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Impact of non-pharmacological initiatives for COVID-19 on hospital admissions due to pediatric acute respiratory illnesses

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Educational Aims

The reader of this article will come to appreciate that:

- Acute respiratory illnesses (ARIs) are the most common causes of illness and mortality in children under five worldwide.
- Interventions to deal with the COVID-19 pandemic reduced hospital admissions due to ARIs in children.
- NPI are important to reduce the rate of hospitalizations due to ARIs.
- Such preventive measures apply at both the community level, where human interaction is greater, and at the hospital level, where nosocomial transmission of viruses has greater direct consequences.

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ABSTRACT

Introduction: Interventions to deal with the COVID-19 pandemic may impact the burden of other respiratory diseases. The aim of this study is to analyze the impact of non-pharmacological initiatives (NPI) against COVID-19 on the number of hospitalizations due to pediatric acute respiratory illnesses (ARIs).
Material and methods: This is a retrospective analysis of pediatric hospitalizations in Porto Alegre, Brazil. We analyzed the monthly incidence of hospital admissions from 2018 to 2020 due to ARIs included in the study. The time series was divided into the period before introducing NPI (2018 and 2019), and the period when NPI were running (2020). We compared means between the years with Student's *t*-test. The Dickey-Fuller test was used for secular trend analysis. For seasonality, Fischer's G test was performed. Dynamic linear univariate and multivariate models were used to estimate the association between the predictors (the introduction of NPI, secular trend, and seasonality) and outcome (the incidence of ARI admissions). For the statistical analysis, the cut-off probability for rejecting the null hypothesis was defined as <5%.
Results: From 2018 to 2020, 10,109 hospital admissions were due to the respiratory causes included in this study. There was a significant decrease in 2020 in the mean incidence of the ARIs studied compared with 2018 and 2019. The number of hospitalizations due to respiratory diseases in children decreased by 64% for asthma and 93% for bronchiolitis. A secular trend of monthly admissions rates due to ARIs was only observed in the laryngotracheitis data ($p = 0.485$), but seasonality was detected in all analyses. According to the univariate and multivariate analysis, the introduction of NPI was associated with a decrease in the incidence of ARI admissions.
Conclusion: There was a significant reduction in hospital admissions due to ARIs in children. Our data suggest a significant impact of NPI on reducing the spread of viruses associated with ARIs in children. These results support respiratory illness prevention strategies.

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INTRODUCTION

Acute respiratory illnesses (ARIs) are the most common causes of disease and mortality in children under five worldwide [1]. Different bacteria and viruses, including human coronaviruses (HCoVs), are responsible for most cases of ARIs. Prior to 2019, there were four well-known HCoVs that caused common ARIs, which could be isolated in about 5% of children hospitalized with respiratory disease. Reinfections were common and, in 10–50% of cases, they were found as co-infections along with other predominant respiratory viruses, with which they also shared seasonal and cyclical patterns of occurrence [2]. Two other HCoVs, Sars-CoV and MERS-CoV, were found to be responsible for outbreaks of serious respiratory disease in adults but were milder and very infrequent in children [3].

At the end of 2019, Sars-CoV-2 emerged as a new zoonotic HCoV, causing the disease COVID-19 [2,4]. It quickly spread worldwide and became the worst pandemic since the devastating influenza-A from 1918, in terms of human lives lost and its negative global socio-economic impact [5]. The number of moderate to severe cases of COVID-19 rose exponentially in hospitals worldwide throughout the first and second waves of 2020, but the disease consistently behaved benignly in most children compared to adults [6].

As part of the preemptive and contention measures for COVID-19 recommended by the World Health Organization, non-pharmaceutical initiatives (NPI) were promptly instituted globally. They included, among other measures, social distancing, the use of face masks, reinforcing the importance of handwashing, health care centers prioritizing suspected COVID-19 cases, and even city and state lockdowns [7]. Since then, studies have shown that in 2020 there was a reduction in general pediatric care, emergency department visits, and hospital admissions of infants with bronchiolitis [8,9]. The aim of this study is to analyze the impact of non-pharmacological initiatives against COVID-19 on the number of hospitalizations due to pediatric ARIs.

