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# Critical analysis of Drug-Related Problems arising from prescription errors in a hospital setting

## *Análise crítica dos Problemas Relacionados a Medicamentos advindos de erros de prescrição em ambiente hospitalar*

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**ABSTRACT**

**Objectives**: This study aims to conduct a comprehensive quantitative analysis of pharmaceutical occurrences recorded at the Prescription Assessment Center, focusing on prescription errors within the context of a university hospital (Onofre Lopes University Hospital). **Methods**: This research adopted a retrospective methodology, integrating quantitative analyses to investigate pharmaceutical occurrences at Onofre Lopes University Hospital (HUOL) in 2022. Focusing on hospitalized adult patients, we evaluated recorded pharmaceutical interventions, covering aspects from indication to the risk of adverse effects. We utilized Python and its libraries for statistical analysis, including descriptive, association, temporal, and comparative analyses, adhering to strict statistical and ethical standards. **Results**: A total of 1,490 Medication-Related Problems (MRPs) were identified, with an average of 124 records per month, 41% of which were related to elderly patients. Excluding problems related to antimicrobial control, the primary MRPs identified were excessive dosage (26.63%), incomplete prescription (20.37%), and inadequate dilution (17.17%). Among high-risk medications, those most associated with recorded MRPs were 50% glucose (115 occurrences), opioid analgesics (37), and insulins (22). **Conclusions**: The analysis revealed that common errors included inadequate dosages and incomplete prescriptions, with high alert medications frequently involved. The implementation of prevention strategies and continuous education for healthcare professionals is crucial to minimize the incidence of MRPs

**Keywords:** Prescription evaluation. Pharmaceutical intervention. Drug-related problems. Patient safety.

**RESUMO**

**Objetivos**: Este estudo visa realizar uma análise quantitativa abrangente das ocorrências farmacêuticas registradas na Central de Avaliação da Prescrição, enfocando os erros de prescrição no contexto de um hospital universitário (Hospital Universitário Onofre Lopes). **Métodos**: Este estudo adotou uma metodologia retrospectiva, integrando análises quantitativas para investigar ocorrências farmacêuticas no Hospital Universitário Onofre Lopes (HUOL) em 2022. Focando em pacientes adultos internados, avaliamos intervenções farmacêuticas registradas, abordando desde a indicação até o risco de efeitos adversos. Empregamos Python e suas bibliotecas para análise estatística, incluindo análises descritivas, de associação, temporais e comparativas, respeitando rigor estatístico e ético. **Resultados**: Foram identificados um total de 1.490 Problemas Relacionados a Medicamentos (PRM), com uma média de 124 registros por mês, sendo 41% deles relacionados a pacientes idosos. Excluindo-se os problemas relacionados ao controle de antimicrobianos, os principais PRM identificados foram dosagem excessivamente alta (26,63%), prescrição incompleta (20,37%) e diluição inadequada (17,17%). Entre os medicamentos de alto risco, os mais associados a PRM registrados foram glicose a 50% (115 ocorrências), analgésicos opioides (37) e insulinas (22). **Conclusões**: A análise revelou que erros comuns incluem dosagens inadequadas e prescrições incompletas, com medicamentos potencialmente perigosos frequentemente envolvidos. Entre várias atividades que podem ser implementadas para melhorar pode-se citar estratégias de prevenção de prevenção de erros de prescrição com educação continuada para profissionais de saúde no sentido de minimizar a incidência de PRM.

**Palavras-chave:** Avaliação da prescrição; Intervenção farmacêutica; Erros de prescrição; Problemas relacionados a medicamentos; Segurança do paciente.

## Introduction

The Pharmaceutical Care Network Europe (PCNE) defines a medication-related problem (MRP) as an "event or circumstance related to medication that interferes or may potentially interfere with the desired clinical outcomes." These problems can encompass factors such as adverse reactions, adherence issues, drug interactions, inappropriate or ineffective use of medications, and may be related to medication errors,[1] which represent a significant challenge to patient safety and the quality of healthcare.[2]

These events, which are entirely preventable, can result in adverse consequences for patients, highlighting the importance of identifying and preventing these occurrences. In the hospital context, these errors have the potential to directly affect the safety and efficacy of treatment and are known to be associated with increased mortality and prolonged hospitalization times, impacting the rising costs for the involved hospital—this constitutes a high-risk and significant issue.[3] It is established that every medication error constitutes an MRP, but not every MRP is a medication error, as it is a broader concept.

