



# Social inequality and pneumonia hospitalization in children under five years of age in Maranhão, Brazil


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## Abstract

*Objectives:* to describe the characteristics of pneumonia hospitalizations in children under five years of age across the State of Maranhão, Brazil, and explore patterns of spatial distribution of admissions.

*Methods:* ecological study using data on occurrences (age, gender, skin color/race, month of occurrence, and municipality of residence) between 2012 and 2017 taken from the Unified Health System's Hospital Information System and municipal level socioeconomic indicators for 2010. Each respiratory disease, including pneumonia, was presented as a percentage of overall admissions for respiratory tract diseases, together with the monthly distribution of admissions as a percentage of total annual cases, and annual rate of admissions by gender. The General  $G^*$  statistic was calculated to identify significant clustering of municipalities with similar proportions of hospital admissions for pneumonia relative to overall hospital admissions.

*Results:* pneumonia was the leading cause of admissions for respiratory disease, accounting for 57% of all cases and occurring with greater frequency in the rainy season (February to June) and in cities with lower socioeconomic indicator values. The rate of admissions decreased over the study period. Significant clusters ( $p < 0.05$ ) of municipalities with high proportions of hospital admissions for pneumonia relative to overall hospital admissions occurred predominantly in the south of the state, while clusters with low proportions were located mainly in and around the metropolitan region of the state capital São Luís.

*Conclusions:* pneumonia was shown to be a key cause of hospitalization in children and its distribution was associated with contextual socioeconomic factors, reflecting the quality of life and health status of children in Maranhão.

**Key words** Hospitalization, Pneumonia, Child health, Development indicators, Social inequality



## Introduction

Pneumonia is the leading cause of hospital admissions in children under five years of age in middle and high-income countries,<sup>1,2</sup> with variations in magnitude by region, state, and city.<sup>1,3,4</sup> The occurrence of the disease is strongly associated with individual characteristics, physical and socioeconomic factors, and sanitation.

Hospital admissions for pneumonia are a sensitive marker of health care weaknesses and inadequate material living conditions and sanitation.<sup>3-5</sup> This is because pneumonia is one of the most readily solvable public health problems in global health terms<sup>3,6,7</sup> and therefore should not present such a large volume of cases and admissions.<sup>3</sup> Incidence is associated with poor social organization, health system inefficiencies, low levels of social development, high income inequality, and social vulnerability.<sup>3,5,8</sup>

Childhood pneumonia is largely related to poverty, inadequate vaccination coverage, outdoor air pollution from burning biomass, indoor pollution from burning firewood for cooking,<sup>3,6,9</sup> and street dust and dust from agricultural activities.<sup>9</sup> It can also be related to malnutrition, poor care practices, lack of proper sanitation, low country education levels, lack of experience of caring for children, and active and passive smoking among family members.<sup>1,5</sup> These factors are aggravated by lack of social and health services and actions and climatic variations.<sup>10</sup>

Children under five years of age are repeatedly exposed to infection by viruses and bacteria. Acute respiratory infections caused by these agents remain the most frequent causes of morbidity and mortality among this group, accounting for around two million deaths per year and 70% of all outpatient cases and hospitalizations worldwide.<sup>1,2,5</sup> Globally, pneumonia accounts for 18% of all deaths of children under five years of age.<sup>2</sup>

The prevalence of pneumonia in this age group is around five times greater in developing countries than in developed countries. Brazil stands out as being one of the 15 countries with the highest incidence of this disease in children under five years of age.<sup>11</sup> Data from the country's national health information system, DATASUS, show that this age group accounted for one-third of all hospital admissions for pneumonia (1,277,196 cases) between 2012 and 2017. The Northeast Region was home to the second largest proportion of cases in the country, with 27.6% of all cases, 15.5% of which occurred in the State of Maranhão, occupying second place in the region and eighth place overall among Brazil's

states.<sup>12</sup>

Studies show that social and health inequalities are deeper in Maranhão than in the rest of Brasil.<sup>13-15</sup> Striking differences remain between regions, with some of the state's cities presenting socioeconomic indicators similar to those of countries like Haiti, Laos, Yemen, and Madagascar.<sup>14,15</sup> These precarious material living conditions adversely affect the health of vulnerable and disadvantaged groups such as children.<sup>13</sup>

Studies in other Brazilian states<sup>1,10,11,16,17</sup> have described the characteristics of hospitalizations for pneumonia in children and their relation with socioeconomic and contextual indicators. However, this type of study has yet to be conducted in the State of Maranhão, meaning that there is a lack of knowledge about the dynamics of the occurrence of pneumonia and its spatial distribution. The aim of the present study was therefore to describe the epidemiological characteristics of hospital admissions for pneumonia in children under five years of age in the State of Maranhão and explore patterns of spatial distribution of hospitalizations.

