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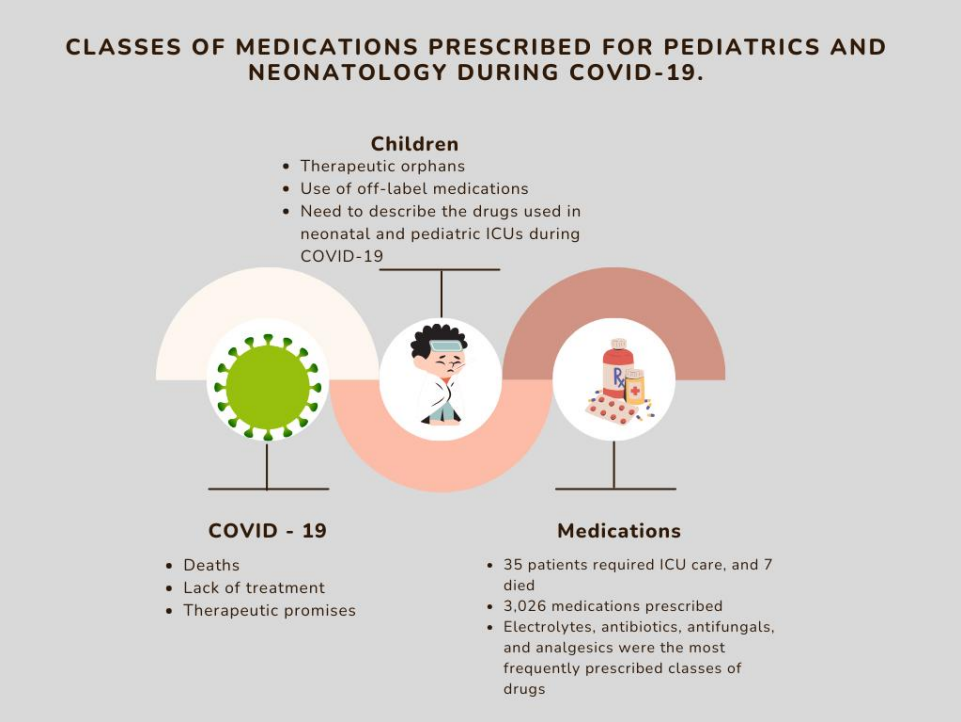
Classes of medications prescribed for pediatrics and neonatology during COVID-19

Ana Elisa Melo[1] **André Oliveira Baldoni**[1] **Isamara Graziele Lima de Souza**[1] **Ricardo Augusto dos Santos Silva**[1] **Tatiane da Silva Dal Pizzol**[2] **Thaísa Amorim Nogueira**[3] **Mariana Linhares Pereira**[1]

[1]Universidade Federal de São João Del Rei, Campus Centro-Oeste – UFSJ. Divinópolis/MG, Brasil.
[2]Universidade Federal do Rio Grande do Sul – UFRGS. Porto Alegre/RS, Brasil.
[3]Universidade Federal Fluminense – UFF. Niterói/RJ, Brasil.
E-mail: meloanaelisa87@gmail.com

Graphical Abstract



Highlights

- *The scarcity of pediatric therapeutic options led to the use of off-label medications.*
- *More than 50% of pediatric patients with COVID-19 required intensive care support.*
- *Case fatality rate of 20% among critically ill patients admitted to the intensive care unit.*
- *Electrolytes, antimicrobials, and analgesics were the most commonly prescribed drugs.*

Abstract

COVID-19 was a global pandemic that affected millions of people, including children and adolescents. Although several therapies were proposed, the scarcity of therapeutic options for the pediatric population was evident, resulting in the use of off-label medications. This study aimed to analyze the prescription of medications for pediatric patients diagnosed with COVID-19 and admitted to neonatal and pediatric intensive care units. This was a retrospective cross-sectional study conducted in two intensive care units at the São João de Deus Health Complex, in Divinópolis, Minas Gerais, Brazil, between 2020 and 2021. The study involved 68 patients diagnosed with COVID-19, of whom 35 required admission to intensive care. Data collection included information on prescribed drugs, route of administration, sociodemographic characteristics, and clinical outcomes. A total of 643 prescriptions were analyzed, comprising 3,026 prescribed medications. Results showed that most patients diagnosed with COVID-19 required intensive care support, with 51.5% admitted to the ICU and a mortality rate of 20% among those requiring intensive therapy. The most prescribed drugs were electrolytes (26.3%), analgesics (14.0%), and antimicrobials (13.4%). The scarcity of effective treatments for COVID-19 led to the use of unlicensed medications, posing a risk of adverse effects. It is concluded that most prescriptions were for symptomatic management, with high mortality rates among critically ill patients.

