Trend of morbidity and mortality indicators due to acute diarrheal disease in children under five years old in the State of Piauí (2000–2019)

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Abstract

Objectives: to analyze the trend of morbidity and mortality indicators due to acute diarrheal diseases in children under five years old in Piauí.

Methods: ecological study with data from the Information Technology Department at the Public Health System. The indicators of hospitalization rate and coefficient of mortality from the disease between 2000 and 2019 were calculated. A descriptive analysis of the indicators was carried out in the studied period and by the macro-regions in the State. For trend analysis, the simple linear regression model with log-transformation was used. Trends were classified as increasing, decreasing and stable, with a significance level of 5%.

Results: the average on hospitalization rate was higher in the semi-arid macro-region (36.6/1000 children under five years old) and lower in Teresina (14.9/1000 children under five years old). The mean mortality coefficients were higher in the coastal macro-region (0.98/1000 live births) and lower in Teresina (0.47/1000 live births). The indicators showed a downward trend in all analyzed locations ($p<0.05$). A turning point was noted from 2009, with a significant reduction in hospitalization rates in the savanna and semi-arid macro-regions.

Conclusion: indicators of morbidity and mortality due to acute diarrheal diseases in children under five years old showed a downward trend in Piauí between 2000 and 2019, with differences in trends between the evaluated macro-regions.

Key words *Spatio-temporal analysis, Indicators of morbidity and mortality, Diarrhea, Health status indicators, Child health*

http://dx.doi.org/10.1590/1806-9304202300000120-en

Introduction

Acute Diarrheal Diseases (ADD) can be caused by viruses, bacteria, protozoa and intestinal helminths. It is estimated that there are around 1.7 billion cases and 525,000 deaths a year because of this disease, which still represents an important cause of morbidity and mortality in children under five years old in the world, and it is the second leading cause of death in this population. The ADDs are potentially preventable through simple measures, such as providing the population with drinking water and good sanitary conditions, health education on the spread of infectious diseases and basic hygiene, exclusive breastfeeding for children up to six months of age and vaccination against rotavirus.[1-6]

Brazil has diverse demographic, social, economic, cultural and health characteristics and numerous local realities. In this context, the prevention and treatment of the ADDs can be considered more complex in the North and Northeast regions, which is aggravated, among other factors, by the occurrence of frequent floods and droughts, which favor the contamination of water and food by pathogens and lead individuals to seek alternative sources of undrinkable water.[1,7-10]

Piauí is characterized by the presence of the savanna, *caatinga* and *mata dos cocais* biomes and predominantly dry climates.[11] In addition, the State is located in a region historically marked by greater socioeconomic and health complexities and frequent droughts, which makes the ADD an important challenge for local health and sanitation authorities. Between 2007 and 2010, 312,447 cases of the ADD were registrated in Piauí.[12-14]

In view of the challenges of preventing the ADDs in children under the age of five, and also taking into account the local socioeconomic, health and environmental complexities, this study aims to analyze the trend of morbidity and mortality indicators for the ADDs in under-five years old in Piauí.

Methods

This is an ecological time trend study on morbidity and mortality indicators for the ADD in children under five years old living in cities in the State of Piauí between 2000 and 2019. Piauí has a land area of 251,755.481 km^2 and a resident population of 3,269,200 people, according to 2022 estimates. It also had a human development index (HDI) of 0.69 in 2021.[15] The study was carried out in the capital of Teresina and in the four health macro-regions (coast, mid-north, savanna and semi-arid).

The data collected came from the *Sistema de Informação Hospitalar* (SIH) (Hospital Information System), the *Sistema de Informação sobre Mortalidade* (SIM) (Mortality Information System) and the *Sistema de Informações sobre Nascidos Vivos* (Sinasc) (Live Births Information System), available online from the *Departamento de Informática do Sistema Único de Saúde* (Datasus) (Information Technology Department of the Public Health System). Population data from the *Instituto Brasileiro de Geografia e Estatística* (IBGE) (Brazilian Institute of Geography and Statistics) was used to calculate hospitalization rates. The morbidity and mortality data for the ADD correspond to the number of hospitalizations and deaths registered according to the WHO 10th Revision International Classification of Diseases (ICD-10) - Chapter I, codes A00 to A09, delimiting the under-five age group (more than 29 days and less than five years).

