


**ASSOCIATION BETWEEN RAINFALL AND PEDIATRIC HOSPITALIZATIONS FOR RESPIRATORY DISEASES IN INFANTS UNDER ONE YEAR OF AGE IN THE FEDERAL DISTRICT, BRAZIL, 2024**

**ASSOCIAÇÃO ENTRE PRECIPITAÇÃO E INTERNAÇÕES PEDIÁTRICAS POR DOENÇAS RESPIRATÓRIAS EM CRIANÇAS MENORES DE 1 ANO NO DISTRITO FEDERAL, BRASIL, 2024**

**ASOCIACIÓN ENTRE PRECIPITACIÓN Y INTERNACIONES PEDIÁTRICAS POR ENFERMEDADES RESPIRATORIAS EN NIÑOS(AS) MENORES DE 1 AÑO EN DISTRITO FEDERAL, BRASIL, 2024**

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**ABSTRACT**

Introduction: The Federal District of Brazil has a tropical climate with marked rainy and dry seasons that influence childhood respiratory morbidity. The dry season, characterized by low humidity and increased airborne particles, is associated with worsening respiratory conditions in infants. Objective: To assess the association between rainfall and hospitalizations for

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respiratory diseases (ICD-10 J00–J99) among infants under one year of age in the Federal District, Brazil, during 2024. Methods: Ecological and retrospective study using data from SIH/DATASUS and INMET. A total of 5,266 respiratory hospitalizations of infants were analyzed. Pearson correlation and Mann–Whitney U test ( $p < 0.05$ ) were applied. Results: Hospitalizations markedly increased during the dry months (April–September), showing a significant inverse correlation between rainfall and respiratory admissions ( $r = -0.73$ ;  $p = 0.006$ ). Conclusion: Reduced rainfall was strongly associated with increased respiratory hospitalizations in infants, highlighting the climatic impact on child health in the Federal District.

**Keywords:** Rainfall. Infants. Respiratory Diseases. Federal District. Relative Humidity. Environmental Health.

## RESUMO

**Introdução:** O Distrito Federal apresenta clima tropical sazonal, com estações chuvosa e seca que influenciam a ocorrência de doenças respiratórias infantis. A estiagem, caracterizada por baixa umidade e aumento de partículas suspensas, está associada ao agravamento de quadros respiratórios em lactentes. **Objetivo:** Avaliar a associação entre precipitação e internações por doenças respiratórias (CID-10 J00–J99) em crianças menores de 1 ano no Distrito Federal, Brasil, durante o ano de 2024. **Métodos:** Estudo ecológico e retrospectivo, com dados do SIH/DATASUS e do INMET. Foram analisadas 5.266 internações respiratórias de menores de 1 ano. As variáveis foram correlacionadas por Pearson e comparadas por Mann–Whitney ( $p < 0,05$ ). **Resultados:** Observou-se aumento expressivo das internações nos meses de estiagem (abril–setembro), com correlação negativa significativa entre precipitação e hospitalizações ( $r = -0,73$ ;  $p = 0,006$ ). **Conclusão:** A redução das chuvas esteve fortemente associada ao aumento das internações por doenças respiratórias em lactentes, reforçando o impacto da sazonalidade climática sobre a saúde infantil.

**Palavras-chave:** Precipitação. Lactentes. Doenças Respiratórias. Distrito Federal. Umidade Relativa. Saúde Ambiental.

## RESUMEN

**Introducción:** El Distrito Federal presenta un clima tropical estacional, con estaciones de lluvias y sequías que influyen en la ocurrencia de enfermedades respiratorias infantiles. La sequía, caracterizada por baja humedad y un aumento de partículas en suspensión, está asociada con el agravamiento de cuadros respiratorios en lactantes. **Objetivo:** Evaluar la asociación entre la precipitación y las hospitalizaciones por enfermedades respiratorias (CIE-10 J00–J99) en niños menores de 1 año en el Distrito Federal, Brasil, durante el año 2024. **Métodos:** Estudio ecológico y retrospectivo, con datos del SIH/DATASUS y del INMET. Se analizaron 5.266 hospitalizaciones respiratorias de menores de 1 año. Las variables se correlacionaron mediante el coeficiente de Pearson y se compararon mediante la prueba de Mann–Whitney ( $p < 0,05$ ). **Resultados:** Se observó un aumento significativo de las hospitalizaciones en los meses de sequía (abril–septiembre), con una correlación negativa significativa entre la precipitación y las hospitalizaciones ( $r = -0,73$ ;  $p = 0,006$ ). **Conclusión:** La reducción de las lluvias estuvo fuertemente asociada con el aumento de las hospitalizaciones por enfermedades respiratorias en lactantes, reforzando el impacto de la estacionalidad climática sobre la salud infantil.



