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# Impact of nonpharmacological COVID-19 interventions in hospitalizations for childhood pneumonia in Brazil

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## Abstract

**Background and Objective:** The knowledge about the impact of the non-pharmacological measures to control the COVID-19 pandemic can give insight into ways in which they can also be applied for other respiratory diseases. To assess the impact of containment measures of the COVID-19 pandemic on pneumonia hospitalizations in children from 0 to 14 years of age in Brazil.

**Methods:** Data from hospital admissions for pneumonia were obtained from the Department of Informatics of Brazilian Public Health System database in the period of 2015–2020 and analyzed by macroregions and age groups. To evaluate the effect of containment measures, on the incidence of pneumonia, the absolute reduction and relative reduction were calculated by analyzing the subsets 2015-2019 vs. 2020.

**Results:** Comparing the subsets of April–August 2015–2019 vs. April–August 2020 for Brazil (total), there was an significant reduction in the average incidence of hospitalizations, with numbers ranging from −82% [IRR 0.17 (0.14–0.21)] for <4 years (prepandemic 741.8/100,000 vs. pandemic 132.7/100.000), −83% [IRR 0.17 (0.10–0.27)] for 5–9 years (prepandemic 113.6/100,000 vs. pandemic 19.6/100.000), −77% [IRR 0.23 (0.11–0.46)] for 10–14 (prepandemic 42.0/100,000 vs. pandemic 9.8/100.000) and −82% [IRR 0.18 (0.15–0.21)] for all children ≤14 years (prepandemic 897.4/100,000 vs. pandemic 162.1/100.000).

**Conclusion:** We found a significant decrease in cases of all cause pneumonia in children under 14 years and especially in the age group <9 years during the COVID-19 pandemic, which may be associated with the nonpharmacological measures applied to control the SARS-CoV-2.

KEYWORDS
COVID-19, hospitalization, pediatrics, pneumonia

  

## 1 | INTRODUCTION

Pneumonia is a form of acute respiratory infection that is most commonly caused by viruses or bacteria, accounting for 15% of all deaths of children under 5 years of age worldwide.[1] Recently an impressive decline has been noted in both respiratory syncytial virus (RSV) and influenza-associated with mitigation strategies implemented in response to the SARS-CoV-2 pandemic.[2–5]

In Brazil, there was a significant reduction in hospitalization for acute bronchiolitis in children under one year old, of the order of more than 70%.[5] In China, research using a national electronic epidemiological database showed a concomitant decrease in influenza, enterovirus, and all-cause pneumonia during the COVID-19 pandemic. Infection control measures, including the use of masks, hand hygiene, and social distancing, can impact on reducing the burden of other infectious pathogens in pediatrics,[2,6,7] beyond the prevention of COVID-19.

The Ministry of Health received the first notification of a confirmed case of COVID-19 in Brazil on February 26, 2020. From February 26, 2020 to April 17, 2021, 13,900,091 cases and 371,678 deaths were confirmed. The highest numbers of new cases (100,158 cases) occurred on March 25, 2021, and new deaths (4249 deaths) occurred on April 8th 2021.[8] Collective measures to contain the pandemic was implemented in the middle of March: social distancing, restriction of commerce activities, and nonessential services. Suspension of teaching activities at all educational levels throughout the country started in mid-March.[9] Additionally, besides overall hygiene measures and mask protection strategies, children have stayed out of schools and daycare centers.[10] The moment when the containment strategies for the COVID-19 pandemic were implemented in Brazil, coincides with the already documented increase in hospitalizations for pneumonia in the same period in previous years.[11] Considering the uniqueness of the behaviors suggested by the mitigation measures, this study seeks to evaluate the impact of the containment measures originally used against the pandemic of COVID-19 on hospitalizations for pneumonia in children aged 0–14 years old.