Medication errors can be divided according to the stage of the healthcare practice in which they occur, subdividing into prescription, dispensing, and administration errors. Prescription errors are the most serious among those that can occur in this practice, and when there is no detection and appropriate intervention, they can cause harm to patients.[4] These errors are defined as clinically significant errors in which, as a result of a decision by the prescriber or their writing process, there is an unintentional reduction in the likelihood that the treatment will be effective or an increase in the risk of harm to the patient compared to established clinical practices.[5] They can be classified, with some examples of categories being errors of omission, incorrect doses, incorrect route of administration, and inadequate duration of treatment.[6]

Studies conducted in Brazilian hospitals highlight alerts regarding the recurring incidence of prescription errors, even in electronic prescribing systems, particularly emphasizing errors of omission. In the Brazilian context, errors related to dosing and inadequate dilution or infusion time also stand out in number. Additionally, the fact that these prescription errors frequently occur for potentially dangerous medications, such as opioids, constitutes a high-risk scenario for patients, with the potential for severe complications. However, systematic reviews have observed that the number of studies investigating prescription errors in Brazilian hospitals and the associated MRPs is still low, necessitating more research for a better understanding of the local landscape.[7-10]

By understanding the nature and frequency of potential MRPs arising from prescription errors in the hospital environment, it is possible to develop effective strategies to prevent them and improve the quality of pharmaceutical care. This analysis aims to contribute to the enhancement of the processes of prescribing, dispensing, and administering medications at HUOL, thereby promoting a safer and more effective practice in patient care.[11]

## Objectives

The primary objective of this study was to conduct a quantitative analysis of pharmaceutical occurrences recorded in the Prescription Assessment Center (CAP) concerning recurring prescription errors at the Onofre Lopes University Hospital (HUOL), evaluating a period corresponding to the year 2022.

## Methods

This study adopted a retrospective approach, conducting quantitative analyses to investigate the pharmaceutical occurrences recorded at the Prescription Assessment Center (CAP) of the Onofre Lopes University Hospital (HUOL) during the year 2022.

HUOL is a medium-sized hospital with 244 beds, part of the hospital complex of the Brazilian Company of Hospital Services (EBSERH), providing medium and high complexity services to a population of nearly 1 million people.

The pharmaceutical occurrences referred to correspond to the records documented by pharmacis-

ts when identifying MRPs, primarily during the evaluation and screening of electronic prescriptions for hospitalized patients in the institution. These records describe the identified MRPs and include information such as the associated medications, the patient's bed, and the medical record number of the patient to whom the prescription was assigned. Therefore, within the record of an occurrence, more than one MRP may be reported.

The study involved the evaluation of activities carried out and recorded in the regular practice of clinical pharmacy. During the prescription assessment at CAP, specific aspects related to pharmacotherapy and subsequent changes in prescriptions are evaluated, including a wide range of activities (indication, dosage, risk of adverse effects, potential interactions, among others) so that all prescriptions related to hospitalized patients undergo the evaluation process. All patients assessed in the aforementioned stages, for whom MRPs were identified, were recorded in the pharmaceutical communication book of the hospital's Central Pharmacy, and subsequently entered into a pharmacy work database as part of its standard practice.

To preserve patient confidentiality, the spreadsheet was anonymized in advance, displaying only age, involved medication, and MRP code. All MRPs recorded in the occurrence book were analyzed, excluding those related to patients hospitalized in pediatrics and cardiology departments, whose records are maintained in separate documents to which we did not have access.