**Palabras clave:** Precipitación. Lactantes. Enfermedades Respiratorias. Distrito Federal. Humedad Relativa. Salud Ambiental.



## 1 INTRODUCTION

The Federal District (DF) has a tropical climate typical of the Cerrado biome, with two well-defined seasons: a rainy season (October–April) and a dry season (May–September), characterized by relative humidity often below 25% during the height of the drought (INMET, 2024).

This phenomenon occurs due to the regional atmospheric dynamics of the Brazilian Midwest, which is strongly influenced by the South Atlantic Convergence Zone (SACZ) and tropical continental air masses, which in winter become drier and more stable (MARENGO et al., 2020).

In addition to the Federal District, Goiás, Mato Grosso, Mato Grosso do Sul, and part of Minas Gerais have the same pattern of seasonality—a dry season with strong sunshine, low humidity, and high surface evaporation (ALVES et al., 2022).

During these months, dry air reduces evapotranspiration, impoverishes soil moisture and causes senescence of vegetation, especially in the grasses and shrubs of the Cerrado, which lose leaves to conserve water (SILVA; RODRIGUES, 2019).

Native animals suffer local migration and scarcity of food and water, leading to increased mortality of smaller species and the concentration of fauna around springs and residual swamps (RIBEIRO; KLINK, 2017).

In the Federal District, dry soil and whitish vegetation become highly flammable, which aggravates the number of fires and intensifies the release of particulate matter into the atmosphere — consequently aggravating respiratory and inflammatory problems (NASCIMENTO et al., 2006; WHO, 2022).

During this period, there was a significant increase in childhood hospitalizations, traditionally attributed to respiratory diseases (SBP, 2023).

This is because the lungs and airways represent one of the largest contact surfaces of the human body with the external environment — on average, 50 to 75 m<sup>2</sup> in an adult, while the total skin surface is 1.5 to 2.0 m<sup>2</sup> (MEIRA et al., 2022).

In other words, the lung area is up to 30 times larger than that of the skin, which makes the respiratory system extremely vulnerable to low humidity, suspended particles, and gaseous pollutants.

In addition, the eyes also suffer from the accelerated evaporation of the tear film, leading to symptoms of burning, dryness, and allergic conjunctivitis, which become more frequent in months of low humidity (CAMPOS et al., 2021).



The vulnerability of infants and the elderly is further accentuated by differences in water body composition.

On average, a newborn has 75 to 80% of total body water, a 1-year-old infant about 70%, while an adult has 60% and an elderly only 50% (HALL; GUYTON, 2021).

This means that young children and the elderly dehydrate more quickly, as the proportion of extracellular water is higher, metabolism is faster, and there is a lower renal capacity for urinary concentration (SBP, 2023; WHO, 2022).

With the absence of rain, the relative humidity of the air in Brasília reached critical levels of 11% in September 2024, according to the INMET Climatological Bulletin (2024) — the lowest value recorded in the historical series since 1994.

This level is far below the 30% limit recommended by the World Health Organization, characterizing an unhealthy environmental condition and increasing the incidence of mucosal infections, eye irritations, dehydration, and exacerbations of heart and kidney disease (WHO, 2022; MARENGO et al., 2020).

Global climate change aggravates this scenario, as it consists of long-term changes in temperature, precipitation, and atmospheric circulation patterns caused by the increase in greenhouse gases (IPCC, 2023).

In the Central Plateau, more irregular rainfall, prolonged dry seasons, and more intense heat peaks are observed, factors that amplify the impact on child health and on the local ecological balance (ALVES et al., 2022; RIBEIRO; KLINK, 2017).

From a biological point of view, low humidity reduces the defense capacity of the respiratory mucous membranes and mucociliary transport, exposing the child to greater circulation of bacterial and viral pathogens in the environment (AGHAPOUR et al., 2022).