Keywords: COVID-19. SARS-CoV-2. Critical Care. Pandemic.

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INTRODUCTION

COVID-19 was characterized as a pandemic, being the first caused by a coronavirus[1], and resulted in the deaths of 7,090,776 people worldwide. In Brazil, it affected 39,210,405 individuals, of whom 715,295 died[2,3].

COVID-19 affected individuals of all ages, including children and adolescents[2,3]. The clinical characteristics in this population included symptoms such as fever, cough, sore throat, nasal congestion, and rhinorrhea[4] — nonspecific symptoms easily confused with other respiratory diseases, though diagnostic tests for antigens, antibodies, and imaging could aid differentiation[5].

Once the pandemic was declared, the global scientific community began research efforts to contain the virus, develop new therapies, repurpose existing drugs, and create vaccines for disease prevention. Although several therapies appeared promising, many medications began to be used without proven efficacy, driven by public and political discourse, thus exposing the population to adverse reactions[6]. Until the first vaccine became available in 2020, essential measures that demonstrated effectiveness in reducing viral spread included social isolation, mask use, and hand hygiene with alcohol-based sanitizer[7,8]. Despite emerging therapeutic promises for COVID-19, few or no options were available for pediatric populations[6] — a group historically affected by the lack of drug studies, often referred to as "therapeutic orphans"[9,10].

The absence of studies and the need to provide treatment to this population frequently lead healthcare professionals to use medications "off-label," meaning the drug is prescribed and used outside the specifications of its label. This may involve therapeutic indication, route or frequency of administration, dosage, age group, or formulation. In some cases, drugs are "unlicensed," meaning the pharmaceutical form is modified for pediatric use. Nonetheless, these drugs may still be prescribed by qualified professionals[11].

In neonatal and pediatric units, the prescription of off-label or unlicensed medications is common due to the lack of pediatric-specific formulations and dosing information[9,10,12,13]. In neonatal intensive care units, approximately 90% of newborns may receive off-label or unlicensed medications[13].

The urgent demand for therapeutic options also arose in the pediatric population, and studies with drugs considered "promising" were conducted in children as well[14,15] — thereby exposing not only adults but also children to medications with unproven efficacy.

The use of such drugs without scientific evidence may lead to adverse events, increased morbidity, and higher mortality rates[16]. Therefore, it is essential to analyze the profile of medications used in pediatrics to ensure the safe and appropriate use of drugs in pediatric patients hospitalized in intensive care units due to COVID-19. Although the disease is now under control, children may still require these medications.

The objective of this study was to analyze the prescription of medications for patients diagnosed with COVID-19 who were admitted to neonatal and pediatric intensive care units.

METHODOLOGY

This was a cross-sectional study with retrospective data collection from electronic medical records. The study was conducted in two neonatal and pediatric intensive care units (ICUs) of the São João de Deus Health Complex, located in the municipality of Divinópolis, Minas Gerais, Brazil.

A total of 1,513 children aged 12 years or younger were admitted to the hospital between February 26, 2020, and June 30, 2021. Among these, 68 were diagnosed with ICD-10 codes B342 (Coronavirus infection, unspecified site) and B972 (Coronavirus as the cause of diseases classified elsewhere), and 35 were admitted to one of the two neonatal and pediatric ICUs of the institution. The inclusion criteria comprised patients meeting the diagnostic codes described in the International Classification of Diseases (ICD-10) for COVID-19, aged under 12 years, and admitted to an intensive care unit. Patients treated exclusively in outpatient settings or those not meeting the age or diagnostic criteria were excluded.

Data collection was based on the analysis of electronic medical records, considering information issued between February 26, 2020, and June 30, 2021. The following variables were extracted: medication names and routes of administration, sociodemographic information (sex, age, weight, and health insurance coverage), and length of hospital stay.

Prescribed medications were identified and classified according to the Anatomical Therapeutic Chemical (ATC) system, with analysis conducted up to the second level of classification, corresponding to the main anatomical group and the main therapeutic subgroup[17].