## Methods

An exploratory ecological study was conducted using time series datasets of registered hospital admissions for pneumonia in children under five years of age in the State of Maranhão between 2012 and 2017. A total of 293,608 hospitalizations of children under five years of age were registered during this period, 54,651 of which were related to pneumonia.

Information on admissions (age group, gender, color/race, month of occurrence, and municipality of residence) in the last five years was collected in May 2018 from the online database of the Unified Health System's Hospital Information System (SIH/SUS).<sup>12</sup> In addition, we also considered the Human Development Index (HDI), Gini coefficient, and Social Vulnerability Index (SVI) of each of Maranhão's 217 municipalities in 2010,<sup>14,15</sup> the latest year for which disaggregated municipal level data is available,<sup>12,15</sup> to provide an overview of well-being, living conditions, and socioeconomic status in these municipalities.<sup>12,15,18</sup> Values range between 0 and 1, where SVI and Gini values closer to 1 indicate greater vulnerability/inequality and HDI values closer to 1 indicate higher levels of human development. Frequencies of pneumonia were presented according to the following parameters based on cut-off points established by the literature<sup>12,15,18</sup>: HDI - low, medium, and high; Gini - low and extreme; and

SVI- low, medium, and high.

Each respiratory disease, including pneumonia, was presented as a percentage of overall admissions for respiratory tract diseases. We also identified the monthly distribution of admissions as a percentage of total annual cases and annual rates of admissions by gender. A map was produced to identify significant spatial clustering of high and low proportions of hospital admissions for pneumonia relative to overall hospital admissions using the General  $G^*$  statistic, which represents the spatially weighted z-score. The results of the analysis are interpreted within the context of the null hypothesis, which states that there is no spatial clustering of feature values.<sup>19</sup>

To calculate the General  $G^*$  statistic, we created weights for each municipality based on their relationship with their nearest neighbors (neighbor matrix, Queen spatial matrix).<sup>17</sup> We then examined the segregation between cities in the formation of significant clusters of proportions of hospital admissions for pneumonia relative to overall hospital admissions, considering the significance level on both sides of an assumed normal distribution. This allowed us to observe any significant spatial clustering of high, positive ( $p < 0.05$ ) and low, negative ( $p < 0.05$ ) segregation scores<sup>17</sup> for admissions for pneumonia in comparison to what would be expected from a random distribution of these frequencies. Other authors have used the General  $G^*$  statistic for similar purposes.<sup>20</sup> The analysis was performed using GeoDa.

This study was conducted using freely accessible online data containing non-confidential information, thus dismissing the need for approval by an ethics committee, and in accordance with the norms and standards set out in Resolution 466 of 12/12/2012 published by the National Health Council.

## Results

There were 54,651 hospital admissions for pneumonia in children under five years of age in Maranhão between 2012 and 2017, accounting for 18.6% of all admissions in this age group during this period. Pneumonia was the leading cause of admissions for respiratory disease, accounting for 57% of all cases (Figure 1). The children admitted to hospital for pneumonia were predominantly male (55.1%), aged one to four years (65.1%), and brown (49.9%). It is worth noting that color/race was ignored in 42.4% of admissions. The frequency of admissions showed a downward trend between 2013 and 2016, falling from 20.1% to 11.6%, before rising

to 14.9% in 2017. Almost 100% of admissions occurred in cities with medium HDI and extreme income inequality (Gini index). The proportion of hospital admissions for pneumonia relative to overall hospital admissions increased with increasing social vulnerability, from 29.1% in cities with medium SVI to 66% in cities with high SVI (Table 1).

Temporal variations in the occurrence of pneumonia throughout the study period were also analyzed. While hospital admissions occur throughout the whole year, admissions were proportionally greater between February and March, showing peaks between March and May (Figure 2).