MATERIALS AND METHODS

This study is a retrospective analysis of data from Porto Alegre's public health registry from 2020. Porto Alegre is the southernmost state capital of Brazil, with a four-season climate and an important number of ARI hospitalizations that habitually follow cyclic viral seasonality. For this study we used GERINT, a digital system designed to control and regulate the city's public hospital admissions. We searched for diseases using the coding of the International Statistical Classification of Diseases and Related Health Problems, version 10 (ICD-10) [10]. We included the following: laryngitis/tracheitis (J04 to J06.0), bronchiolitis (J21.0, J21.8, J21.9), bacterial and viral pneumonia (J10 to J18.9), bronchitis (J20 to J20.9), and asthma (J45 to J46). The study included children and adolescents aged 0–18 years old from both sexes who were hospitalized from January 2018 to December 2020, with any of the aforementioned diagnoses.

To calculate the social isolation index (SID) in 2020, we used data obtained by *In Loco*, a geolocation company that tracks mobile phone signals daily to estimate population mobility as a measure of social distancing (the lesser the mobility, the greater the social distancing assumed) [11]. Brazilian state and city authorities have used this index to monitor social distancing during the COVID-19 pandemic.

Monthly and annual admission rates per 100,000 children were calculated by dividing the number of hospitalizations by the estimated pediatric population expressed in 100,000 s [12]. Porto Alegre's pediatric population in the three years included in the study was collected from the Brazilian National Health Registry (DATASUS) [13].

The main analysis of the impact of COVID-19 considered the introduction of non-pharmacological initiatives (NPI) at the start of the pandemic in Brazil (February 2020) and how it was reflected in each disease category. The statistical analysis considered the monthly incidence of hospital admissions from 2018 to 2020 due to the included ARIs. The time series was divided into pre-NPI (2018 and 2019) and NPI in place (2020). The mean incidence between the years was compared using Student's *t* test. The Dickey-Fuller test was used for the secular trend analysis. If $p < 0.05$, the series were considered stationary, and a secular trend was not confirmed. For seasonality, Fischer's *G* test was performed. Dynamic linear univariate and multivariate models were used to estimate the association between the predictors (the introduction of NPIs, secular trend, and seasonality) and outcome (the incidence of ARI admissions). For the statistical analysis, the cut-off probability for rejecting the null hypothesis was defined as less than 5% ($p < 0.05$). The statistical analysis was performed using the R software (www.r-project.org/).

The study was approved by the Ethics and Research Committee of Porto Alegre's Municipal Health Department (Number 4.419.620)

RESULTS

From 2018 to 2020, 10,109 hospital admissions were identified for children younger than 19 years of age due to the ARIs included in the study. There was a significant decrease in the mean incidence of all ARIs in 2020 compared to 2018 and 2019 (Table 1).

Table 1
Impact of non-pharmacological initiatives on the monthly incidence of ARIs in children, Porto Alegre, Brazil (2018 and 2019 vs 2020).

ARI	Mean (SD) 2018	Mean (SD) 2019	Mean (SD) 2020	Mean difference (95% CI), 2018–2020	P^* value	Mean difference (95% CI), 2019–2020	P^* value
Bronchiolitis	145.6 (112.9)	151.9 (127.1)	10.5 (5.3)	135.1 (118.3–151.8)	<0.001	141.4 (139.5–143.2)	<0.001
Asthma	33.4 (16.0)	31.6 (18.8)	10.9 (4.7)	22.5 (21.0–23.9)	<0.001	20.7 (18.9–22.4)	<0.001
Pneumonia	17.0 (8.2)	18.0 (8.9)	3.4 (2.1)	13.6 (12.2–14.9)	<0.001	14.6 (13.1–16.0)	<0.001
Acute bronchitis	16.2 (11.3)	19.8 (13.4)	4.1 (2.1)	12.1 (10.4–13.7)	<0.001	15.7 (13.7–17.6)	<0.001
Laryngotracheitis	3.1 (1.2)	3.0 (2.7)	0.63 (0.7)	2.4 (2.0–2.93)	<0.001	2.3 (1.3–3.3)	<0.001

ARIs: acute respiratory illnesses; SD: standard deviation; 95% CI: 95% confidence interval.
* *T* test.