In this study, the classification of MRPs was based on the "Pharmacotherapy Workup" (PW), as adapted by the clinical pharmacy service of the Onofre Lopes University Hospital (HUOL). The Pharmacotherapy Workup establishes a systematic approach based on the principles set forth by Cipolle, Strand, and Morley, allowing for an in-depth evaluation of patients' medication therapies by checking aspects of indication, effectiveness, safety, and patient adherence,[12] focusing on the identification, resolution, and prevention of MRPs. They are originally classified into unnecessary pharmacotherapy, need for additional pharmacotherapy, ineffective drug, too low dose, too high dose, adverse drug reaction, and lack of adherence to therapy.[13,14]

Statistical analyses were conducted with the help of Python programming language and libraries such as NumPy, Pandas, SciPy, and statsmodels, ensuring methodological rigor and reproducibility. Initially, descriptive analyses were performed, calculating absolute and relative frequencies, means, and standard deviations to characterize the distribution of MRPs by type, age group, involved medications, and monthly distribution. For temporal analysis, the ARIMA (1,1,1) time series model was used, selected based on visual identification criteria of residues and the augmented Dickey-Fuller (ADF) stationarity test, with $p < 0.05$ considered statistically significant. Comparisons between groups (e.g., MRPs associated with high-risk medications vs. other medications) were evaluated through association tests (such as the chi-square test), and when necessary, Fisher's exact test was adopted. All analyses were performed with a significance level of 5% ($\alpha = 0.05$), with findings having a p-value $< 0.05$ considered statistically significant.[15]

For the first phase of the study, the sample included all occurrence records and MRPs for adult patients over 18 years old hospitalized in medical wards during the study period. The number of MRPs and occurrences, as well as the ages of the patients, were collected. Thus, an extensive descriptive analysis of the data collected from the Prescription Assessment Center (CAP) of the Onofre Lopes University Hospital (HUOL) during the year 2022 was initially conducted. This analysis included the calculation of absolute and relative frequencies for each type of pharmaceutical occurrence and prescription error, as well as the determination of measures of central tendency and dispersion for relevant numerical variables, such as patient age and the number of occurrences per month. The results were presented in graphs, providing a clear visualization of the distribution and variability of the data.

The temporal analysis was conducted using time series methods to examine the evolution of MRPs throughout the year. Predictive models were developed to estimate future occurrences based on the patterns identified in the historical data. All statistical analyses were conducted with statistical rigor and interpreted cautiously to ensure the robustness and validity of the results obtained in this study.

For the second phase of the study, a quantitative analysis of the main MRPs found and their associated medications was performed using the names of medications and MRP codes established at the institution. In this analysis, MRPs related to antimicrobials were deliberately excluded, as more than 90% of them pertained to the lack of antimicrobial control in the system or the need to renew or complete treatment, with these documentation failures representing nearly 50% of the total MRPs. Thus, for better representativeness and analysis of the proportion of other MRPs, antibiotics were removed from the analysis, except for vancomycin and polymyxins, which fall under high surveillance medications with a low therapeutic index. Therefore, the total sample corresponds to all MRPs recorded in the year that were not associated with antimicrobials.

The research was duly approved by the Ethics and Research Committee of UFRN, as determined by Resolution No. 466/13, under CAAE 69113323.3.0000.0253 and opinion number 6.214.204, with the Informed Consent Form (ICF) waived. The data collected during the research were handled in accordance with the General Data Protection Law, No. 13.709/2018.

## Results

The average age of the participants was 54 years, with a standard deviation of 17 years. During the study period, a total of 1,490 MRPs and 1,453 recorded occurrences were documented, resulting in an average of 124 intervention records per month, with the calculated population standard deviation being 32. The month with the highest number of records was March (n = 214), and the month with the lowest was December (n = 79). The result of the quantitative analysis is expressed in Figure 1.The analysis of the distribution of Medication-Related Problems (MRPs) throughout the months of the year revealed relevant findings regarding temporal patterns in the incidence of MRPs. The graph showed variations in the density of MRPs over the months, identifying months with higher incidences of MRPs, suggesting possible correlations with seasonal factors such as variations in disease prevalence, changes in medical prescribing patterns, or even shifts in patient behavior. The months with the highest density of MRPs may coincide with periods of increased circulation of respiratory diseases, which often require intensive medication treatment, leading to an increase in medication-related risks.[16-19]

