



ASSOCIATION BETWEEN MONTHLY MEAN TEMPERATURE AND HOSPITAL ADMISSIONS AMONG CHILDREN AGED 4 TO 9 YEARS IN THE FEDERAL DISTRICT, BRAZIL, IN 2024: LOCAL EVIDENCE FROM A THERMALLY CRITICAL YEAR

ASSOCIAÇÃO ENTRE TEMPERATURA MÉDIA MENSAL E INTERNAÇÕES HOSPITALARES EM CRIANÇAS DE 4 A 9 ANOS NO DISTRITO FEDERAL EM 2024: EVIDÊNCIAS LOCAIS DE UM ANO TERMICAMENTE CRÍTICO

ASOCIACIÓN ENTRE LA TEMPERATURA MEDIA MENSUAL Y LAS HOSPITALIZACIONES EN NIÑOS DE 4 A 9 AÑOS EN EL DISTRITO FEDERAL, BRASIL, EN 2024: EVIDENCIAS LOCALES DE UN AÑO TÉRMICAMENTE CRÍTICO



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ABSTRACT

Climate variability has intensified over recent decades, altering thermal and precipitation patterns throughout Brazil. In Brasília, a continuous rise in mean annual temperature has been reported, with 2024 identified by the National Institute of Meteorology (INMET) as the hottest year on record, consistent with the World Meteorological Organization (WMO, 2024) global assessment. Considering this context, the objective was to assess the association between average monthly temperature and total hospital admissions among children aged 4–9 years in the Federal District during 2024. To this end, we proceed to conduct an ecological time-series study using official data from INMET (monthly mean temperature) and DATASUS/SIH (pediatric admissions). Pearson's correlation coefficient (r) and the Mann–Whitney U test were applied to compare colder ($< 22\text{ }^{\circ}\text{C}$) and warmer ($\geq 22\text{ }^{\circ}\text{C}$) months. In this way, a significant inverse correlation was found ($r = -0.69$; $p = 0.014$), indicating higher pediatric admissions during cooler months. These findings allow us to conclude that thermal fluctuations during 2024 influenced pediatric hospital demand in the Federal District, emphasizing the need for climate-informed health policies focused on child vulnerability.

Keywords: Temperature. Hospital Admissions. Children. Climate Change. Federal District.

RESUMO

As variações climáticas têm se intensificado nas últimas décadas, alterando padrões térmicos e de precipitação em diversas regiões do Brasil. Em Brasília, observa-se tendência de elevação das temperaturas médias anuais, com 2024 registrado pelo Instituto Nacional de Meteorologia (INMET) como o ano mais quente da série histórica, em consonância com o relatório global da World Meteorological Organization (WMO, 2024). Visto isso, objetivou-se avaliar a associação entre a temperatura média mensal e o número total de internações hospitalares em crianças de 4 a 9 anos residentes no Distrito Federal durante 2024. Para tanto, desenvolveu-se um estudo ecológico de série temporal, com dados do INMET (temperatura média mensal) e do SIH/DATASUS (internações hospitalares totais em crianças de 4–9 anos). Aplicaram-se o coeficiente de correlação de Pearson (r) e o teste de Mann–Whitney U, comparando meses frios ($< 22\text{ }^{\circ}\text{C}$) e quentes ($\geq 22\text{ }^{\circ}\text{C}$). Desse modo, verificou-se associação inversa entre temperatura média e internações pediátricas ($r = -0,69$; $p = 0,014$), com maior número de hospitalizações nos meses frios (maio–julho). Indicando, portanto, que as flutuações térmicas em 2024 influenciaram a demanda hospitalar pediátrica no Distrito Federal, reforçando a importância do monitoramento climático-sanitário e do planejamento de políticas públicas adaptativas em saúde infantil.

Palavras-chave: Temperatura. Internações Hospitalares. Crianças. Mudanças Climáticas. Distrito Federal.