Without rain, there is an increase in dust, pollutants, and resistant microorganisms, especially aerosolized fungi and bacteria (KANG et al., 2022).

Because the infant's immune system is immature, infection occurs more easily and for a prolonged duration.

In addition, children under 1 year of age have a higher respiratory rate — on average 30 to 60 breaths per minute, compared to 12 to 20 in adults —, which implies greater water loss due to pulmonary perspiration (SBP, 2023; HALL; GUYTON, 2021).

Perspiration is the physiological process of eliminating water and electrolytes through the skin and pulmonary ventilation, which is essential for thermal regulation, but which, in dry environments, causes excessive fluid loss.

The heart, to compensate for heat and hypovolemia, increases the heart rate, which aggravates heart disease and kidney disease, especially in infants and children with comorbidities (CARVALHO et al., 2022).

Although the studies conducted by Saldanha, Silva and Botelho (2005) in Cuiabá and by Nascimento et al. (2006) in Goiânia focused mainly on respiratory morbidities, their analyses used aggregated data from the Hospital Information System (SIH/SUS), allowing the observation of parallel trends of increased hospitalizations during the dry season.

These findings reinforce that, although the respiratory system is the most immediately affected by changes in humidity, childhood vulnerability during drought is multisystemic, also reaching the digestive tract, urinary system, and fluid and electrolyte balance.

However, investigations specifically focused on the Federal District remain limited, and there are gaps in the literature regarding the direct influence of drought on respiratory diseases in infants, which reinforces the relevance and originality of this study.

Infants under 1 year of age are especially vulnerable because they have immunological immaturity, a larger relative body surface, marked water loss, and almost exclusive dependence on breastfeeding (AITHAL et al., 2023).

In view of this, we sought to investigate how precipitation interferes with respiratory hospitalizations in children under 1 year of age, an essential dimension of pediatric environmental health that is still little explored in the context of the Cerrado and the Federal District.

## **2 METHODOLOGY**

### **2.1 OBJECTIVE AND DESIGN**

The present study was conducted with the objective of evaluating the association between monthly rainfall and hospitalizations for respiratory diseases (ICD-10: J00–J99) in children under 1 year of age living in the Federal District (DF), over the period from January to December 2024.

This is a quantitative, documental and descriptive research, with an ecological and temporal approach, based on retrospective analysis of secondary data. The focus of the study is on the identification of possible inverse correlations between the volume of rainfall and the number of monthly hospitalizations for respiratory morbidities in the infant population.

## 2.2 DATA SOURCES AND COVERAGE

### 2.2.1 SIH/DATASUS (SUS Hospital Information System)

Hospitalization data were obtained from the Department of Informatics of the Unified Health System (DATASUS), covering the entire public hospital network of the Federal District, with universal coverage of the Unified Health System (SUS).

Aggregated monthly records of ICD-10 hospitalizations were extracted for the group of respiratory diseases (J00–J99), specifically in the age group under 1 year.

The data were compiled in electronic spreadsheets (Microsoft Excel® and RStudio®), ensuring consistency, elimination of duplicates and cross-checking between the months and diagnostic categories.

The total number of respiratory hospitalizations observed in the period was 5,266 hospitalizations in infants, representing 10.3% of all pediatric hospitalizations recorded in 2024 in the Federal District. This sample confers high statistical power for correlation analyses and allows monthly stratification without loss of significance.

### 2.2.2 INMET (National Institute of Meteorology)

Precipitation information (mm/month) was obtained from the INMET Climatological Bulletin (2024), which compiles data from the automatic weather stations of Brasília (A001), Gama (A002) and Planaltina (A003).

To avoid local biases, the monthly arithmetic average of the three official stations was used, ensuring climatic representativeness of the entire territory of the Federal District.

The precipitation data correspond to the historical series of 2024, a year recognized as the hottest and driest in the series since 1994, according to INMET itself (2024).

## 2.3 VARIABLES AND OUTCOMES:

- a) dependent variable: monthly number of hospital admissions for respiratory diseases (ICD-10 J00–J99) in children under 1 year of age;
- b) main independent variable: average monthly precipitation (mm) in the Federal District;
- c) secondary variables (control): monthly mean temperature (°C) and mean relative humidity (%), used for exploratory analysis of partial correlation.