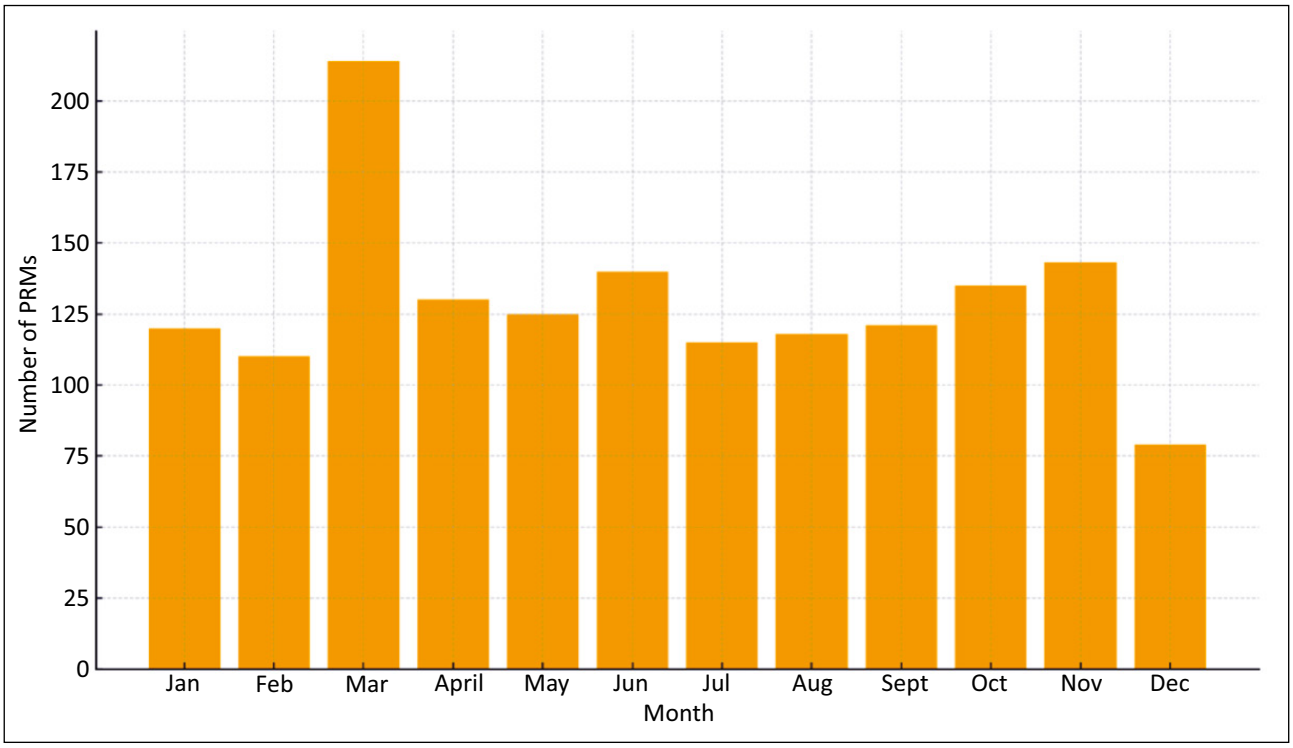
Notably, a more significant concentration of MRPs was observed in the older age groups, particularly among individuals aged 70 years or older, accounting for 41% of the sample (Figure 02).

In the analysis of the prevalences of Medication--Related Problems (MRPs), excluding documentation failures—specifically the lack of antimicrobial control and the need for renewal of deadlines—a significant incidence of prescribing errors related to dosage was evidenced (21).

Our detailed investigation into the association between Medication-Related Problems (MRPs) and specific categories of drugs adopted rigorous classification criteria based on the established National List of Essential Medicines (RENAME) for better visualization of the data (23). Antibiotics were deliberately excluded according to the methodology, and substances with a narrow therapeutic index (NTI) and potentially dangerous medications (PDM) were highlighted, which will be further examined throughout the study.The results indicated that 50% glucose solution (n = 115) and antiemetics (n = 108) were the main medications associated with MRPs, closely followed by analgesics/antipyretics (n = 80) and antihypertensives (n = 72), with a predominance of incidents related to excessive dosing and incomplete prescriptions. It is noted that some potentially dangerous medications, such as 50% glucose, opioids, and insulins, presented a significant number of MRPs (Table 02).