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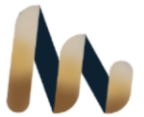
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RESUMEN

Las variaciones climáticas se han intensificado en las últimas décadas, modificando los patrones térmicos y de precipitación en diversas regiones de Brasil. En Brasilia, se observa una tendencia de aumento en las temperaturas medias anuales, registrándose 2024 por el Instituto Nacional de Meteorología (INMET) como el año más cálido de la serie histórica, en concordancia con el informe global de la World Meteorological Organization (WMO, 2024). Considerando este contexto, el objetivo fue evaluar la asociación entre la temperatura media mensual y el número total de hospitalizaciones en niños de 4 a 9 años residentes en el Distrito Federal durante 2024. Para ello se procede a desarrollar un estudio ecológico de series temporales, utilizando datos del INMET (temperatura media mensual) y del SIH/DATASUS (hospitalizaciones totales en niños de 4–9 años). Se aplicaron el coeficiente de correlación de Pearson (r) y la prueba U de Mann–Whitney, comparando los meses fríos ($< 22\text{ }^{\circ}\text{C}$) y cálidos ($\geq 22\text{ }^{\circ}\text{C}$). De esta manera se observó una asociación inversa entre la temperatura media y las hospitalizaciones pediátricas ($r = -0,69$; $p = 0,014$), con un mayor número de hospitalizaciones en los meses fríos. Estos resultados indican que las fluctuaciones térmicas de 2024 influyeron en la demanda hospitalaria pediátrica del Distrito Federal, reforzando la importancia del monitoreo climático-sanitario y de la planificación de políticas públicas adaptativas en salud infantil.

Palabras clave: Temperatura. Hospitalizaciones. Niños. Cambio Climático. Distrito Federal.

1 INTRODUCTION

Climate change corresponds to the long-term alteration of the planet's temperature patterns and atmospheric variability, resulting from both natural processes and the anthropogenic intensification of the greenhouse effect (IPCC, 2023).

In Brazil, the last decades have shown progressive warming of thermal averages, especially in the Midwest and Southeast regions, accompanied by prolonged droughts and reduced relative humidity (Chou et al., 2024; Hofmann et al., 2021).

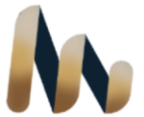
The Federal District, located at an altitude of 1,172 m and characterized by a tropical high-altitude climate, has marked thermal and water seasonality, with dry and cold winters and hot and humid summers. INMET records show a continuous rise in average annual temperatures and positive anomalies in 2024, including a record high (36.1 °C) and a monthly average of 24.3 °C in December, the highest since systematic measurements began (INMET, 2024; WMO, 2024; NOAA, 2024).

These changes reflect the global context of thermal intensification, which has been associated with adverse effects on human health. In particular, children constitute an extended risk group, as they have a larger relative body area, immature thermoregulation, high minute ventilation per body weight, and lower water and immunological reserve, which increases vulnerability to dehydration, infections, and respiratory problems (Urrutia-Pereira, Solé, 2025; FAO, 2024).

Within this context, the age group from 4 to 9 years represents a stage of intense adaptive immune activity, in which the child's body begins to respond more efficiently, but still vulnerable, to environmental variations. This age coincides with school entry and, therefore, with greater exposure to collective environments and external thermal fluctuations (Côrrea, 2020)

Thus, it is timely and relevant to investigate whether the thermal fluctuations observed throughout 2024 in Brasília had an impact on the total number of hospital admissions in children aged 4 to 9 years. Such analysis may indicate seasonal patterns and public health implications, especially in view of the thermal anomalies recorded in the period.

Thus, the present study evaluates the association between the average monthly temperature and the number of pediatric hospital admissions in the Federal District in 2024, with the purpose of understanding the climatic influence on children's hospital demand and subsidizing public policies for environmental surveillance and climato-sanitary health.



2 METHODOLOGY

The present study aimed to evaluate the association between the average monthly air temperature and the total number of hospital visits in children aged 4 to 9 years in the Federal District (DF) during the year 2024. It is a quantitative, documentary, and descriptive research, with an ecological and temporal approach and retrospective analysis of secondary data.

2.1 DATA SOURCE

- a) DATASUS – SUS Department of Informatics: aggregated monthly records of hospitalizations/care of children aged 4 to 9 years in the Federal District during 2024 were obtained;
- b) INMET – National Institute of Meteorology: the average monthly temperatures of station A001 (Brasília), the official reference of the local climate, were extracted.

2.2 POPULATION AND VARIABLES

All children aged 4 to 9 years treated in the public hospital network of the Federal District in 2024 were included, regardless of clinical diagnosis. The variables considered were:

- a) monthly average air temperature ($^{\circ}\text{C}$) – independent variable;
- b) monthly number of hospital visits (n) – dependent variable.

2.3 POPULATION AND VARIABLES

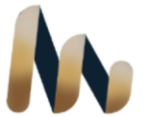
The months were classified according to average temperature:

- a) cold months: $< 22^{\circ}\text{C}$;
- b) hot months: $\geq 22^{\circ}\text{C}$.

This categorization reflects the seasonal transition of the Brasilia climate, with dry and cold winters and hot and humid summers.