The rate of admissions per 1,000 inhabitants fell during the study period and was greater in boys than in girls. The overall rate in 2012 was 13/1,000 inhabitants (14.3/1,000 inhabitants in boys *versus* 11.8/1,000 inhabitants in girls). Rates fell to their lowest level in 2016 (overall= 9.6/1,000 inhabitants, boys= 10.4/1,000 inhabitants, girls= 8.7/1,000 inhabitants), before rising once again in 2017, reaching levels similar to those observed in 2012 (overall= 12.5/1,000 inhabitants, boys= 13.3/1,000 inhabitants, girl = 11.6/1,000 inhabitants) (Figure 3).

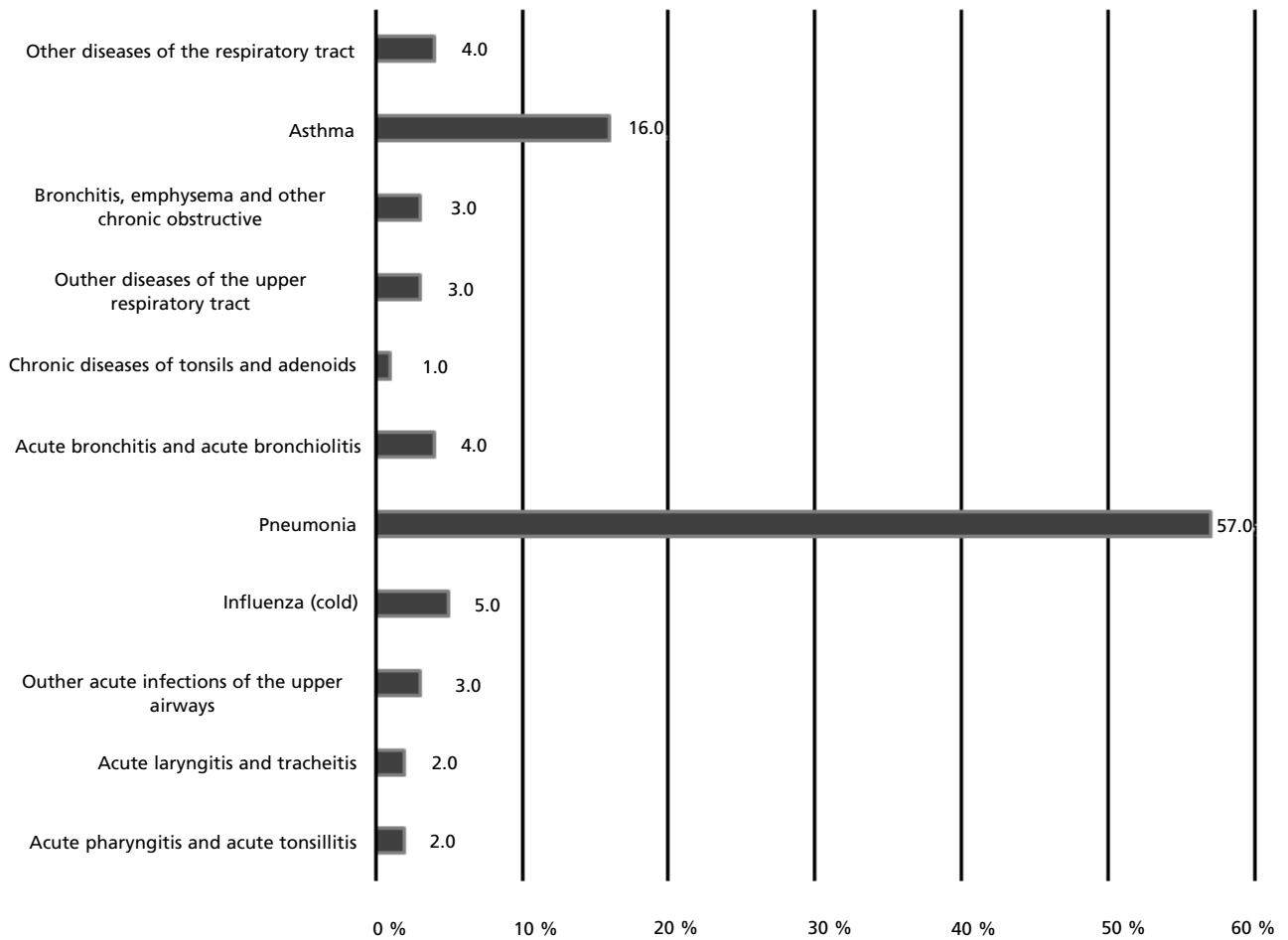
The spatial analysis showed significant clusters of high, positive ( $p < 0.05$ ) and low, negative ( $p < 0.05$ ) segregation scores for admissions for pneumonia. Clusters of municipalities with higher proportions of hospital admissions for pneumonia relative to overall hospital admissions occurred predominantly in the south of the state (17 cities), while those with lower proportions were located mainly in around the metropolitan region of the state capital São Luís (14 cities). The remaining 186 cities did not show any significant deviation from the average proportion of hospital admissions for pneumonia relative to overall hospital admissions for pneumonia in the state (Figure 4).