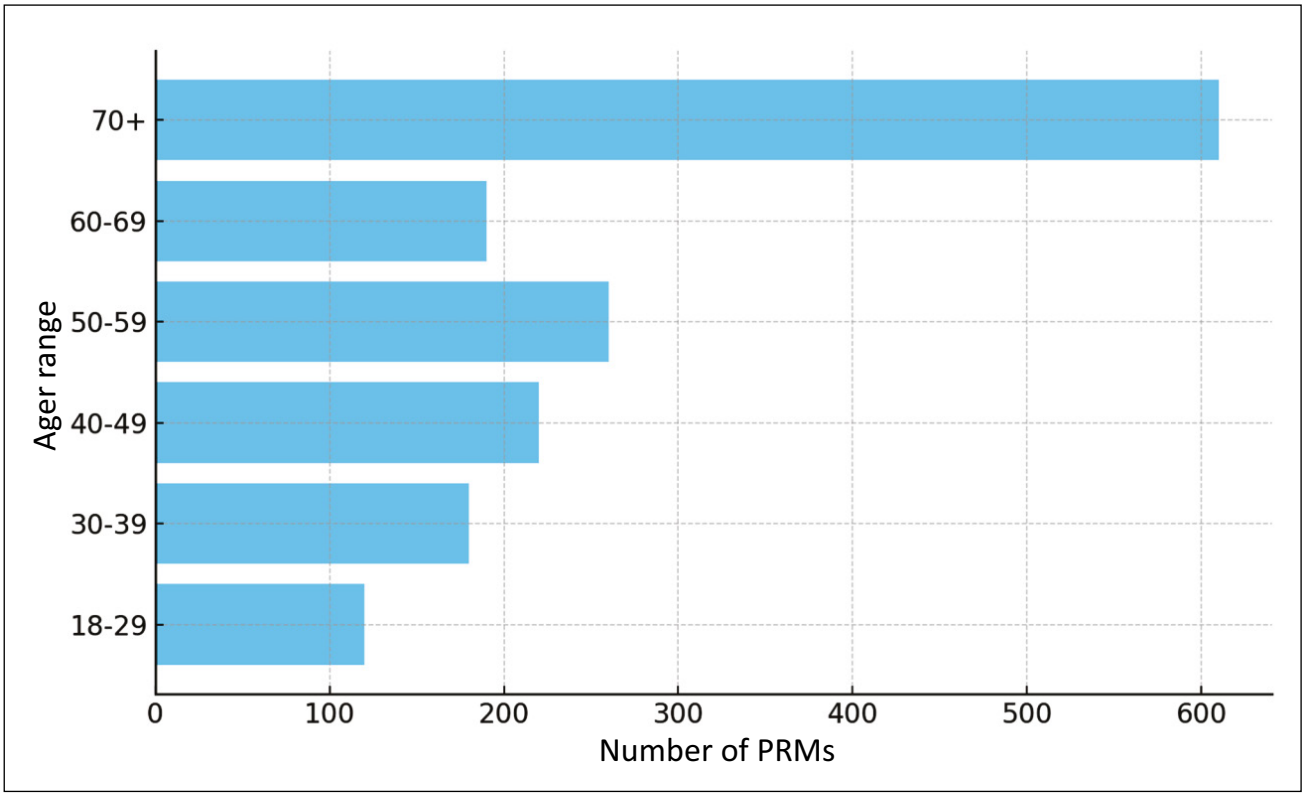
Table 3 presents a detailed analysis of the Medication-Related Problems (MRPs) associated with high-alert medications (HAMs) and substances with a narrow therapeutic index (NTI).[24] This selection of drugs, recognized for their high potential risk, was rigorously examined to identify MRPs of significant clinical importance associated with their use. Notably, clindamycin stood out in this study, with all incidents attributed exclusively to documentation failures.