The morbidity and mortality indicators for the ADD in under-five during the study period were calculated as follows: hospitalization rate for the ADD (number of hospital admissions for the ADD in children under five years old living in Piauí divided by the corresponding total population under-five and multiplied by 1000) and mortality coefficient for the ADD (number of deaths from the ADD in under-five living in Piauí divided by the corresponding number of live births and multiplied by 1000).

An exploratory analysis of the ADD morbidity and mortality indicators was carried out over time, considering the study period (2000-2019) and the macro-regions in the State. In the second stage, a trend analysis was carried out using a simple linear regression model ($Y = \beta 0 + \beta 1x$), with hospitalization and mortality rates due to the ADD in under-five as the dependent variable (Y) and the years of the study as the independent variable (X). The Y variable was log-transformed and centered on the midpoint of the time series (2009), becoming the centered-year variable. In addition to the trend over the study period, we observed potential inflection points in the series, where there is a change in the slope of the estimated line. The choice of the model was based on the value of the coefficient of determination (r^2), the analysis of residuals and statistical significance. A significance level of 5% was adopted. The data was tabulated and processed using Tabwin© (version 3.6b), Microsoft Excel 2010® and the R program.

Results

Table 1 shows the measures of central tendency and dispersion of morbidity and mortality indicators by the ADD in under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions between 2000 and 2019. In relation to the morbidity indicator, the average hospitalization rate for under-five was highest in

Table 1

Descriptive analysis of morbidity and mortality indicators for acute diarrhea in children under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions, 2000-2019.

	Hospitalization rate per 1000 children under-five		
	$\bar{x}$ ± SD	Minimum	Maximum
State of Piauí	25.3 ± 9.5	9.2	38.7
City Capital of Teresina	14.9 ± 9.6	1.9	32.5
Savanna Macro-region	27.5 ± 9.4	12.5	46.4
Coastal Macro-region	24.5 ± 9.1	10.7	37.5
Mid-North Macro-region	19.6 ± 9.0	6.4	33.8
Semi-arid Macro-region	36.6 ± 13.4	9.9	53.8
	Mortality rate per 1000 live births		
	$\bar{x}$ ± SD	Minimum	Maximum
State of Piauí	0.78 ± 0.56	0.10	1.72
City Capital of Teresina	0.47 ± 0.45	0,000	1.39
Savanna Macro-region	0.85 ± 0.59	0.22	2.13
Coastal Macro-region	0.98 ± 0.81	0,000	2.58
Mid-North Macro-region	0.57 ± 0.49	0,000	1.43
Semi-arid Macro-region	0.96 ± 0.63	0,000	2.16

the semi-arid macro-region (36.6/1000 children under five; standard deviation = 13.4) and lowest in the city capital of Teresina (14.9/1000 children under five; standard deviation = 9.6). For the mortality indicator, the highest mortality coefficient was 0.98 deaths per 1,000 live births in the coastal macro-region and the lowest was in the city capital of Teresina, with 0.47 deaths per 1,000 live births.

Figures 1 and 2 demonstrate the distribution of morbidity and mortality indicators for the ADD in under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions between 2000 and 2019. It can be seen that, for both indicators, there were reductions in hospitalization rates and mortality coefficients over the period. For hospitalization rates, there was an inflection point in 2010 for the coastal macro-region, in 2012 for the semi-arid macro-region and from 2005 in the savana macro-region. For mortality coefficients, these inflections can be seen in the coastal and semi-arid macro-regions from 2010.

In the State of Piauí, in the city capital of Teresina and in the coastal and mid-north macro-regions, hospitalization rates for the ADD in under-five showed a decline in the indicator. In the savanna macro-region, hospitalization rates increased until 2006, with a reduction in the following years. In the semi-arid macro-region, there were two periods of reductions, the first until 2012 and a sharper reduction thereafter. With regard to mortality coefficients, all the study sites demonstrated a reduction in the indicator over the studied period, but an inflection point was observed, with a sharper decrease until 2010, including stability for the savanna macro-region.