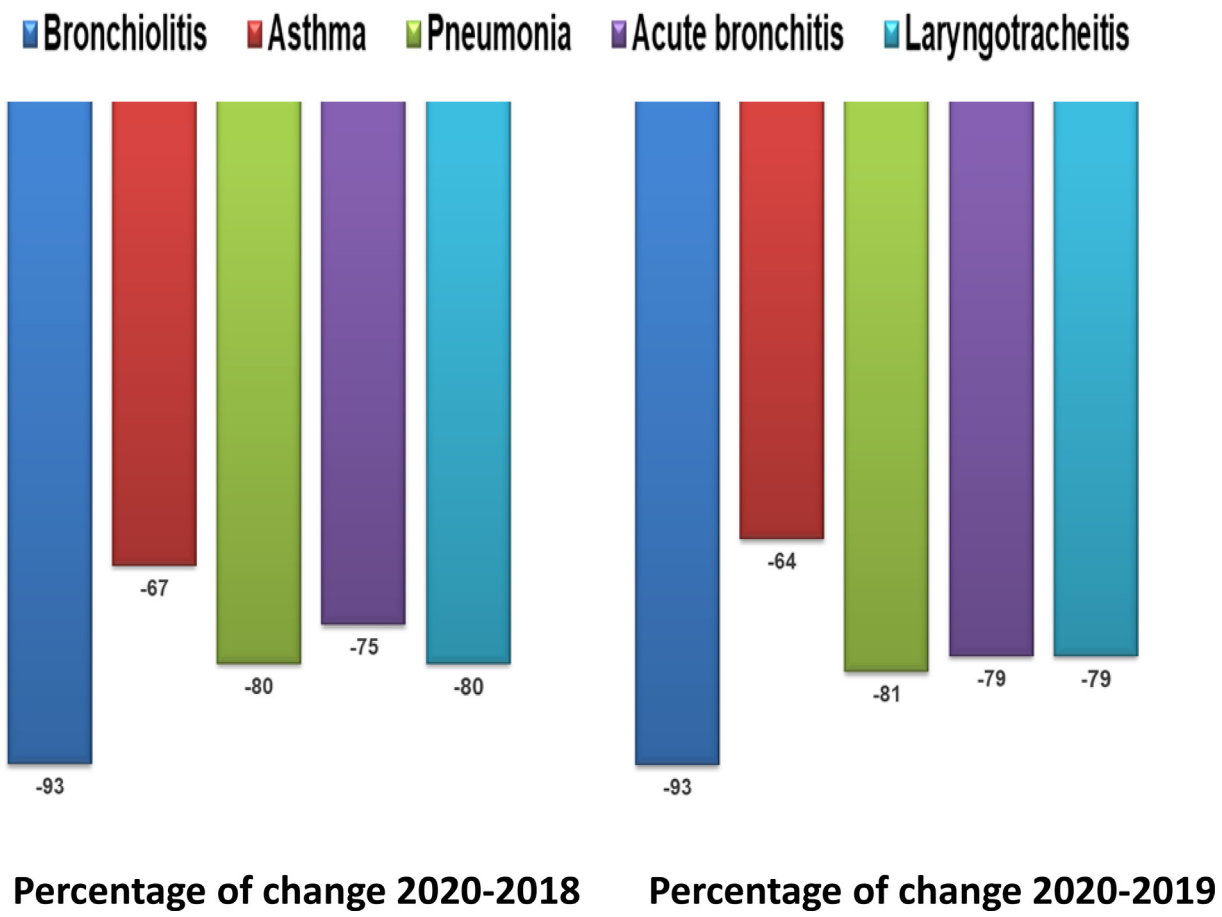

Fig. 1. Percentage change in hospitalizations due to acute respiratory illnesses in children < 19 years of age in Porto Alegre (2018 and 2019 vs 2020).