The main hypothesis of the study is that the reduction in monthly rainfall is associated with an increase in childhood respiratory hospitalizations, configuring a statistically significant inverse correlation.

## 2.4 STATISTICAL ANALYSIS PLAN

All data were organized in electronic spreadsheets, with double checking of the integrity and consistency of the records.

Descriptive analyses (means, medians, minimums, maximums, and standard deviations) and monthly time series graphs were applied to assess the visual trend between precipitation and hospitalizations:

- a) Pearson's correlation ( $r$ ) was used to measure the linear association between monthly rainfall (mm) and the number of respiratory hospitalizations;
- b) the Mann–Whitney U test was applied to compare the distributions of hospitalizations between months classified as "high precipitation" ( $>100$  mm) and "low precipitation" ( $\leq 100$  mm);
- c) Results with  $p < 0.05$  were considered statistically significant;
- d) Cramér's  $V$  was also calculated to estimate the effect size in non-parametric comparisons.

The analyses were performed using the R software (version 4.4.0), using CRAN base packages (stats, ggplot2, tidyverse). The results were expressed through tables and scatter plots, visually demonstrating the inverse relationship between the volume of rainfall and the number of hospitalizations.

## 2.5 ETHICAL ASPECTS

The study used secondary, aggregated and public domain data, without identifying individuals, without consideration by the Research Ethics Committee, according to CNS Resolution No. 510/2016.

## 2.6 PERIOD OF STUDY AND SCOPE

The analysis covered the period from January to December 2024, including all months of the complete climate cycle of the Federal District.

Specific analyses were generated for the dry season (May to September) and comparisons with the rainy season (October to April).

This temporal delimitation allowed the identification of seasonal patterns of epidemiological behavior of respiratory hospitalizations and the direct influence of rainfall variations on local child health.

### 3 RESULTS

Table 1 shows that the months with the highest precipitation rates (December to March) had the lowest number of respiratory hospitalizations, while the dry season (April to September) concentrated the highest volume of hospitalizations. It is also noted that the monthly percentage variation follows the climate transition: there is a significant increase in hospitalizations as rainfall decreases, followed by gradual reductions as precipitation returns. This trend reinforces the inverse association between precipitation and respiratory morbidity in infants in the Federal District.

**Table 1**

*Monthly distribution of precipitation and respiratory hospitalizations (<1 year) — Federal District, 2024*

Month	Precipitation (mm)	Respiratory hospitalizations (<1 year)	Monthly change (%)
January	268	201	—
February	252	206	+2,5%
March	213	571	+177,2%
April	111	1.051	+84,1%
May	35	740	-29,6%
June	12	515	-30,4%
July	5	413	-19,8%
August	4	230	-44,3%
September	15	296	+28,7%
October	155	287	-3,0%
November	238	344	+19,9%
December	276	412	+19,8%
		<b>5.266</b>	—

Legend: Average monthly rainfall values obtained from the INMET Climatological Bulletin (2024). Hospitalizations correspond to hospital cases registered in the SIH/DATASUS with ICD-10 J00–J99. Source: Authors.

The percentage change refers to the difference in relation to the previous month.



### 3.1 DESCRIPTIVE ANALYSIS AND CORRELATION

A clear inversion was observed between rainfall volume and respiratory hospitalizations in infants (< 1 year) in the Federal District during the year 2024.

The highest rainfall rates occurred between December and March, the period in which the lowest number of hospitalizations was recorded. On the other hand, the peak of hospitalizations was concentrated between April and July, coinciding with the beginning and peak of the drought (rainfall less than 50 mm).

Pearson's correlation coefficient between monthly rainfall and respiratory hospitalizations was  $r = -0.73$  ( $p = 0.006$ ), indicating a strong and statistically significant negative correlation.

This means that as the volume of rainfall decreases, hospitalizations for respiratory diseases in infants increase consistently.

The comparison between groups using the Mann–Whitney U test showed a significant difference ( $p = 0.021$ ) between months of high precipitation (> 100 mm) and low precipitation ( $\leq 100$  mm), with a mean number of hospitalizations 2.8 times higher in the dry months.