Study participants were categorized as follows: preterm newborn (<37 weeks of gestation), term newborn (0–28 days), infant (29 days–<2 years), and child (2–<12 years).

A descriptive statistical analysis was performed, including calculations of absolute and relative frequencies, means, and standard deviations. Results were expressed as mean ± standard deviation (SD) for continuous variables and as percentages (%) for categorical variables. When applicable, 95% confidence intervals (95% CI) were used to estimate the precision of the observed proportions. All analyses were performed using Microsoft Excel 2016, complemented by manual statistical calculations.

This study was approved by the Human Research Ethics Committee of the São João de Deus Hospital. CAAE: No. 37936120.1.3001.5130.

RESULTS

Among the 68 patients diagnosed with COVID-19, 35 (51.5%) required admission to an intensive care unit (ICU) and had their prescriptions analyzed. A descriptive analysis of sociodemographic variables showed that most patients admitted to intensive care were male (57.1%). The analysis further revealed a predominance of male infants (45.0%) among hospitalized patients. The majority of patients (94.3%) were treated under the Brazilian Unified Health System (SUS), as shown in Table 1.

There were 7 deaths (20.0%) among the patients who required intensive care, of which 4 (57.1%) were infants and 3 (42.9%) were children. Considering the total of 68 patients diagnosed with COVID-19, the overall case fatality rate was 10.3% (95% CI: 4.2–19.8%).

Table 1 - Sociodemographic characteristics of children diagnosed with COVID-19 and admitted to intensive care in 2020 at a hospital in the municipality of Divinópolis, Minas Gerais, Brazil (n = 35).

Variables	Preterm	Term	Infant	Child	Total
Sex					
Female n (%)	0 (0)	0 (0)	7 (46.7)	8 (53.3)	15 (42.9)
Male n (%)	1 (5.0)	5 (25.0)	9 (45.0)	5 (25.0)	20 (57.1)
Age	0.02 ± 0.01	0.6 ± 0.3	3.2 ± 1.1	12 ± 2.5	15.8 ± 5.3
Health Care Coverage					
SUS n (%)	1 (3.0)	4 (12.1)	16 (48.5)	12 (36.4)	33 (94.3)
Private insurancen n (%)	0 (0)	1 (50.0)	0 (0)	1 (50.0)	2 (5.7)
Diagnosis					
ICD B342 n (%)	1 (2.8)	5 (14.4)	16 (45.7)	13 (37.1)	35 (100.0)

*Minor discrepancies in totals are due to rounding.

A total of 643 medical prescriptions were analyzed, corresponding to 3,026 prescribed medications, with an average of 18.3 ± 2.8 prescriptions per patient. The mean number of distinct drugs prescribed was 169.3 ± 101.27 per patient. The most frequently prescribed drug class was electrolytes (26.3%), with 0.9% sodium chloride solution and 50% hypertonic glucose being the most commonly used. This was followed by antimicrobials and analgesics, while antihypertensive agents represented the smallest proportion (1.8%), as shown in Table 2. The mean length of hospital stay was 8.2 ± 10.5 days.

Table 2 - Frequency of drug classes prescribed for pediatric patients admitted to intensive care in 2020 at a hospital in the municipality of Divinópolis, Minas Gerais, Brazil (n = 3,026 medications).

ATC Classification	n (%)
Electrolytes (B05)	795 (26.3)
Analgesics (N02)	425 (14.0)
Antimicrobials/Antifungals (J01)	406 (13.4)
Antiepileptics (N03)	312 (10.3)
Drugs for obstructive airway diseases (R03)	270 (8.9)
Unclassified*	212 (7.0)
Psycholeptics (N05)	203 (6.7)
Anesthetics (N01)	173 (5.7)
Vasoprotectives (C05)	102 (3.4)
Agents acting on the renin-angiotensin system (C09)	64 (2.1)
Antihypertensives (C02)	64 (2.1)

*Includes medications whose classification could not be found on the ATC consultation website.

DISCUSSION

Most patients were male infants, a finding consistent with larger multicenter studies[18]. This may be explained by the higher likelihood of developing the critical form of the disease (14.0%) among children under one year of age[5].