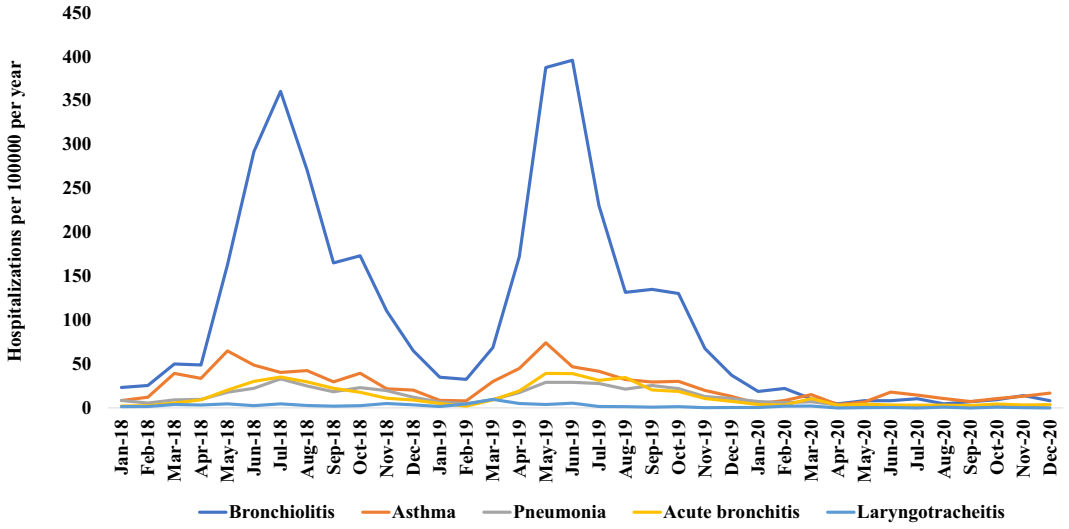

Fig. 2. Monthly distribution of incidence of hospitalizations for respiratory diseases in children < 19 years of age in Porto Alegre (2018–2020).

The percentage reduction in the incidence of hospitalizations for ARIs ranged from 64% for asthma to 93% for bronchiolitis (Fig. 1).

A secular trend in monthly admission rates due to ARIs was only observed for laryngotracheitis ($p = 0.485$), but seasonality was detected for all diseases (Fig. 2). In the univariate analysis, based on the monthly incidence of ARI admissions, the introduction of NPI was associated with a decrease in the incidence of all ARI admissions ($p < 0.001$) and this did not change when the model was adjusted for secular trend and seasonality (Table 1e and Table 2e in the online supplementary material).

The social distancing index (SDI) in Porto Alegre during 2020 was irregular throughout the months covered, with a median of 39% (ranging from 23% to 68.4%). Visually, the number of ARI admissions and the SDI showed opposing trends, with hospitalizations being lower when there was a high SDI and vice versa (Fig. 3).