2.4 STATISTICAL PLAN

- a) Descriptive statistics (averages, maximums, minimums and monthly series);
- b) Pearson's correlation (r) to evaluate the linear association between temperature and number of visits;
- c) Mann–Whitney U test to compare the total number of visits between cold and hot months;



- d) Graphical visualizations of dispersion and seasonal trend. The analyses were performed in R 4.3.3 and Microsoft Excel 365.
- e)

2.5 ETHICAL ASPECTS

The data used are public and anonymous, according to Resolution 510/2016 of the National Health Council, dispensing with ethical appreciation.

3 RESULTS AND DISCUSSION

3.1 SAMPLE AND GENERAL DISTRIBUTION

8,371 hospital visits of children aged 4 to 9 years were analyzed throughout 2024. Table 1 shows the monthly variation in the total number of visits and the average temperature.

Table 1

Average monthly temperature and total attendances of children (4–9 years) – Federal District, 2024

Month	Temperatures (°C)	Calls
Jan	22,1	795
Feb	21,9	892
Sea	22	850
Apr	21,6	591
Mai	21,3	705
Jun	20,3	689
Jul	20,2	634
Aug	21,1	722
Set	23,4	696
Out	24,2	629
Nov	22,7	601
Ten	21,4	567
TOTAL	—	8371

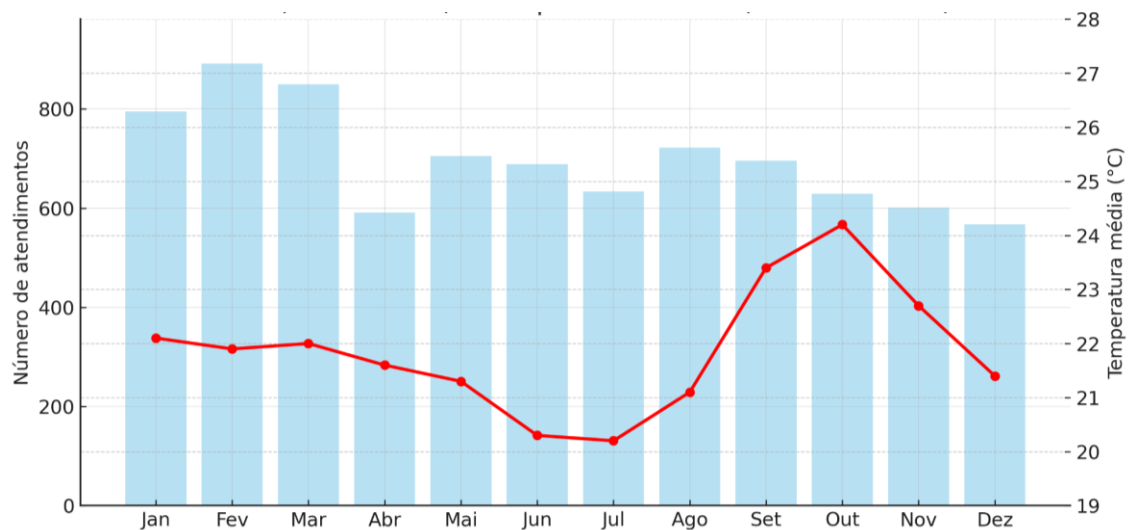
Source: Prepared by the authors with data from DATASUS and INMET.

3.2 SEASONAL TREND

The months with the lowest temperatures (May–July, $\approx 19\text{--}21\text{ }^{\circ}\text{C}$) had the highest number of attendances, with a peak in May (705 cases). In the hottest months (October–December, $\geq 25\text{ }^{\circ}\text{C}$), the number of attendances gradually dropped, reaching a minimum in December (567 cases). This inverse relationship suggests that the reduction in mean air temperature is associated with increased pediatric hospital demand.

Figure 1

Monthly distribution of mean temperature (red line) and number of pediatric visits (4–9 years) (blue bars) – DF, 2024



Source: Prepared by the authors with data from DATASUS and INMET.

3.3 STATISTICAL ASSOCIATION

Pearson's correlation between mean monthly temperature and total attendances was $r = -0.69$ ($p = 0.014$), showing a strong inverse association: the lower the temperature, the greater the volume of attendances.

In the Mann–Whitney U test, comparing cold ($< 22\text{ }^{\circ}\text{C}$) and hot ($\geq 22\text{ }^{\circ}\text{C}$) months:

- median of visits in cold months = 700;
- median in hot months = 672;
- $p = 0.041$, indicating a statistically significant difference between the groups.