The results show that 35 (51.5%) of the patients who tested positive for COVID-19 required intensive care support — a relatively high proportion compared with national data on ICU admissions for patients with acute respiratory syndrome and/or COVID-19 across Brazil, which ranged from 18.3% among preschoolers to 27.9% among infants in 2020[19]. The higher ICU admission rate in the present study may be explained by the inclusion of only confirmed cases, whereas Silva (2023)[19] did not stratify patients by diagnosis.

The case fatality rate among pediatric patients diagnosed with COVID-19 was 10.3%, increasing to 20% among those requiring intensive care. These values exceed those reported by Marques *et al.* (2021)[20], who identified a hospital fatality rate of 9.5% among children and adolescents with severe acute respiratory syndrome due to COVID-19 in Brazil up to the 38th epidemiological week of 2020. The differences may stem from distinct population characteristics, as the national study included adolescents up to 18 years old and cases of unspecified acute respiratory syndrome. Moreover, the hospital analyzed in the present study serves as a regional referral center, admitting severe cases from a health microregion comprising 54 municipalities, which may justify the higher proportion of deaths observed[20].

The most frequently prescribed therapeutic classes were those related to life support, such as electrolytes, antimicrobials, antifungals, and analgesics. The high frequency of electrolyte prescriptions may be associated with the need for intravenous hydration and correction of hydroelectrolytic imbalances, conditions commonly observed in intensive care patients[21].

The elevated use of antimicrobials was also reported in other studies, since among the drugs initially considered promising for treating COVID-19 were antibiotics such as azithromycin[15]. In addition to antibiotics, antifungal agents were also used, likely for treating or preventing infections in these patients. Another study found similar trends, reporting the use of antibiotics in 76% of pediatric patients and antifungals in 4%[18].

The frequent prescription of analgesics can be explained by disease-related symptoms such as fever, treated with analgesic and antipyretic agents[4,22]. Furthermore, the predominance of supportive medications may reflect the absence of proven, specific therapeutic options for COVID-19. Thus, symptom management and treatment of complications — particularly in critically ill ICU patients — remained the primary therapeutic strategy available.

The pandemic demanded extensive efforts to employ medications not originally indicated for pediatric populations, resulting in widespread use of off-label or unlicensed drugs. The main challenge associated

with this practice lies in ensuring patient safety and meeting specific treatment needs[23].

Notably, a study conducted in Brazilian hospitals found that nearly 15% of hospitalized children experienced adverse drug reactions, predominantly gastrointestinal and dermatological. These reactions were classified as probably related, of moderate severity, and largely preventable, underscoring the importance of active pharmacovigilance with continuous monitoring and critical evaluation of therapeutic regimens to enhance patient safety[24].

This study included only patients from a hospital located in the interior of Minas Gerais, a referral center for a health microregion encompassing 54 municipalities. The sample was stratified by age according to WHO criteria, and only patients with confirmed COVID-19 diagnoses were included. These inclusion criteria ensured standardized analysis and internal comparability of data, distinguishing this research from other studies that included adolescents up to 17 years or patients with unspecified acute respiratory syndrome.

CONCLUSION

The analysis of prescriptions revealed that most medications used in neonatal and pediatric patients with COVID-19 were primarily intended for symptom management, with electrolytes, analgesics, and antimicrobials being the most frequently prescribed. A wide range of therapeutic classes was identified, with a predominance of those for symptomatic support, reflecting the therapeutic approach adopted in the absence of specific treatment protocols. These findings provide a detailed overview of the prescribing profile in pediatric COVID-19 patients and may help guide clinical practice and future research on pharmacological management in this population.

CRediT author statement

Conceptualization: Melo, AE; Pereira, ML. Methodology: Melo, AE; Pereira, ML; Baldoni, AO. Validation: Pereira, ML; Pizzol, TSD; Nogueira, TA; Baldoni, AO. Statistical Analysis: Melo, AE; Pereira, ML. Formal Analysis: Pereira, ML; Pizzol, TSD; Nogueira, TA; Baldoni, AO. Investigation: Melo, AE; Silva, RAS; Souza, IGL. Resources: Melo, AE; Silva, RAS. Writing – Original Draft Preparation: Melo, AE; Silva, RAS. Writing – Review & Editing: Melo, AE; Silva, RAS. Visualization: Pereira, ML; Pizzol, TSD; Nogueira, TA; Baldoni, AO. Supervision: Pereira, ML; Baldoni, AO. Project Administration: Melo, AE; Pereira, ML.

All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the workreported in this paper.

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