Table 2 shows the trend in morbidity and mortality indicators for the ADD in under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions between 2000 and 2019 according to the model adopted, $\ln(Y) = \beta 0 + \beta 1x$. Regarding to hospitalization rates, there was a reduction in all study sites ($p<0.05$), except for the period between 2000 and 2009 in the savanna ($p=0.610$) and semi-arid ($p=0.778$) macro-regions, which showed stability. For the mortality coefficients, there was a reduction between 2000 and 2019 for all the study sites ($p<0.05$). When the periods before and after 2010 were divided, there was stability in the indicator in the savanna macro-region from 2010 ($p=0.061$).

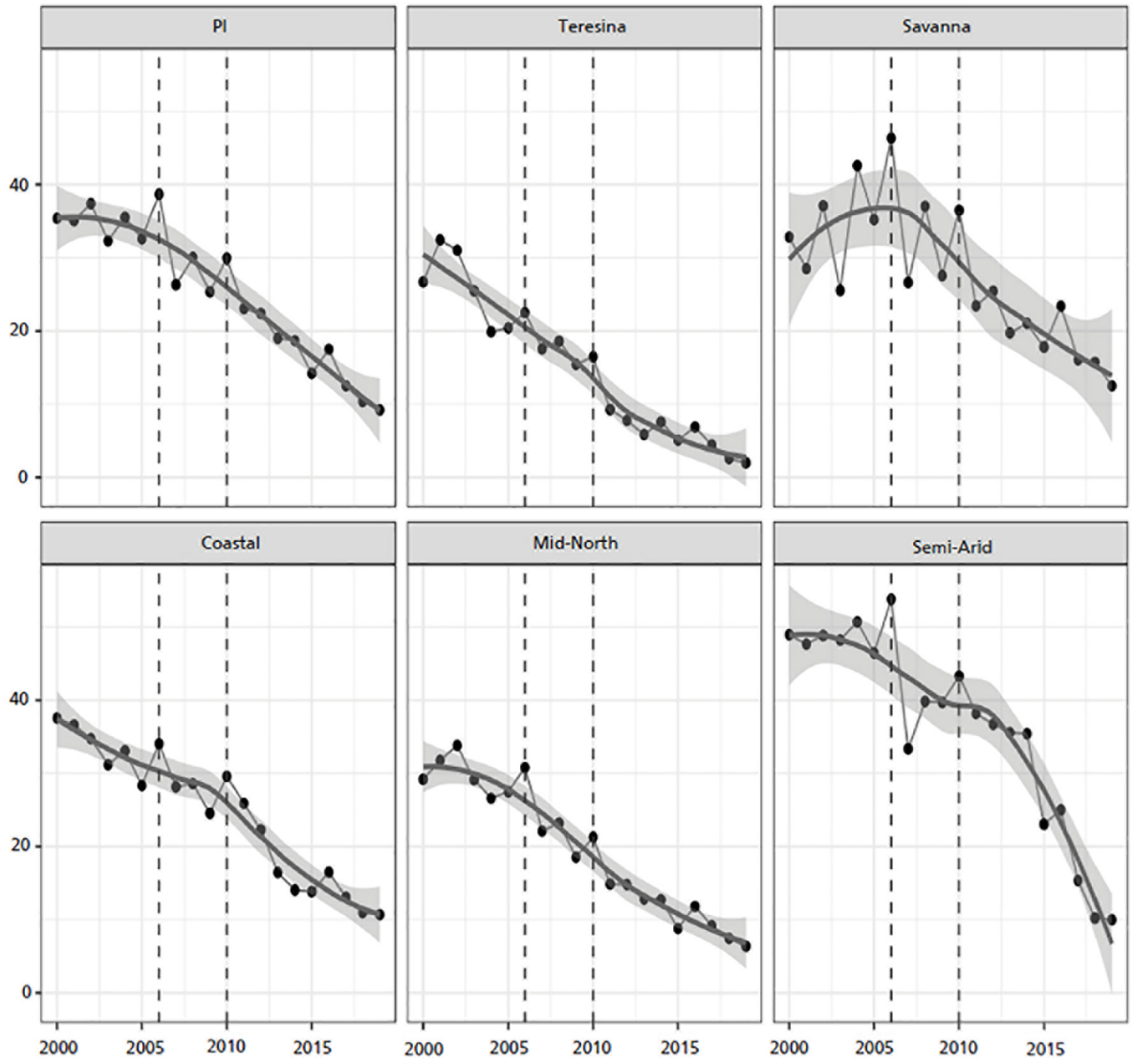
Discussion

In general terms, the trend analyses of this study showed that hospitalization rates and under-five mortality coefficients for the ADD decreased between 2000 and 2019, with greater reduction trends for the city capital of Teresina. Among the macro-regions, the reduction in hospitalization rates in the period was more pronounced in the mid-north and semi-arid macro-regions. For the mortality coefficient, the greatest decrease occurred in the coastal and mid-north macro-regions. In the trend before and after 2010, there was stability in the mortality indicator in the savanna macro-region from 2010.

