

TITLE PAGE

Title: Impact of nonpharmacological COVID-19 interventions in hospitalizations for pneumonia in Brazil.

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Conflict of interest statement

The authors declare no conflict of interests.

Running title: Impact of containment measures on pneumonia.

Keywords: COVID-19; pneumonia; hospitalization; pediatrics.

ABSTRACT

Background and Objective: The knowledge about the impact of the nonpharmacological measures to control the COVID-19 pandemic can give insight to 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 macro-regions and age groups. To evaluate the effect of containment measures, used in the pandemic, 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, there was an expressive reduction in the average incidence of hospitalizations, with numbers ranging from -87% [IRR 0.12 (0.10 to 0.14)] for < 4 years, -79% [IRR 0.21 (0.07 to 0.57)] for 5-9 years, -73% [IRR 0.26 (0.05 to 1.21)] for 10-14 and -86% [IRR 0.14 (0.06 to 0.29)] for <14 years.

Conclusion: We found a significant decrease in cases of pneumonia during the COVID-19 pandemic. Nonpharmacological public health interventions can contribute to the decline of other respiratory infectious diseases.

79 INTRODUCTION

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

85 In Brazil, there was a significant reduction in hospitalization for acute bronchiolitis in
86 children under one year old, of the order of more than 70%.⁵ In China, research using a
87 national electronic epidemiological database showed a concomitant decrease in
88 influenza, enterovirus, and all-cause pneumonia during the COVID-19 pandemic.

89 Infection control measures, including the use of masks, hand hygiene, and social
90 distancing, can impact on reducing the burden of other infectious pathogens in
91 pediatrics,^{2,6,7} beyond to the prevention of COVID-19.

92 The Ministry of Health received the first notification of a confirmed case of COVID-19
93 in Brazil on February 26th 2020. From February 26 to October 17th 2020, 5,224,362
94 cases and 153,675 deaths were confirmed. The highest number of new cases (69,074
95 cases) and new deaths (1,595 deaths) occurred on July 29th.⁸ Collective measures to
96 contain the pandemic were implemented in the middle of March: social distancing,
97 restriction of commerce activities, and non-essential services. Suspension of teaching
98 activities at all educational levels throughout the country started by mid-March.⁹

99 Additionally, besides overall hygiene measures and mask protection strategies, children
100 have stayed out of schools and daycare centers.¹⁰ The moment when the containment
101 strategies for the COVID-19 pandemic were implemented in Brazil, coincides with the
102 already documented increase in hospitalizations for pneumonia in the same period in
103 previous years.¹¹ Considering the uniqueness of the behaviors suggested by the
104 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 to 14 years old.

METHODS

Our data were collected through Department of Informatics of Brazilian Public Health System (DATASUS, <http://datasus.saude.gov.br/>),¹¹ which is a robust nationwide database. Further information about DATASUS is described elsewhere.^{5,12–14}

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) – International Classification of Diseases (ICD-10) (Pneumonia — J12-J18). Also, data from all macro-regions of Brazil were analyzed (North, Northeast, Southeast, South and Midwest). 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 ≤ 4 years, 5-9 years, 10-14 years and ≤ 14 years, including both sexes. 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 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).¹⁵ Brazilian National Health Agency provides percent-age of population, which has health insurance each year, which during the study period varied from 20.80% in 2015 to 19.60% in 2020 for the

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131 population under fourteen years old.¹⁶ This percentage was excluded from the
132 denominator, as this population uses other hospital structures, and admission data are
133 not included in DATASUS.

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

145 To ensure quality, two independent authors reviewed all data. This study does not
146 contain personal or individual data, so it was considered exempt from evaluation by the
147 Research Ethics Committee.

148 **Statistical Analysis**

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

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153 **RESULTS**

154 From January 2015 to August 2020, there were 2,509,078 hospitalizations due to
155 respiratory diseases (all hospitalizations registered for diseases related to the respiratory
156 system) registered in DATASUS, of children under 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 (≤ 4 years, 5-9 years, 10-14 years, and ≤ 14 years), the monthly distribution of the hospitalization incidence of hospitalizations 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 January 2016 with 4.5 / 100,000 for children aged 10-14 years old and the highest in April 2015 with 2358.8 / 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 from on month of June. In 2020, there was no increase in the incidence with an important drop in April for all age groups, when compared to the previous year (April 2019 vs April 2020). The hospitalization rate reduction was -85.3% [IRR 0.14 (0.13 to 0.16)] of hospitalizations in children ≤ 4 years, - 76.9% [IRR 0.23 (0.08 to 0.60)] in children aged 5-9 years and -66.6% [IRR 0.33 (0.08 to 1.32)] in children aged 10-14 years (Figure 1).