## Discussion

The findings show that pneumonia remains the main cause of hospital admissions among children in Maranhão, accounting for over a half of all admissions for respiratory diseases over the study period. Children aged between one to four years, boys, and brown children accounted for the highest proportion of cases, with the frequency and rate of admissions showing a downward trend throughout the study period. The monthly distribution of admissions as a percentage of total annual cases was constantly above 5%, rising between February and June, before gradually falling towards December. The peak months of occurrence indicate a seasonal distribu-

Figure 1

Hospital admissions for respiratory diseases in children under five years of age in the State of Maranhão, Brazil. 2012 to 2017.



tion trend coinciding with and aggravated by the rainy season, followed by a fall in rates and stabilization in the dry season, suggesting the need to address this health problem throughout the year.

Other studies have described seasonal patterns in hospital admissions for pneumonia,<sup>1,2,9</sup> with explanations varying depending on the region. In the center-west<sup>1</sup> and southeast<sup>9</sup> regions of Brazil, for example, incidence is greater between May and September, during the dry season, when low precipitation and humidity hinders the dispersion of pollutants, compromising air quality and facilitating the spread of pneumonia.<sup>1,9</sup> In contrast, the present study showed that incidence was greater in the rainy season, when children are more susceptible to influenza infection, which can precede bacterial pneumonia,<sup>1</sup> especially in socially deprived areas

with poor sanitation.

The data presented reveal that the proportion of hospital admissions for pneumonia relative to overall hospital admissions is greater in cities with higher levels of social inequality and the spatial analysis showed significant clustering of high and low proportions of hospital admissions for pneumonia relative to overall hospital admissions. Studies conducted in other regions of Brazil<sup>1,6,7,21-23</sup> have reported a lower prevalence of cases of pneumonia than the present study. The excess of preventable hospitalizations in Maranhão draws attention to the poor accessibility and quality of health services, sanitation facilities, and social and economic infrastructure in the state in relation to states in richer regions. Areas with high prevalence of cases should therefore be the focus of government actions to

**Table 1**

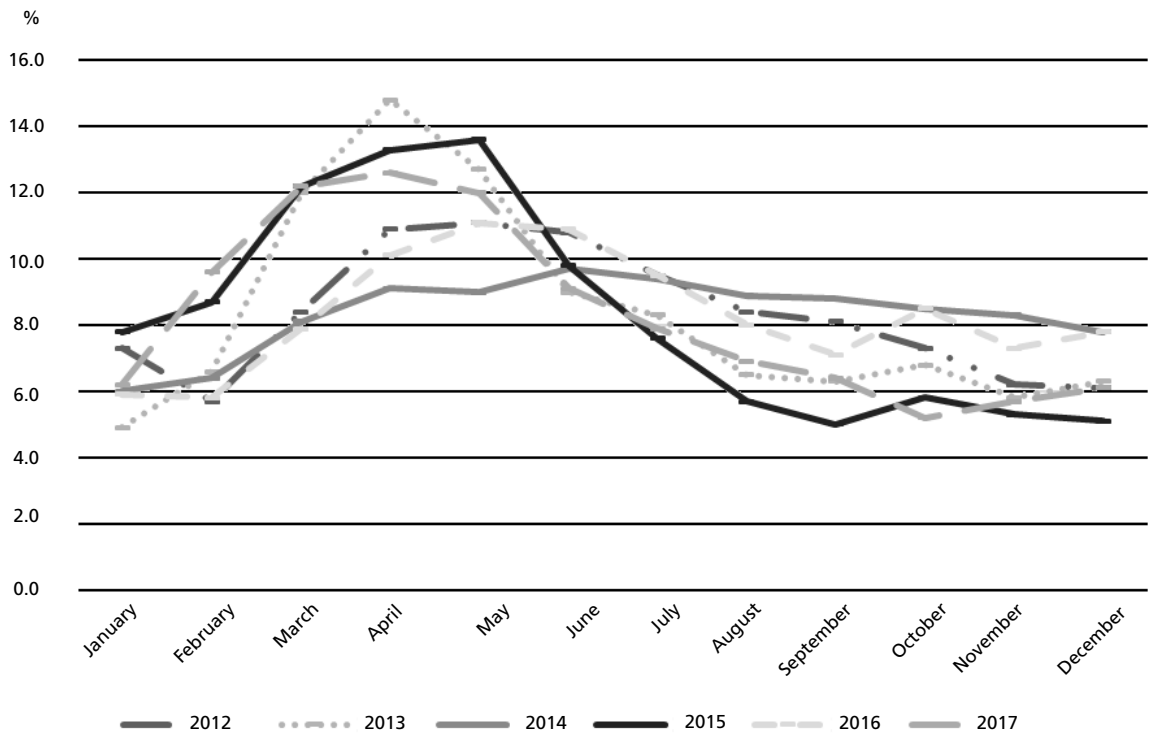
Social and demographic characteristics of hospital admissions for pneumonia in children (n = 54,651) under five years of age in the State of Maranhão, Brazil. 2012 to 2017.