In Regard to hospitalizations for the ADD in children under-five years old, the savanna and semi-arid macro-regions had the highest values compared to the other macro-regions. As for the mortality coefficient, only the coastal macro-region had higher values than the savanna and semi-arid macro-regions. For hospitalizations, until 2006, there was an increase in rates in the savanna macro-region, with a sharp reduction in the following years,

Figure 1

Temporal distribution of hospitalization rates for acute diarrhea in children under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions, 2000-2019.



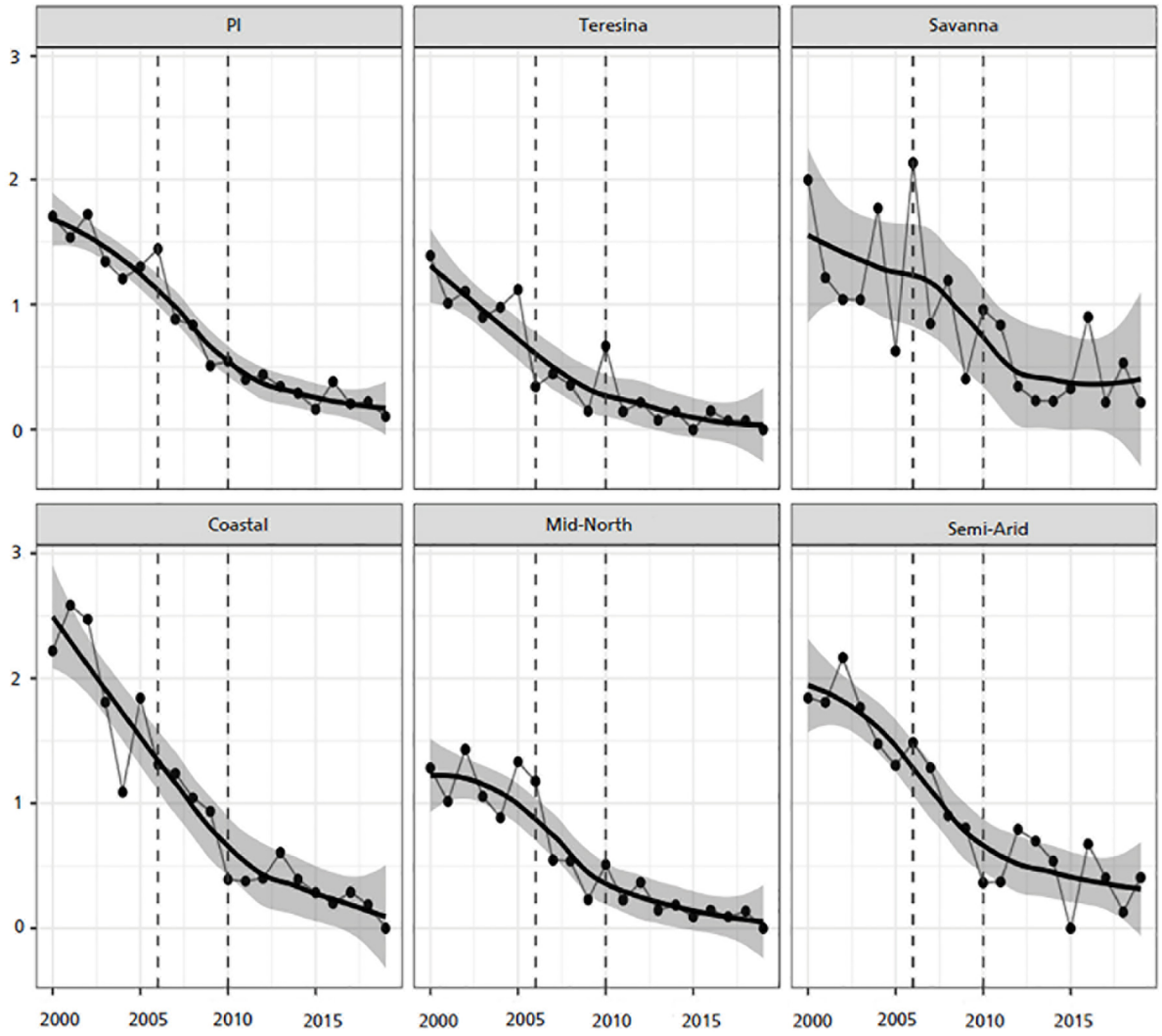
suggesting a possible role for the introduction of the rotavirus vaccine combating AIDs in children under-five.[6] It should also be noted that, within Piauí, the savanna and semi-arid macro-regions are inserted in a region marked by greater socioeconomic and environmental complexities due to frequent droughts and greater distance from major economic centers. Therefore, these regions should be a priority in government actions to reduce infant mortality in Piauí, especially due to cases of the ADD.[11,15,16]

