America Clinical Practice Guideline for the Management of Outpatient Parenteral Antimicrobial Therapy. *Clin Infect Dis.* 2019;68(1):e1-e35. doi:10.1093/cid/ciy745
20. Rodrigues LP, Rezende ATO, Delpino FM, et al. Association between multimorbidity and hospitalization in older adults: systematic review and meta-analysis. *Age Ageing.* 2022;51(7):afac155. doi:10.1093/ageing/afac155
21. Xu X, Mishra GD, Jones M. Evidence on multimorbidity from definition to intervention: An overview of systematic reviews. *Ageing Res Rev.* 2023;89:101995. doi: 10.1016/j.arr.2023.101995
22. Loesch GH, Cruz JAW, Gasparetto J, Oliveira DDS, Telles JP, Tuon FF. Cost minimization analysis of outpatient parenteral/oral antibiotic therapy at a trauma hospital: Public health system. *Infect Control Hosp Epidemiol.* 2021;42(12):1445-1450. doi:10.1017/ice.2021.22
23. Oliveira PR, Felix CS, Carvalho VC, et al. Outpatient parenteral antimicrobial therapy for orthopedic infections – a successful public healthcare experience in Brazil. *Braz J Infect Dis.* 2016;20(3):272-5. doi:10.1016/j.bjid.2016.03.005
24. Martins AAS, Casali AK, Fortes FMD, et al. Fusarium: o fungo responsável por causar cegueira em pacientes submetidos à cirurgia de catarata no Brasil em 2023 – uma revisão de literatura. *Braz J Health Rev.* 2024;7(4):e71402. doi: 10.34119/bjhrv7n4-122
25. Barlow G, Barr DA, Seaton RA. Outpatient parenteral antimicrobial therapy (OPAT) and the general physician. *Clin Med.* 2013;13(5):495-9. doi:10.7861/clinmedicine.13-5-495
26. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis.* 2007;44(2):159-177. doi:10.1086/510393
27. Bishop EJ, Tiruvoipati R. Management of *Clostridioides difficile* infection in adults and challenges in clinical practice: review and comparison of current IDSA/SHEA, ESCMID and ASID guidelines. *J Antimicrob Chemother.* 2022;78(1):21-30. doi:10.1093/jac/dkac404



28. Baddour LM, Wilson WR, Bayer AS, et al. Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications: A Scientific Statement for Healthcare Professionals From the American Heart Association. *Circulation*. 2015;132(15):1435-1486. doi:10.1161/CIR.0000000000000296
29. Freitas TC, Sousa JA, Oliveira AB, et al. Dehospitalization: pharmacoeconomic aspects and the impacts of days saved from hospitalization in renal transplant patients using carbapenems. *Rev Bras Farm Hosp Serv Saude*. 2023;14(3):994. doi: 10.30968/rbfhss.2023.143.0994
30. Shcherbakova N, Tereso G. Clinical pharmacist home visits and 30-day readmissions in Medicare Advantage beneficiaries. *J Eval Clin Pract*. 2016;22(3):363-368. doi:10.1111/jep.12495
31. Coffey A, Leahy-Warren P, Savage E, et al. Interventions to Promote Early Discharge and Avoid Inappropriate Hospital (Re)Admission: A Systematic Review. *Int J Environ Res Public Health*. 2019;16(14):2457. doi:10.3390/ijerph16142457
32. Dimitrova M, Gilchrist M, Seaton RA. Outpatient parenteral antimicrobial therapy (OPAT) versus inpatient care in the UK: a health economic assessment for six key diagnoses. *BMJ Open*. 2021;11(9):e049733. doi:10.1136/bmjopen-2021-049733