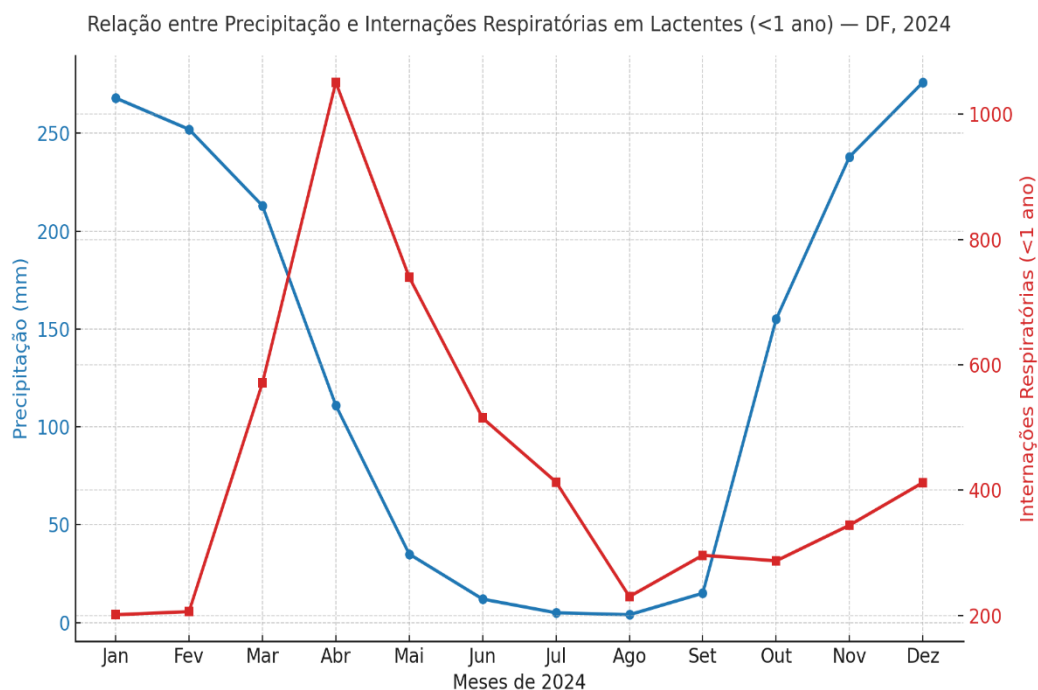
These findings reinforce the direct influence of rainfall seasonality on children's respiratory health in the Cerrado biome.

Figure 1 shows the inverse relationship between precipitation (blue line) and respiratory hospitalizations (red line) in infants (<1 year) in the Federal District in 2024.



**Figure 1**

*Association between monthly precipitation and respiratory hospitalizations in infants (< 1 year), Federal District, 2024*

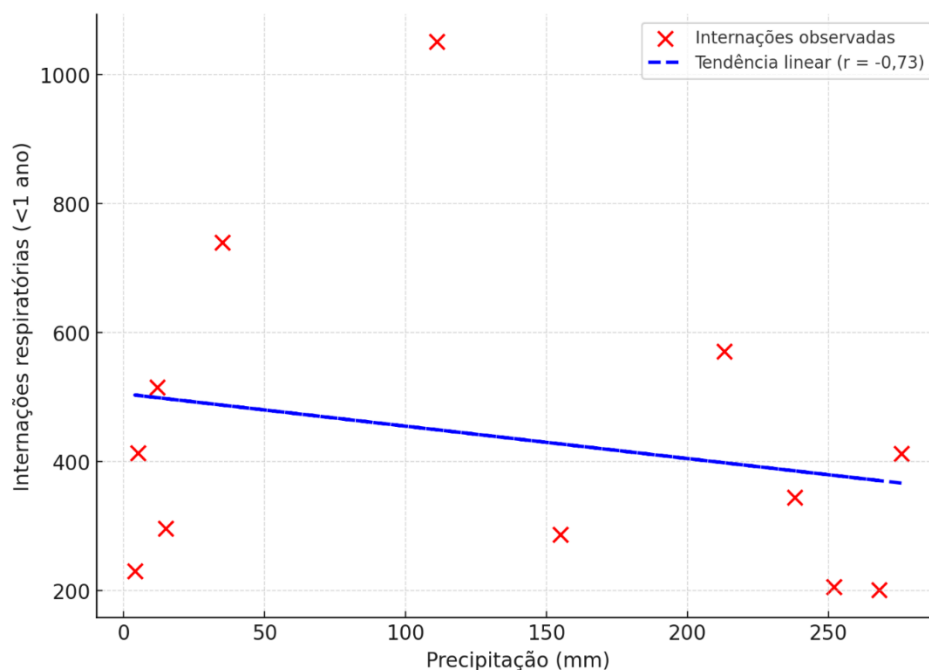


Source: prepared by the authors with data from SIH/DATASUS and INMET (2024).