## 2 | METHODS

Our data were collected through the Department of Informatics of Brazilian Public Health System (DATASUS, http://datasus.saude.gov.br/),[11] which is a robust nationwide database. The DATASUS provides universal coverage of the Brazilian population. The absolute numbers of hospitalizations in the public system were obtained according to the International Classification of Diseases, version 10 (ICD-10), considering the main diagnosis at admission. The department is able to store health information for the entire Brazilian population and has connections with all State Centers of the Ministry of Health, FUNASA, National Health Surveillance Agency (ANVISA), Indian House (Casa do Índio), and with the 27 state health secretariats.[12] Further information about DATASUS is described elsewhere.[5,13–15]

### 2.1 | Study design and participants

Data from hospital admissions for pneumonia were obtained from the DATASUS database for the period of 2015–2020 (month to month) in Brazil. The hospitalization data were obtained through the following links: "Informações de Saúde" (Health Information) (TABNET) – "Epidemiológicas e Morbidade" (Epidemiological and Morbidity) – "Morbidade Hospitalar" (Hospital Morbidity), "Lista de Morbidade" (Morbidity List) – ICD-10, "Pneumonia — J12-J18". All hospitalizations registered for diseases related to the respiratory system in DATASUS were also collected (ICD-10, "Respiratory system diseases — J00-J99"). Also, data from all macro-regions of Brazil were analyzed (North, Northeast, Southeast, South, and Midwest) because of variation in population density, socioeconomic characteristics, and climatic variation.[16] The months of January to August were used for analysis because they coincide with autumn and winter, in addition to being the typical period of increased incidence of childhood pneumonia in Brazil.[11] The age groups of interest were of all children ≤14 years stratified into the subgroups: ≤4 years, 5–9 years, and 10–14 years, including both sexes. To assess the reliability of the report, ICD-10, chapter II, and code C00-D48 — neoplasm (tumors) (e.g., tumors from all causes) — was used as comparison, as social distancing measures are not expected to have a major impact on these conditions. On this platform, there is no way to access clinical data, only the number of hospitalizations that can be stratified by age (range) and location.

To evaluate the effect of pandemic containment measures on the incidence of pneumonia, the absolute reduction (without pandemic containment measures—with pandemic containment measures) and relative reduction (without pandemic containment measures—with pandemic containment measures/without pandemic containment measures) were calculated by analyzing the subsets 2015–2019 vs. 2020. For this analysis, the months from April to August were used, with March being chosen as the cut-out because it is the period of implementation of the measures to contain the pandemic in Brazil in 2020 and because a greater impact of the measures is expected from the month of April, including the law that closed schools and daycare centers for children.[10] Data analysis has been truncated at the end of August for the purpose of this article since there is a delay in data entry.

To ensure quality, two independent authors reviewed all data. This study does not contain personal or individual data, so it was considered exempt from evaluation by the Research Ethics Committee. Furthermore, the project was approved by the Pontifical University of Rio Grande do Sul's research system (SIPESQ, in Portuguese).

### 2.2 | Statistical analysis

To calculate the monthly incidence of hospitalizations in the public health system, we used the following formula: total number of hospitalizations/population number by age (per year and place [Brazil-IBGE]) x 100,000

inhabitants).[17] Brazilian National Health Agency provides percentage of the population, that has health insurance each year, which during the study period that ranged from 20.80% in 2015 to 19.60% in 2020 for the population under fourteen years old.[18] This percentage was excluded from the denominator, as this population uses other hospital structures, and admission data are not included in DATASUS.

To calculate the difference in incidence rates between the without and with pandemic containment measures periods, incidence rate ratio (IRR) was used to assess statistical significance, considering a 95% confidence interval (CI).

## 3 | RESULTS

From January 2015 to August 2020, there were 2,509,078 hospitalizations due to respiratory diseases (all hospitalizations registered for diseases related to the respiratory system) registered in DATASUS, of all children ≤14 years of age in Brazil. Pneumonia represented 49.3% (1,238,783) of these cases with a predominance in children under 4 years old, representing 81% of these hospitalizations.

For all age groups (all children ≤14 years, ≤4 years, 5–9 years, and 10–14 years), the monthly distribution of the hospitalization incidence due to pneumonia in the months from January to March was similar, with a trend of increasing cases throughout the studied period (2015–2020). The lowest incidence was observed in February 2018 with 21.5/100,000 for children aged 10–14 years old and the highest in April 2015 with 999.7/100,000 hospitalizations for those under four. In the period from April to May of the years 2015, 2016, 2017, 2018, and 2019 there was an increasing trend, with a decrease beginning in June (Figure 1).

When comparing the subsets of April-August 2015–2019 vs. April-August 2020, there was an expressive reduction in the incidence of hospitalizations, with numbers ranging from – 82% [IRR 0.18 (0.15–0.21)] for all children ≤14 years old, −82% [IRR 0.17 (0.14–0.21)] for children under 4 years old, −83% [IRR 0.17 (0.10–0.27)] for children aged 5–9 years and −77% [IRR 0.23 (0.11–0.46)] for children aged 10–14 years for data from Brazil [total] (Table 1 and Figure 2A–D). Conversely, hospitalizations for neoplasm (tumors) had little variation in the same periods (Figure 2E).