**Figure 1.** Number of MRPs recorded by month in 2022.




**Source:** Prepared by the author (2023).

**Figure 2.** Distribution of MRPs by age group in 2022.




**Source**: Prepared by the author (2023).

**Table 1.** Percentage of the main MRPs identified, excluding MRPs related to documentation failures.

| MRP | Quantity | Percentage |
|---|---|---|
| Very low dosage | 49 | 6,52% |
| Very high dosage | 200 | 26,63% |
| Inadequate Route of Administration | 46 | 6,12% |
| Inadequate Dilution | 129 | 17,17% |
| Incomplete Prescription | 153 | 20,37% |
| Total Registered MRPs (excluding documentation failures | 751 | 100% |

**Source**: Prepared by the author (2023).

**Table 2.** Main Medications Associated with MRPs

| Medications | Quantity of MRPs |
|---|---|
| 50% Glucose* | 115 |
| Antiemetics | 108 |
| Analgesic/Antipyretic | 80 |
| Antihypertensives | 72 |
| Opioids* | 37 |
| Antipsychotics | 23 |
| Insulins* | 22 |
| Antacids | 19 |
| Vitamins | 18 |
| Albumin | 11 |
| Vancomycin* | 8 |
| Benzodiazepines | 7 |
| Phenytoin* | 7 |
| Anticoagulants* | 6 |
| Steroidal Anti-inflammatory | 6 |
| NSAIDs | 6 |

*Potentially dangerous medications and/or narrow therapeutic index

**Source:** Prepared by the author (2023).

In this study, we identified a total of 202 Medication-Related Problems (MRPs) associated with drugs considered high-risk, representing 27.65% of the total records, excluding documentation failures. The detailed analysis revealed a predominance of MRPs associated with 50% glucose solution (n=115), opioids (n=37), and insulin (n=22). Additionally, there was a significant presence of anticoagulants (mainly enoxaparin), vancomycin, polymyxins, and potassium chloride. Among the opioids, nalbuphine emerged as the drug most frequently involved in prescribing errors, followed by tramadol and morphine.

**Table 3.** Main High-Risk Medications Associated with MRPs and Number of Times They Were Recorded

| **50% Glucose** | **115** |
|---|---|
| Incomplete Prescription (absence of dilution) | 74 |
| Inadequate Dilution | 37 |
| Excessive Dosage | 2 |
| Inadequate Route of Administration | 2 |
| **Opioids** | **37** |
| Excessive Dosage | 24 |
| Inadequate Dilution | 5 |
| Very Low Dosage | 3 |
| Inadequate Duration | 3 |
| Duplicate Therapy | 2 |
| **Insulins** | **22** |
| Inadequate Route of Administration | 17 |
| Incorrect Administration | 2 |
| Inadequate Dilution | 2 |
| Excessive Dosage | 1 |
| **Vancomycin** | **8** |
| Absence of Infusion Time | 6 |
| Inadequate Dilution | 1 |
| Inadequate Duration | 1 |
| **Phenytoin** | **7** |
| Inadequate Dilution | 3 |
| Incorrect Administration | 2 |
| Incompatibility | 2 |
| **Anticoagulants** | **6** |
| Inadequate Route of Administration | 3 |
| Excessive Dosage | 2 |
| Inadequate Dilution | 1 |
| **KCl** | **4** |
| Inadequate Duration | 3 |
| Inadequate Route of Administration | 1 |
| **Polymyxins** | **3** |
| Inadequate Dilution | 2 |
| Inadequate Duration | 1 |
| **Total** | **202** |

**Source:** Prepared by the author (2023).

Predictive models were fundamental in understanding the temporal dynamics of Medication-Related Problems (MRPs). By utilizing a time series approach through the ARIMA (1, 1, 1) model, it was possible to capture and forecast future trends based on historical data. Figure 3 illustrates the predictions of MRPs for the next three months, indicating a decreasing trend in occurrences.

The analysis revealed that the adjusted ARIMA model demonstrated a strong temporal dependence among the observations. The forecasts generated by the model suggest a decrease in MRPs, with esti-

mates of 73.82%, 66.64%, and 59.46% chance of an MRP occurring in the next three months, respectively. This decreasing trend is a valuable indication for health managers and policymakers, suggesting that recent interventions may be contributing to the reduction of MRPs.