Since 1988, Brazil has undergone a series of demographic, socio-economic and physical infrastructure changes, which have had a positive impact on the lives of the population. These changes include the creation of the *Sistema Único de Saúde* (SUS) (Public Health System) in 1990 and the introduction of the *Estratégia Saúde da Família* (ESF) (Family Health Strategy) in 1994, which enabled the implementation of a new health model in the country, focused on health promotion and prevention and based on principles such as universalization, equity and comprehensiveness.[17,18] The most recent analyses show that the *SUS* actions have led to a significant change in the morbidity and mortality profile from communicable diseases in the country over the years.[16] In this context, Leal *et al.*[17] showed that proportional mortality from diarrhea in children under five years of age fell from 14% to 1.4% between 1990 and 2015 in Brazil, representing a significant improvement in the health situation in children.

Another factor in the reduction of indicators was the inclusion of the rotavirus vaccine in the *Plano Nacional de Imunização* (PNI) (National Immunization Plan) in 2006, which significantly reduced hospitalizations for severe cases of diarrhea in this population. Until 2006, the *SUS* admitted around 120,000 cases of children under-five with diarrhea each year, with a reduction of around 40,000 of

Figure 2

Temporal distribution of mortality coefficients due to acute diarrhea in children under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions, 2000-2019.



these hospitalizations between 2008 and 2009 alone.[16] Overall, the data from this study also showed a decrease in the mortality and hospitalization coefficients for ADD in the State of Piauí, in the city capital of Teresina and in the health macro-regions from 2006 for the studied period.

There are several elements involved in improving the profile of morbidity and mortality from diarrhea in children under-five, especially those of a socioeconomic and health nature and those related to greater *Atenção Básica* (Primary Care) coverage. For example, Paiva *et al.*[19] highlighted the role of *Atenção Básica* (Primary Care) and the great importance of improvements in water quality, basic sanitation and the hygiene conditions of the population in tackling diarrhea in Brazil, especially in the most vulnerable groups, such as children and elderly people. In addition, it has been shown that the joint action of *Programas de Transferência Condicionada de Renda* (PTCR) (Conditional Cash Transfer Programs), such as the *Programa Bolsa Família* (PBF) (Family Welfare Program) improves health inequities, also resulting in a reduction in morbidity and mortality from diarrhea and malnutrition in children.[20]

Even though infant mortality in Brazil has been falling since 1990, infant mortality rates are still quite high in some geographical regions, mainly due to the relative weight of deaths from diarrhea, pneumonia and malnutrition. Analyses of the distribution of morbidity and mortality due to diarrhea in children under-five between the micro-regions of the Brazilian regions demonstrate that there is great heterogeneity between the micro-regions, especially in the North and Northeast, where issues such as extreme poverty, social and demographic conditions and basic sanitation are more worrisome.[21]

Trend analyses make it possible to assess the behavior of a given disease in a population through the joint analysis of historical series of morbidity and mortality, making

Table 2

Trend estimates for acute diarrhea morbidity and mortality indicators in children under-five in the State of Piauí, in the city capital of Teresina and in the health macro-regions for the periods 2000-2019, 2000-2009 and 2010-2019.