When comparing the subsets by macro-regions of Brazil (April-August 2015–2019 vs. April-August 2020), a drop in hospitalizations was observed that ranged from −77% [IRR 0.23 (0.15–0.34)] in the Southeast to −87% [IRR 0.12 (0.07–0.21)] in the Northeast in children under 4 years old. For children aged 5–9 years the fall ranged from −69% [IRR 0.30 (0.11–0.79)] in the Southeast region to −90% [IRR 0.10 (0.02–0.38)] in the South and in children aged between 10 and 14 years of age, hospitalizations ranged from −62% [IRR 0.37 (0.08–1.79)] to −89% [IRR 0.19 (0.03–0.98)] in the South (Table 1).

## 4 | DISCUSSION

Using a Brazilian Big data epidemiological platform, we found an important reduction in overall pneumonia hospitalizations during the period in which measures to contain the COVID-19 pandemic

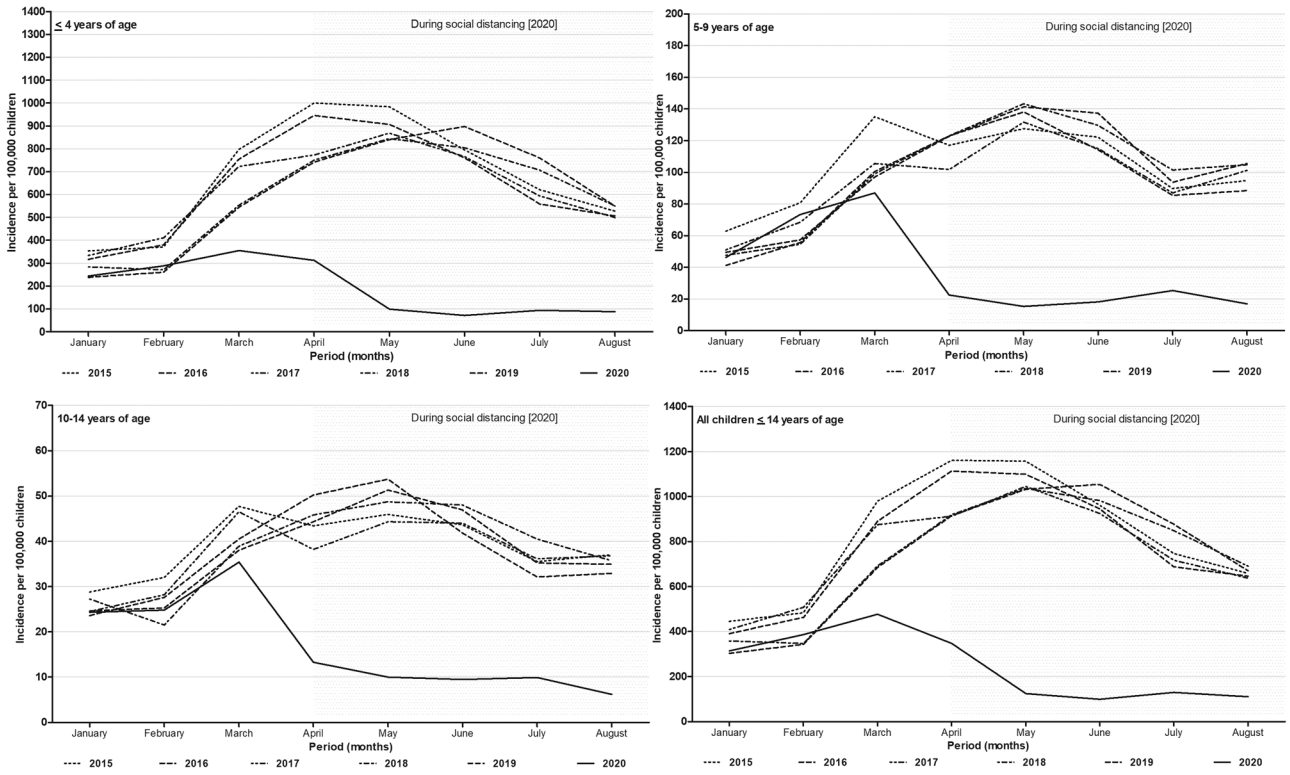


**FIGURE 1** Monthly distribution of incidence of hospitalizations for pneumonia in children under 14 years of age in Brazil (2015–2020)