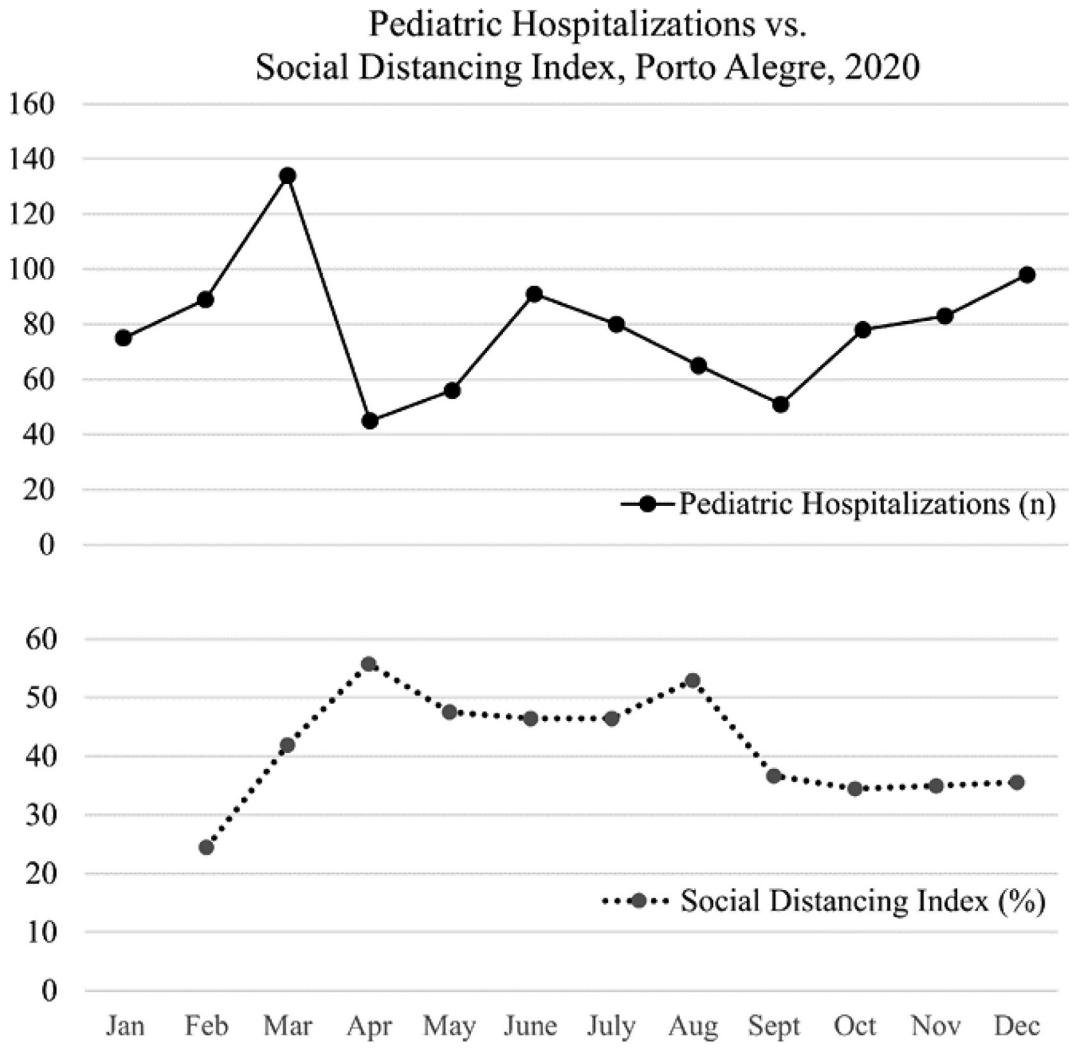

Fig. 3. Acute respiratory illness admissions and social distancing in 2020, Porto Alegre, Brazil.

The overall expenditures for ARIs in Porto Alegre were 76% and 77% less in 2020 compared to 2018 and 2019 respectively (Table 3e).

DISCUSSION

Our study found that non-pharmacological initiatives to deal with the COVID-19 pandemic were associated with an important decrease in hospital admissions due to pediatric acute respiratory illnesses in Porto Alegre.

This downward epidemiological shift in pediatric ARIs during the COVID-19 pandemic may be primarily explained by the routine implementation of NPIs, starting with simple hygiene and barrier measures to prevent the spread of respiratory pathogens [14]. Such measures were implemented in hospitals as well as other locations where infants and older children gather in groups, including day-care centers, preschools, and even schools. Adult social distancing was variable and generally lower than anticipated, which is not exclusive to Porto Alegre [8]. In any case, it was certainly higher among children, since daycare centers and schools remained closed throughout 2020, which reduced face-to-face interactions, hence, reducing the transmission of respiratory viruses and bacteria. The SDI is based on monitoring adults, but we found it was inversely related with pediatric ARI admissions (more distancing, less admissions; more admissions, less distancing), suggesting that adults contribute to the transmission of infectious agents to children. Also, hand washing, and the use of hand sanitizer, increased considerably in adults, as well as the use of masks in work environments and public spaces [14–16]. It is important to note that no single NPI alone led to this epidemiological shift. International groups tracking data on NPI use in several countries have found that best results are obtained when different initiatives are combined (HAIG, 2020).