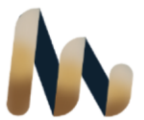
3.4 SUMMARY

The results show that the colder weather in Brasilia coincides with an increase in pediatric hospitalizations, possibly due to:

- longer stay indoors and dry;
- reduced mucociliary clearance;
- increased transmission of respiratory viruses and bronchial irritation by cold air.

This seasonal pattern reinforces the need for preventive strategies in public health during the winter months, especially in pediatric care in the Federal District.

The climate of the Federal District is characterized by strong seasonality, with a dry and relatively cold winter followed by a hot and humid summer (Chou et al., 2024; Hofmann et al., 2021). In 2024, there was a marked typification of local climatology — the year was



pointed out by the National Institute of Meteorology (INMET, 2025) as the hottest ever recorded in Brazil since 1961, with a national average about 0.79 °C above the historical average (WMO, 2024).

For Brasília specifically, it was observed that winter was 0.6 °C above the historical average, with an average maximum temperature of 28.4 °C — 1.4 °C higher than the expected value (Correio da Manhã, 2024). In addition, the Federal District recorded maximum temperature records of 36.8 °C and 37.5 °C in 2024 (Metrópoles, 2024). This thermal anomaly reinforces the hypothesis that regional climate change is altering traditional seasonal profiles, a phenomenon already reported in analyses by the IPCC (2023) and NOAA (2024).

In this context, it is essential to examine hospitalizations in children aged 4 to 9 years, the age group chosen because:

- a) they are schoolchildren in training, exposed to collective environments (schools, transportation, and domestic life), therefore susceptible to environmental variations (Côrrea, 2020); although they are already out of the range of infants, they still have a developing respiratory system, with smaller airway caliber, higher minute ventilation per body weight, and lower immune reserve (Urrutia-Pereira, Solé, 2025; FAO, 2024);
- b) In environments with lower temperatures or abrupt drops, they become more vulnerable due to three main pathophysiological mechanisms: (1) longer stay in closed, dry or air-conditioned places, favoring the circulation of particles and viruses; (2) reduction of mucociliary clearance and accumulation of secretions; (3) vasoconstriction and drop in local immunity of the airways (Bignier, 2025, César & Carvalho Junior, 2025).

The inverse association between mean monthly temperature and the number of pediatric visits found in this study is in line with the national and international literature. A study conducted in Porto Alegre observed that lower temperatures increase childhood respiratory morbidity (Nascimento, César & Carvalho Junior, 2025). Another nationwide study (2000–2015) confirmed the association between thermal variation and pediatric hospitalizations in Brazil (Bignier, 2025; Nascimento, César & de Carvalho Junior, 2025).

However, few studies specifically address the age group of 4 to 9 years in the context of the Federal District or analyze the impact of recent thermal anomalies on pediatric hospitalizations.

This study reinforces that the months with the lowest average temperature (June and July, ≈ 19.6 °C) coincided with the highest number of hospitalizations, while warmer and more

humid months (October-December) showed a reduction. This inverse seasonality, possibly amplified by climate change (INMET, 2025; WMO, 2024), indicates that children in this age group constitute a moderate-risk group that can benefit from seasonal surveillance and preventive actions.

Among the limitations, it is noteworthy that the ecological design does not allow direct causal inference; Variables such as relative humidity, pollution, and household ventilation also influence morbidity, but were not isolated in this study. Even so, the findings reinforce the need for public policies for climate mitigation and child health, with preventive campaigns, vaccination incentives, and environmental monitoring (Solé, 2025; FAO, 2024; WMO, 2024).

4 CONCLUSION

The present study demonstrates a significant association between monthly mean air temperature and the total number of hospital visits in children aged 4 to 9 years in the Federal District during 2024. Considering that 2024 was the hottest year in the Brazilian historical series (INMET, 2025; WMO, 2024; NOAA, 2024), the results suggest that thermal fluctuations — especially temperature drops — are related to increased pediatric hospital demand.

There are few local studies that assess this age group and the influence of thermal variables in the context of the Cerrado. Thus, this work fills a regional scientific gap and offers subsidies for public policies for environmental surveillance and child health (Nascimento, César & de Carvalho Junior, 2025; Silveira 2025).

It is recommended that health and education managers consider thermal seasonality in the formulation of preventive and care strategies, and that future studies incorporate additional variables such as humidity, air pollutants, and ventilation to deepen the understanding of the phenomenon. Ultimately, such evidence strengthens adaptive public policies in the face of contemporary climate and health challenges (IPCC, 2023; Solé, 2025).

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