**TABLE 1** Total absolute number and incidence of hospitalizations for pneumonia from 2015 to 2020 in children under 14 years of age in Brazil (total) and Brazilian macroregions

| | Period April-August 2015-2019[c] | Period April-August 2020[c] | | Relative difference in rate (without social distancing vs. with social distancing)[a] | |
|---|---|---|---|---|---|
| Average[c] | Total absolute number of hospitalizations (number of hospitalizations per 100,000/children/subset of month)[a] | | Absolute difference in rate[a] | Change (%) | IRR (95% CI)[b] |
| ≤4 years | | | | | |
| Brazil (Total) | 20,810 (741.8) | 3806 (132.7) | −609.1 | −82 | 0.17 (0.14–0.21) |
| North | 2,690 (166.5) | 507 (31.5) | −135.0 | −81 | 0.18 (0.12–0.27) |
| Northeast | 5,477 (131.6) | 703 (17.0) | −114.6 | −87 | 0.12 (0.07–0.21) |
| Southeast | 7,561 (130.9) | 1750 (30.3) | −100.6 | −77 | 0.23 (0.15–0.34) |
| South | 3,417 (174.5) | 488 (24.6) | −149.9 | −86 | 0.14 (0.09–0.21) |
| Midwest | 1,665 (138.3) | 358 (29.3) | −109.0 | −79 | 0.21 (0.14–0.31) |
| 5–9 years | | | | | |
| Brazil (Total) | 3,171 (113.6) | 672 (19.6) | −94.0 | −83 | 0.17 (0.10–0.27) |
| North | 376 (22.9) | 67 (4.1) | −18.8 | −82 | 0.17 (0.06–0.51) |
| Northeast | 1,045 (24.3) | 209 (5.0) | −19.3 | −79 | 0.20 (0.07–0.53) |
| Southeast | 1,026 (18.2) | 320 (5.6) | −12.6 | −69 | 0.30 (0.11–0.79) |
| South | 441 (23.7) | 47 (2.4) | −21.3 | −90 | 0.10 (0.02–0.38) |
| Midwest | 283 (24.5) | 29 (2.5) | −22.0 | −90 | 0.10 (0.02–0.37) |
| 10–14 years | | | | | |
| Brazil (Total) | 1,212 (42.0) | 316 (9.8) | −32.2 | −77 | 0.23 (0.11–0.46) |
| North | 154 (9.1) | 31 (1.9) | −7.2 | −79 | 0.20 (0.04–0.99) |
| Northeast | 442 (9.5) | 111 (2.5) | −7.0 | −74 | 0.26 (0.06–1.05) |
| Southeast | 339 (5.8) | 125 (2.2) | −3.6 | −62 | 0.37 (0.08–1.79) |
| South | 174 (8.9) | 32 (1.7) | −7.2 | −89 | 0.19 (0.03–0.98) |
| Midwest | 103 (8.7) | 17 (1.5) | −7.2 | −83 | 0.17 (0.03–0.97) |
| All ≤14 years | | | | | |
| Brazil (Total) | 25,193 (897.4) | 4794 (162.1) | −735.3 | −82 | 0.18 (0.15–0.21) |
| North | 3,220 (198.5) | 605 (37.5) | −161.0 | −81 | 0.18 (0.13–0.26) |
| Northeast | 6,964 (165.4) | 1023 (24.5) | −140.9 | −85 | 0.14 (0.09–0.22) |
| Southeast | 8,926 (154.9) | 2195 (38.1) | −116.8 | −75 | 0.24 (0.17–0.35) |
| South | 4,032 (207.1) | 567 (28.7) | −178.4 | −86 | 0.13 (0.09–0.20) |
| Midwest | 2,051 (171.5) | 404 (33.3) | −138.2 | −80 | 0.19 (0.13–0.28) |

[a]Incidence number.

[b]CI, confidence interval; IRR, incidence rate ratio.

[c]Average of periods.

in 2020 were taken, with an average reduction scale of more than 80% for children under 14 years old. The age group under nine years was the most affected.