When comparing the subsets of April-August 2015-2019 vs April-August 2020, there was an expressive reduction in the average incidence of hospitalizations, with numbers ranging from -87% [IRR 0.12 (0.10 to 0.14)] for children under 4 years old, -79% [IRR 0.21 (0.07 to 0.57)] for children aged 5-9 years, -73% [IRR 0.26 (0.05 to 1.21)] for children aged 10-14 and -86% [IRR 0.14 (0.06 to 0.29)] for children under 14 years old from data from Brazil (Table 1 and Figure 2).

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 to 0.34)] in the Southeast to -87% [IRR 0.12 (0.07 to 0.21)] in the Northeast in children under 4 years old. For children aged 5-9 years the fall ranged from

182 -69% [IRR 0.30 (0.11 to 0.79)] in the Southeast region to -90% [IRR 0.10 (0.02 to
183 0.38)] in the South and in children aged between 10-14 years of age, hospitalizations
184 ranged from -62% [IRR 0.37 (0.08 to 1.79)] to -89% [IRR 0.19 (0.03 to 0.98)] in the
185 South (Table 1).

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187 **DISCUSSION**

188 Using an epidemiological platform of health big data science of Brazil, we showed an
189 expressive reduction in overall pneumonia hospitalizations during the period in which
190 measures to contain the COVID-19 pandemic in 2020 were taken, with an average
191 reduction scale of more than 80% for children under 14 years old.

192 Our data suggests an important impact by the measures to contain the COVID-19
193 pandemic in hospitalizations for pneumonia. The evidence supporting the effectiveness
194 of these measures has been obtained largely from observational studies and simulation
195 studies. Important drops in number of cases of influenza, respiratory syncytial virus,
196 enterovirus, and overall pneumonia, have been shown in different regions of the world
197 with a common association with measures to contain the COVID-19 pandemic.

198 2,3,23,24,4,5,17–22

199 Chiu et al²¹ investigated the impact of implemented infectious control strategies on the
200 incidences of influenza, enterovirus infection, and all-cause pneumonia during the
201 COVID-19 pandemic and found a dramatic decrease in all-cause pneumonia.
202 Yeoh et al³ found 98.0% and 99.4% reductions in RSV and influenza detections,
203 respectively, in Western Australian children through the winter of 2020. A study
204 conducted at a private hospital in Brazil showed that children under 5 years old account
205 for 81% of hospitalizations due to respiratory disease (upper respiratory infection,
206 asthma / bronchitis, bronchiolitis, and pneumonia). In the adjusted model, an average
207 reduction of 38 (-37.66%) hospitalizations was observed in the period of social

isolation.²⁵ 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.²² In Singapore, a marked decline of -76% in influenza-like illnesses cases after the implementation of public health measures for COVID-19 was found.²⁶ 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 non-pharmacological interventions implemented, including hygiene and social distancing.²⁷

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 on bacterial diseases indirectly, as both are epidemiologically related.²⁸

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.²⁹ 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.³⁰ 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

233 a decrease in transmissible infections not caused by Sars-CoV-2, the authors show that
234 avoidance of care could be an influential factor as well.³¹ These data corroborate with
235 our hypothesis that such health measures have a significant impact on the spread of
236 several respiratory viruses that still have a lower spread potential than Sars-Cov-2.

237 A limitation of this study is that we have used the information regarding hospital
238 admissions from a third-party database. In order to do that, we have collected the data
239 for each month with a two-month delay. According to our previous experiences, this
240 period is sufficient for DATASUS to present the final numbers or even very
241 approximate values, since the data are included based on the Hospitalization
242 Authorizations forms, in Brazil AIH (Hospital Admission Authorization).^{5,12-14}

243 Furthermore, the individual prevention measures represent a hurdle, for they cannot be
244 exactly quantified, apart from the fact that they are not supposed to be analyzed as an
245 inseparable part of social distancing. Despite of limitations, we consider that the results
246 exhibited truly reflect the current moment, as they show a drastic reduction in the
247 number of hospitalizations for pneumonia during the months when the health measures
248 to prevent the spread of the coronavirus were in vigor in Brazil.

249 In conclusion, using an epidemiological platform of health big data science of Brazil,
250 we found a significant decrease in cases of pneumonia during the COVID-19 pandemic.

251 Nonpharmacological public health interventions contribute not only to the control of
252 COVID-19 but also have a significant impact on the spread of several respiratory
253 viruses that still have a lower spread potential than Sars-Cov-2.

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Figure Caption

Figure I. Monthly distribution of incidence of hospitalizations for pneumonia in children under fourteen years of age in Brazil (2015–2020).

Figure II. Subsets monthly distribution of incidence (without social distance vs with social distance) of hospitalizations for pneumonia in children under fourteen years of age in Brazil (2015–2019vs2020).

Table Caption

Table I. Total absolute number and incidence of hospitalizations for pneumonia from 2015 to 2020 in children under 14 years of age in Brazil and Brazilian macro-regions.