The transmission of respiratory pathogens between humans occurs through direct or indirect contact, respiratory droplets, and fine-particle aerosols, which either enter the airways through breathing or by direct inoculation of other mucosal surfaces [17,18]. The lack of effective medications for treating COVID-19 is what led to the use of different forms of NPI [19–21]. Complete vaccine availability and coverage for most common respiratory viruses may not yet be feasible due to the challenges their biology represents. But, amidst the tragic worldwide implications of COVID-19, the 93% decrease in viral bronchiolitis cases, 80% decrease in pneumonia, and 70% decrease in asthma attacks clearly suggest that there are some lessons we could learn in terms of the epidemiology of ARIs.

First, we can curb the circulation of respiratory viruses in general if we adopt the basic approach used against COVID-19 with NPI. Even the seasonality of all ARIs included in the study radically

changed in Porto Alegre. Comparable findings along the same lines as our results have been found in other countries and continents [20,22–26]. Fewer children with ARIs visited emergency departments [22] and fewer children were hospitalized both in pediatric wards and in intensive care units [26]. On the other hand, other causes of hospitalization, such as urinary tract infections, showed no difference in numbers during 2020 compared to previous years [20]. This reinforces the greater usefulness of NPI for preventing ARIs.

Second, the adoption of NPI to minimize the spread of respiratory viruses should be enhanced within hospital premises as well as initiated and/or properly promoted in the community, in childcare and educational environments [16,27]. Hand washing and the regular use of rubbing alcohol can be reinforced at home and at the community level [28]. The use of face masks by adult caregivers, already ubiquitous before 2020 in many Asian countries, is both cost-beneficial and cost-effective and can be implemented in daycare centers during respiratory viral seasons [29], together with the segregation or proper distancing of sick children. Segregation may require rethinking the physical design of nurseries, preschools and schools, and personnel to re-engineer them, but the reduction in direct and indirect human costs would offset the costs of these changes [15]. The overall expenditures for ARIs in Porto Alegre were 76% in 2020 compared to 2018 and 2019.

Third, funding and legislation frameworks to support all of these measures and initiatives are required to organize, develop, implement, adjust, and audit them. Financial, political, and decision-making establishments must be involved together with healthcare authorities for the success of epidemiological measures.

Our study has some limitations. We retrospectively obtained the data from the city health department registry system. However, this is the official system used to collect and analyze data for public health measures, and it has been successfully in place for over a decade. We also did not have access to viral identification, which could provide a better picture of the impact the COVID-19 pandemic had on specific respiratory viruses. Nonetheless, all acute respiratory disorders showed a noticeable and consistent reduction in numbers, independent of the season, which suggests that all viruses were similarly affected.

CONCLUSIONS

Our study found a striking reduction in hospitalized cases of acute respiratory illnesses with the implementation of non-pharmacological initiatives used to prevent COVID-19. It also highlights the importance of non-pharmacological initiatives in aiming to reduce the rate of hospitalizations due to ARIs. Such preventive measures apply at both the community level, where human interaction is greater, and at the hospital level, where nosocomial transmission of viruses has greater direct consequences.

DIRECTIONS FOR FUTURE RESEARCH

- There was a significant reduction in hospital admissions due to ARIs in children as a result of NPI, but it needs to be studied how these interventions should be applied post pandemic.
- Further investigations are needed to confirm the real impact for each component of NPI in reducing the rate of hospitalizations due to ARIs.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Sabrina Chiapinotto: Conceptualization, Methodology, Data curation, Project administration, Writing - original draft. **Edgar E. Sarria:** Conceptualization, Methodology, Data curation, Project administration, Writing - original draft. **Helena T. Mocelin:** Methodology, Writing - original draft. **Rita Mattiello:** Methodology, Data curation, Writing - original draft. **João A.B. Lima:** Conceptualization, Data curation, Writing - original draft. **Gilberto B. Fischer:** Conceptualization, Supervision, Methodology, Project administration, Writing - original draft.

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 work reported in this paper.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.prrv.2021.04.003.

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