Our data suggest an important impact by the measures to contain the COVID-19 pandemic in hospitalizations for pneumonia. The evidence supporting the effectiveness of these measures has been obtained largely from observational studies and simulation studies. Important drops in the number of cases of influenza, respiratory syncytial virus, enterovirus, and overall pneumonia, have been shown in different regions of the world with a common association with measures to contain the COVID-19 pandemic.[2–5,19–26]

Chiu et al.[25] investigated the impact of implemented infectious control strategies on the incidences of influenza, enterovirus infection,

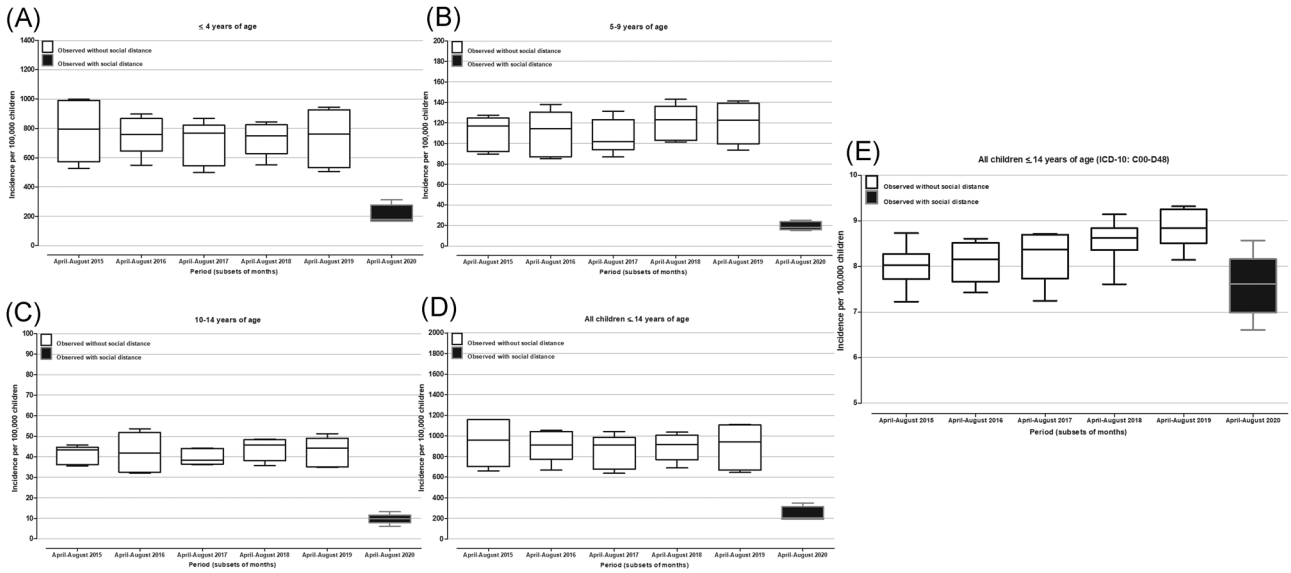


**FIGURE 2** Subsets' monthly distribution of incidence (without social distance vs with social distance) of hospitalizations for pneumonia in children ≤4 years of age (A), 5–9 years of age (B), 10–14 years of age (C), and all children ≤14 years of age in Brazil (D). (E) International Classification of Diseases, Tenth Revision (ICD-10), code C00-D48 – Neoplasm (tumors)

and all-cause pneumonia during the COVID-19 pandemic and found a dramatic decrease in all-cause pneumonia.

Yeoh et al.[3] found 98.0% and 99.4% reductions in RSV and influenza detections, respectively, in Western Australian children through the winter of 2020. A study conducted at a private hospital in Brazil showed that children under five years old account for 81% of hospitalizations due to respiratory disease (upper respiratory infection, asthma/bronchitis, bronchiolitis, and pneumonia). In the adjusted model, an average reduction of 38 (−37.66%) hospitalizations was observed in the period of social isolation.[27] In France, a time series study analyzed the number of pediatric visits and hospital admissions after the lockdown and found decreases of −68% and −45%, respectively. In addition, a significant decrease of >70% of acute gastroenteritis, common cold, bronchiolitis, and otitis media was noticed compared to the expected values.[26] In Singapore, a marked decline of −76% in influenza-like illness cases after the implementation of public health measures for COVID-19 was found.[28] In Belgium, there was a >99% reduction in the number of registered RSV cases in 2020 compared to the last years. The authors associate the fact with the nonpharmacological interventions implemented, including hygiene and social distancing.[29]

Although the impact on viral respiratory infections has been described, all measures may also influence the spread of bacteria that colonizes the respiratory tract, such as *Streptococcus pneumoniae*. The control in the spread of respiratory viral infections can also impact bacterial diseases indirectly, as both are epidemiologically related.[30]