Characteristics	Hospital admissions	
	n	%
Age group (years)		
0 to 1	19,077	34.9
1 to 4	35,574	65.1
Gender		
Male	30,083	55.1
Female	24,568	44.9
Color/race		
White	2,450	4.5
Black	417	0.7
Brown	27,242	49.9
Yellow	232	0.4
Indigenous	1,125	2.1
Without information	23,185	42.4
Year of admissions		
2012	9,727	17.8
2013	10,974	20.1
2014	10,524	19.3
2015	8,961	16.4
2016	6,336	11.6
2017	8,129	14.9
Human Development Index (HDI)*		
Low	207	0.4
Medium	54,444	99.6
High	0	0.0
Gini** (income inequality)		
Low	1,202	2.2
Extreme	53,449	97.8
Social Vulnerability Index (SVI)***		
Low	2,682	4.9
Medium	15,883	29.1
High	36,086	66.0

\* HDI level: low (0.5), medium (0.5 a 0.8), and high (>0.8); \*\*Gini index level: low (<0.5) and extreme (≥0.5); \*\*\*SVI level: low (0 to 0.300), medium (0.301 to 0.400), and high (0.401 a ≥0.501).

**Figure 2**

Temporal variation of hospital admissions for pneumonia (n = 54,474) in children under five years of age in the State of Maranhão, Brazil. 2012 to 2017.



**Figure 3**

Rate of hospital admissions for pneumonia in children (n= 54,651) under five years of age in the State of Maranhão, Brazil. 2012 to 2017.