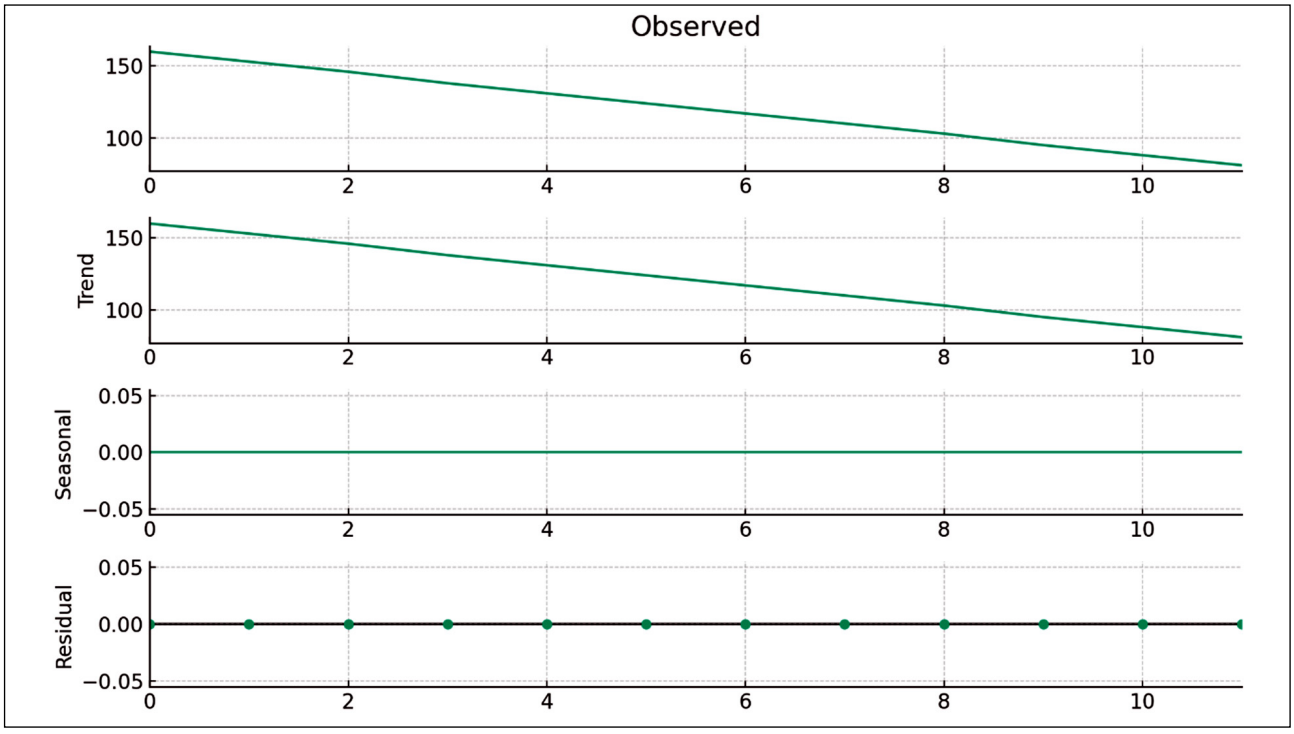
## Discussion

According to what was observed in Figure 1, the analysis suggested the existence of specific periods during the year when vigilance regarding MRPs should be intensified. The identification of these critical periods can guide the implementation of preventive strategies, such as education campaigns for healthcare professionals and patients, revision of prescription protocols, and intensified monitoring of adverse effects. The temporal distribution of MRPs may also reflect the impact of public health initiatives or changes in health policy. For example, the introduction of new treatment guidelines or vaccination campaigns may influence prescribing patterns and, consequently, the incidence of MRPs.[25]

The results demonstrated in the analysis concerning the predominant age group (Figure 2) highlight the need for personalized intervention and health education strategies aimed at reducing the incidence of MRPs, especially among the elderly population. This trend suggests a correlation between advanced age and the incidence of MRPs, possibly reflecting greater complexity in medication management, polypharmacy, or susceptibility to adverse effects. This investigation serves as a call to action for healthcare professionals, researchers, and managers to prioritize patient safety and therapeutic efficacy in the use of medications.[26]