Another important factor is the viral spread index ($R_0$), that is, the expected number of secondary infectious cases produced by a primary infectious case. This index determines the potential for the spread of a virus in a susceptible population.[31] A series of nonpharmacological public health interventions, including cordon sanitaire, traffic restriction, social distancing, home confinement, centralized quarantine, and universal symptom research, have been temporarily associated with improved control of the COVID-19 outbreak in Wuhan, China. The $R_0$ fluctuated above 3.0 before 26 January, decreased to less than 1.0 after 6 February, and further decreased to less than 0.3 after 1 March.[32] A recent multicenter analysis with literature review showed that emergency department visits and hospital admissions were greatly decreased during COVID-19 lockdowns in the Netherlands as in the rest of the world, especially for children with communicable infections. While a large proportion of the reduction can be attributed to a decrease in transmissible infections not caused by Sars-CoV-2, the authors showed that avoidance of care could be an influential factor as well.[33] In fact, the avoidance behavior of health care services has been pointed out for a series of studies and became a concern to the management and prevention of a lot of diseases.[34,35] However, although this factor can be seen as a confounder, it is not possible to count it as a direct or isolated influence on the results found in our study. As supported by previous studies, our main hypothesis is that nonpharmacological health measures to contain the COVID-19 pandemic have a significant impact on the spread of several respiratory viruses that still have a lower spread potential than SARS-CoV-2.

In Brazil, states enacted nonpharmacological interventions to reduce the spread of COVID-19 in the middle of March 2020. Such measures included closing schools and non-essential services, social distancing, and recommendations for increased handwashing and wearing of face masks. As seen in the incidence of COVID-19,[36] school closures likely play a central role in reducing the cases of childhood pneumonia observed in our study, especially in children under four years of age. Children spending prolonged periods at

school. Especially infants and preschoolers can be in close proximity to each other, in classrooms with high numbers of children and increased exposure to respiratory pathogens by peers and caregivers.

However, we point out the limitation of the impossibility of evaluating a single nonpharmacological intervention in isolation, since such measures occurred simultaneously. Furthermore, the individual prevention measures represent a hurdle, as they cannot be exactly quantified, apart from the fact that they are not supposed to be analyzed as an inseparable part of social distancing.

Another limitation of this study is that we have used the information regarding hospital admissions from a third-party database. To do that, we have collected the data for each month with a two-month delay. According to our previous experiences, this period is sufficient for DATASUS to present the final numbers or even very approximate values, since the data are included based on the Hospitalization Authorizations forms, in Brazil AIH (Hospital Admission Authorization).[5,13–15] In addition, the data have a population-based nature, probably no other country in the Southern Hemisphere has such robust national and regional epidemiological data, considering the population size, which strengthens the findings and presents as an advantage over other recent studies. Despite limitations, we consider that the results exhibited truly reflect the current moment, as they show a drastic reduction in the number of hospitalizations for pneumonia during the months when the health measures to prevent the spread of the coronavirus were in vigor in Brazil.

In conclusion, using an epidemiological platform of scientific health data of Brazil, we found a significant decrease in cases of pneumonia in children under 14 years and especially in the age group under nine years during the COVID-19 pandemic. Nonpharmacological public health interventions applied to mitigate SARS-CoV-2 may have contributed to the decline in childhood all-causes pneumonia cases.

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## AUTHOR CONTRIBUTIONS

Frederico Friedrich participated in the conception and design of the study, acquisition, analysis, and interpretation of data; elaborating the article and reviewing it critically. Marcelo C. Scotta and Renato T. Stein participated in the conception and design of the study, analysis, and interpretation of data, elaborating the article and reviewing it critically and Leonardo A. Pinto participated in the design of the study, analysis, and interpretation of data; writing the article and reviewing it critically. Magali Santos Lumertz, Renata Ongaratto, Laura de Castro Garcia, Gustavo Eggers Carvalho, Mariana Puerari Pieta, Lucas Montiel Petry, Giovani Zocche, Marcos Brum, and Marcus Herbert Jones participated in the acquisition, analysis, and interpretation of data; article writing and critical review. All the authors approved the final version for publication.

## CONFLICT OF INTERESTS

The authors declare there are no conflict of interests.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in ["Impact of nonpharmacological COVID-19 interventions in hospitalizations for childhood pneumonia in Brazil"] at https://doi.org/10.22541/au.161915868.80821102/v1, reference number ["PPUL-21-0365].

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