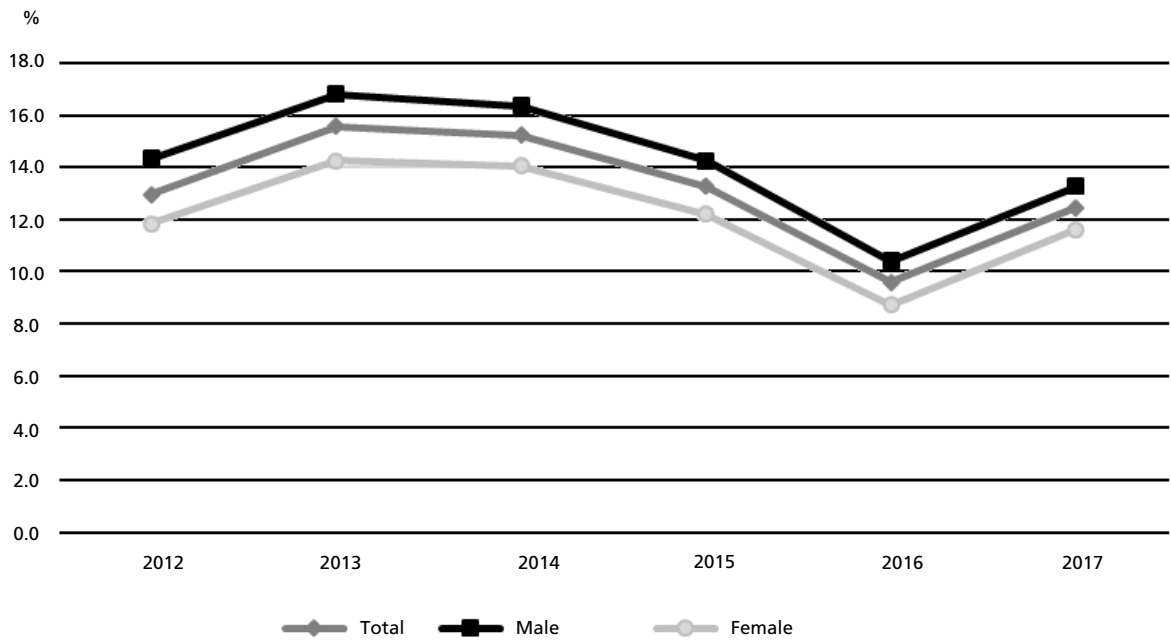
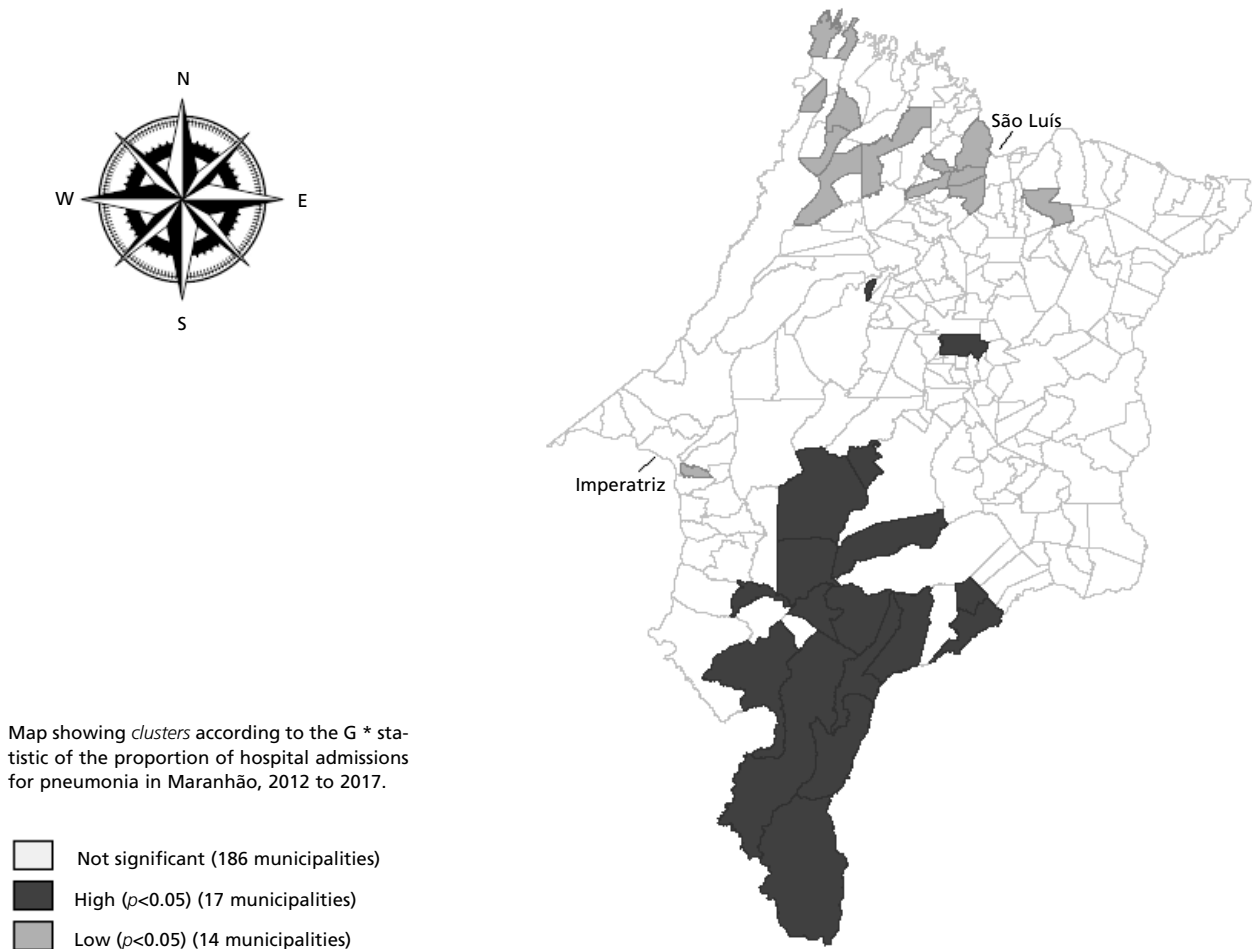


Figure 4

Clusters measured using the General G\* statistic for the proportion of hospital admissions for pneumonia relative to overall hospital admissions in children under five years of age between neighboring municipalities in the State of Maranhão, Brazil. 2012 to 2017.



improve sanitation infrastructure and healthcare services for pneumonia.