The predominance of prescribing errors related to dosage is a finding corroborated by extensive literature review. The aggregation of excessive dosage (26.63%) and insufficient dosage (6.52%) rates reveals that one-third of the MRPs (33.15%) are directly related to discrepancies in prescribed dosage. A study conducted by Néri in a university hospital in Ceará highlighted a predominance of overdosing errors compared to underdosing, corroborating the data presented in Table 1. Additionally, the same study pointed out that most transcription errors involved inadequate doses and incorrect routes of administration, with the latter representing 6.12% of cases, as evidenced in Table 1.

**Figure 3.** Temporal Prediction Model of MRPs Throughout the Year




**Source:** Prepared by the author (2023).

Regarding the prevalence profile of Medication-Related Problems (MRPs), the comparative analysis underscores the critical need for more rigorous approaches in medication prescribing to minimize dosage errors and improve patient safety. The implementation of electronic prescribing systems and the strengthening of the role of clinical pharmacists as reviewers and educators are potential strategies to mitigate such prescribing errors, emphasizing the importance of evidence-based medical practice and safe, effective pharmacotherapy.

This association profile corroborates existing evidence in the literature, as highlighted by Santos (2010), who identified cardiovascular, antimicrobial, analgesic, psychoactive, gastrointestinal, and respiratory medication classes as the most susceptible to prescribing errors. Notably, our findings reinforce this perspective, with the caveat that respiratory action medications did not stand out significantly in our study, partially diverging from previously documented patterns.

This pattern of MRPs also bears similarities to the results presented by Gomes, Galato, and Silva (2017) in a study conducted in a tertiary hospital, where prescribing errors associated with potentially dangerous medications (PDM) were analyzed. In that previous study, regular human insulin, 50% glucose solution, enoxaparin, and tramadol were identified as the main drugs involved. However, discrepancies were noted regarding the proportion of errors related to anticoagulants and the presence of MRPs associated with phenytoin in our study.[27]

This study faced notable limitations, including the inaccessibility of the total number of hospitalized patients on a monthly basis and the absence of specific data related to the cardiology and pediatrics departments, which restricted the scope of the analysis. The unavailability of more detailed information on the pharmaceutical interventions performed also represented a significant limitation to the research. It is important to emphasize that, at the institution in focus, the practice of clinical pharmacy is characterized by a direct intervention model, in which the responsible pharmacists, after visiting patients and having full access to their medical records, discuss interventions directly with the medical team, without recording these actions in the database used for this analysis. Consequently, several interventions pertinent to drug interactions, incompatibilities, and challenges related to therapeutic adherence were not included in this study. Furthermore, participants in the research were not guaranteed access to the medical records and prescriptions of patients for a better understanding of some MRPs.

## Conclusions

Despite the encountered limitations, the data obtained provide relevant insights, demonstrating that Medication-Related Problems (MRPs) represent a significant and recurring occurrence in the hospital environment, especially among elderly patients. The analyses allowed for the identification of the main types of prescribing errors, with an emphasis on inadequate dosages, incomplete prescriptions, and incorrect dilutions, frequently associated with high-risk medications. The results reinforce the importance of a thorough evaluation of medical prescriptions by the pharmaceutical team, highlighting the essential role of the clinical pharmacist in preventing adverse events. The temporal analysis also indicated seasonal fluctuations in the incidence of MRPs, which may support targeted preventive actions. Thus, it is concluded that the implementation of prevention strategies, continuous professional qualification, and multiprofessional integration are fundamental for optimizing medication use.

**Contributions of the Authors**
ARPJA and SRFA participated in all stages of the project: Conception, study design, and participated in the interpretation of collected data; writing of the article and important critical revisions of the intellectual content; final approval of the version to be published; Responsibility for all aspects of the text in ensuring the accuracy and integrity of any part of the work.

**Conflicts of Interest**
The authors declare that they have no conflicts of interest regarding this work.

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**Data Availability Statement**
The underlying contents of the research text are contained in the manuscript.

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