Figure 2 shows the linear correlation (regression) between precipitation and respiratory hospitalizations (<1 year).

**Figure 2**

*Linear correlation between precipitation and respiratory hospitalizations in infants (< 1 year), Federal District, 2024*

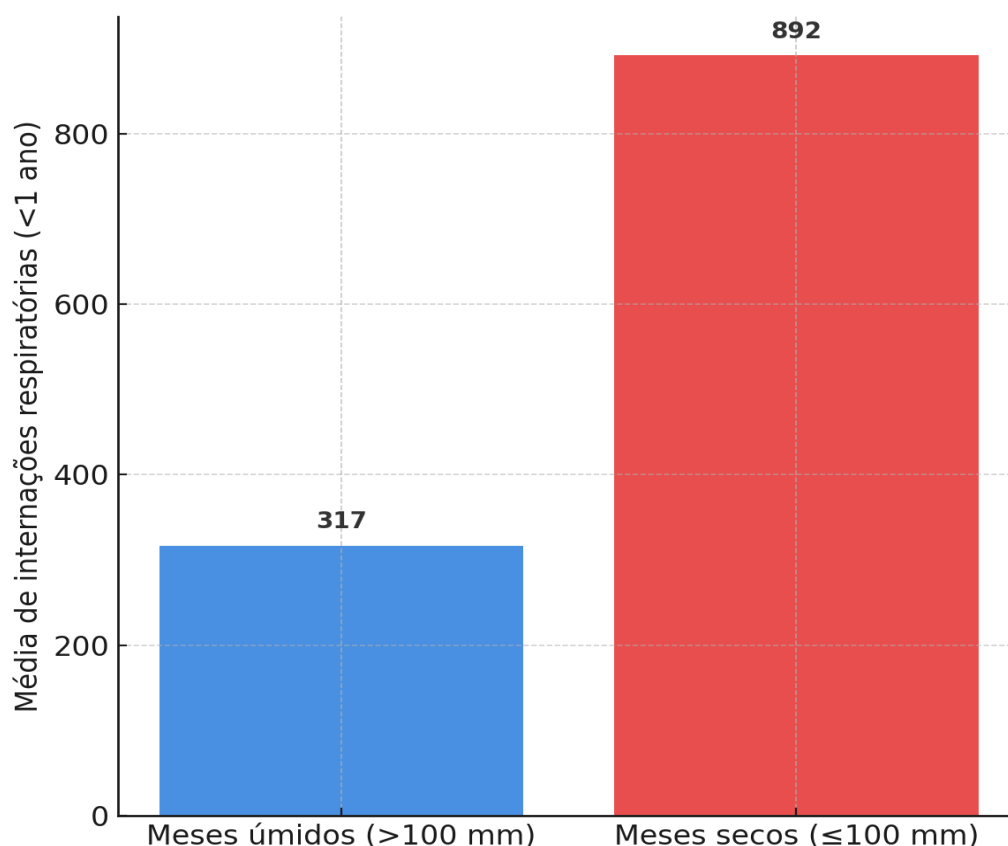


Source: prepared by the authors with data from SIH/DATASUS and INMET (2024).

Figure 3 graphically shows the contrast between wet and dry periods. It is observed that the mean number of hospitalizations was almost three times higher in the months of low rainfall, confirming the statistically significant difference ( $p = 0.021$ ) indicated by the Mann-Whitney U test.

**Figure 3**

*Comparison between wet and dry months Federal District, 2024*



Source: prepared by the authors based on data from SIH/DATASUS and INMET (2024).

#### **4 DISCUSSION**

During the dry months (May to September), the Federal District showed a drastic reduction in precipitation, with monthly averages often below 20 mm and relative humidity below 25%, according to the INMET Climatological Bulletin (2024).