Previous studies have shown that pneumonia severity in children treated in hospitals is associated with the fact that they are from small towns in areas isolated from large urban centers, where early diagnosis and adequate medical intervention is hindered by lack of health facilities and funding.<sup>7,22</sup> Studies have also shown an increase of 80% in the occurrence of pneumonia in deprived areas in comparison to better off areas,<sup>1</sup> indicating that poor living conditions and hygiene are key risk factors for pneumonia.

Our findings show that the rate of admissions for pneumonia fell between 2012 and 2016, before rising in 2017 to rates similar to those observed at the beginning of the study period. One possible explanation for this is the implementation of the national level *Projeto Mais Médicos* (More Doctors

Project), which began in 2013,<sup>24</sup> and the program Força Estadual de Saúde do Maranhão<sup>25</sup> (State of Maranhão Health Force). These interventions increased the number of doctors and multi-professional health teams working in the state's primary health services, improving access to consultations and, possibly, the quality of outpatient care, thus reducing admissions for ambulatory care-sensitive conditions. With respect to the seemingly isolated increase in 2017, it is too early to speculate whether it represents an upward trend over coming years.

Studies in other northeastern states<sup>16,17</sup> indicate that powerful cost-effective actions developed under the Family Health Strategy (FHS) can reduce the occurrence of pneumonia in children under five years of age,<sup>5,6,16,17,21</sup> even in municipalities with poor sanitation facilities and social and economic infrastructure. This is partially explained by the fact

that children registered in the FHS have similar access to consultations with doctors and other health professionals as those who are not registered, who generally have health insurance and better living standards.<sup>26</sup> The FHS therefore has the capacity to reduce inequalities that adversely impact children's health, facilitating access to health services even among disadvantaged groups.<sup>26</sup>

Study limitations include the study design and the fact that information was collected from the online database of the Unified Health System's Hospital Information System, meaning that the study only encompassed hospitalizations in public health services, excluding admissions to private services, which are not captured by DATASUS. Poor municipalities with less effective health systems are likely to have a lower capacity to register cases, leading to underreporting and classification errors. It is therefore possible that the spatial analysis failed to reveal clusters of cities in areas of the state where they would normally be expected, leading to the identification of clusters of low proportions of hospital admissions for pneumonia relative to overall hospital admissions in areas in which high proportions would be expected.

It is also possible that part of the admissions attributed to pneumonia were actually due to asthma. Children with asthma may have short hospital stays and sometimes asthma is mistakenly classified as pneumonia in the patient's medical records, leading to misclassification bias. However, this does not have an impact on the interpretation of the characteristics associated with pneumonia. Another important point is outpatient treatment of pneumonia. Doctors may believe that families with higher socioeconomic status, more time, and greater social support are better able to manage the symptoms of pneumonia at home, meaning that these cases are

excluded from the sample and leading to selection bias. Finally, it is possible that the increase in the rate of admissions in 2017 is due to improvements in the quality of the registration of cases in the SIH/SUS, leading to a reduction in underreporting. However, the analysis of trends in admission rates after 2017 depends on the availability of data. Despite these limitations, the findings of this study provoke reflection, suggesting that pneumonia is a key cause of potentially preventable deaths in early childhood in Maranhão, given that admissions affect a significant proportion of children using public health services.

This study shows that admissions for pneumonia are the leading cause of hospitalization in children under five years of age in Maranhão, accounting for approximately one-fifth of overall admissions and 57% of admissions for respiratory diseases. The findings show that there are risk factors for the development of the disease and that its distribution across the state may be associated with socioeconomic factors and sanitation, reflecting the quality of life and health status of children in Maranhão. These findings reinforce the need to better organize services and develop actions to meet children's healthcare needs.

### Authors' contribution

Gaspar MAR and Soares FA contributed to study conception and the drafting of this article. Barros PHS and Costa ASV collected the data and participated in the discussion of the results. Oliveira BLCA participated in data analysis, the discussion of the results, and in the critical revision of the manuscript. All authors approved the final version of the manuscript.

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