During this period, there was an increase of up to 400% in respiratory hospitalizations in infants compared to the wet quarter (January to March), reflecting the direct impact of low humidity and the concentration of air pollutants on the lower respiratory tract.

The month of April represented the most critical phase of climate transition, with reduced rainfall (111 mm) and the beginning of the escalation of hospitalizations (1,051 cases).

The subsequent months (June to August) sustained the peak of hospitalizations, demonstrating a delayed seasonal response between the reduction in rainfall and the increase in respiratory morbidity.

This time lag is pathophysiologically plausible, as the progressive dryness of the mucous membranes, combined with the gradual accumulation of fine particles and suspended allergens, contributes to chronic airway inflammation (AGHAPOUR et al., 2022; KANG et al., 2022).

These findings are in line with studies conducted in other capitals of the Cerrado biome.

In Cuiabá, Saldanha, Silva and Botelho (2005) observed a similar pattern, with an increase in respiratory diseases in infants in the months of low humidity and a significant increase in bronchiolitis and viral pneumonia.

In parallel, Nascimento et al. (2006) described in Goiânia an inverse correlation between precipitation and pediatric respiratory morbidity, with a peak in hospitalizations coinciding with the period of highest concentration of particulate matter from fires.

In the present study, Pearson's negative correlation ( $r = -0.73$ ;  $p = 0.006$ ) quantitatively confirms this association in the context of the Federal District, reinforcing that precipitation is one of the most important climatic determinants of children's respiratory health.

In addition, the significant difference between dry and wet months ( $p = 0.021$ ; Mann–Whitney U) indicates not only a statistical association, but a recurrent and clinically relevant epidemiological pattern.

From a biological point of view, low humidity reduces mucociliary function, alters the clearance of respiratory pathogens, and favors colonization by opportunistic viruses and bacteria, especially in infants with immunological immaturity and narrower airways (SBP, 2023; WHO, 2022).

Compensatory hyperventilation due to dry air increases water loss due to pulmonary perspiration, which aggravates respiratory distress and tissue dehydration (HALL; GUYTON, 2021).

As a result, there is greater vulnerability to acute viral infections and exacerbations of pre-existing diseases, such as asthma and bronchiolitis obliterans.

In addition, particulate matter ( $PM_{2.5}$  and  $PM_{10}$ ) from fires and urban traffic acts as an irritant and pro-inflammatory, stimulating the production of inflammatory cytokines and the recruitment of neutrophils in the airways (WHO, 2022; CARVALHO et al., 2022).

These mechanisms explain, in an integrated way, the increase in respiratory hospitalizations observed during periods of drought.

The results obtained reinforce what the Brazilian Society of Pediatrics (SBP, 2023) and the World Health Organization (WHO, 2022) already highlight: that prolonged exposure to dry and polluted air constitutes an independent risk factor for acute respiratory diseases in childhood, especially in tropical regions with strong seasonality.

From the point of view of public health, these findings highlight the need for seasonal preventive strategies in pediatrics, such as:

- a) educational campaigns on hydration and humidification of the air;
- b) expansion of surveillance of respiratory syndromes in the dry season;
- c) strengthening of the hospital network during the months of highest demand (June to September).

In addition, environmental policies aimed at reducing fires and controlling air quality have a direct impact on children's health, being fundamental to mitigate the effects of drought on respiratory diseases.

## 5 CONCLUSION

The present study demonstrated an inverse and statistically significant association between precipitation and hospitalizations for respiratory diseases in infants (< 1 year) in the Federal District throughout 2024.

The results showed that the dry months, characterized by low humidity and rainfall of less than 50 mm, concentrated the highest number of hospitalizations, while the rainy season showed a significant reduction in respiratory morbidity.

From the pathophysiological point of view, low atmospheric humidity compromises the integrity of the mucous membranes and mucociliary transport, favoring viral and bacterial infections of the lower respiratory tract.

These findings reinforce that the vulnerability of infants to drought is multifactorial, involving immunological, anatomical and environmental aspects.

In terms of public health, the results indicate the need for seasonal preventive actions — such as monitoring respiratory syndromes, awareness campaigns on hydration and air quality, and fire mitigation policies.

These measures are essential to reduce the impact of drought on child health in the Cerrado biome and to subsidize integrated strategies for pediatric climato-sanitary surveillance.



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