	Period	Model ln(Y) = β 0 + β 1x	Trend	*p*
Hospitalization Rat				
State of Piauí	2000-2019	ln(Y) = 3.14 + (-0,069x)	Decreasing	<0,001
	2000-2009	ln(Y) = 3.34 + (-0,029x)	Decreasing	0,003
	2010-2019	ln(Y) = 3.34 + (-0,116x)	Decreasing	<0,001
City capital of Teresina	2000-2019	ln(Y) = 2.43 + (-0,133x)	Decreasing	<0,001
	2000-2009	ln(Y) = 2.68 + (-0,082x)	Decreasing	<0,001
	2010-2019	ln(Y) = 2.68 + (-0,193x)	Decreasing	<0,001
Savanna Macro-region	2000-2019	ln(Y) = 3.25 + (-0,047x)	Decreasing	<0,001
	2000-2009	ln(Y) = 3.45 + (-0,008x)	Stable	0,610
	2010-2019	ln(Y) = 3.45 + (-0,095x)	Decreasing	<0,001
Coastal Macro-region	2000-2019	ln(Y) = 3.12 + (-0,067x)	Decreasing	<0,001
	2000-2009	ln(Y) = 3.27 + (-0,035x)	Decreasing	0,001
	2010-2019	ln(Y) = 3.27 + (-0,105x)	Decreasing	<0,001
Mid-North Macro-region	2000-2019	ln(Y) = 2.86 + (-0,085x)	Decreasing	<0,001
	2000-2009	ln(Y) = 2.99 + (-0,056x)	Decreasing	<0,001
	2010-2019	ln(Y) = 2.99 + (-0,119x)	Decreasing	<0,001
Semi-arid Macro-region	2000-2019	ln(Y) = 3.50 + (-0,072x)	Decreasing	<0,001
	2000-2009	ln(Y) = 3.83 + (-0,004x)	Stable	0,778
	2010-2019	ln(Y) = 3.83 + (-0,151x)	Decreasing	<0,001
Mortality coefficient				
State of Piauí	2000-2019	ln(Y) = -0.56+ (-0,139x)	Decreasing	<0,001
	2000-2009	ln(Y) = -0.49 + (-0,127x)	Decreasing	<0,001
	2010-2019	ln(Y) = -0.49 + (-0,153x)	Decreasing	<0,001
City capital of Teresina	2000-2019	ln(Y) = -1.25 + (-0,172x)	Decreasing	<0,001
	2000-2009	ln(Y) = -1.29 + (-0,180x)	Decreasing	<0,001
	2010-2019	ln(Y) = -1.29 + (-0,160x)	Decreasing	0,005
Savanna Macro-region	2000-2019	ln(Y) = -0.41 + (-0,097x)	Decreasing	<0,001
	2000-2009	ln(Y) = -0.41 + (-0,098x)	Decreasing	0,034
	2010-2019	ln(Y) = -0.41 + (-0,096x)	Stable	0,061
Coastal Macro-region	2000-2019	ln(Y) = -0.37 + (-0,149x)	Decreasing	<0,001
	2000-2009	ln(Y) = -0.39 + (-0,153x)	Decreasing	<0,001
	2010-2019	ln(Y) = -0.39 + (-0,142x)	Decreasing	<0,001
Mid-North Macro-region	2000-2019	ln(Y) = -0.98 + (-0,161x)	Decreasing	<0,001
	2000-2009	ln(Y) = -0.93 + (-0,150x)	Decreasing	<0,001
	2010-2019	ln(Y) = -2.15 + (-0,176x)	Decreasing	<0,001
Semi-arid Macro-region	2000-2019	ln(Y) = -0.24 + (-0,108x)	Decreasing	<0,001
	2000-2009	ln(Y) = -0.33 + (-0,126x)	Decreasing	0,001
	2010-2019	ln(Y) = -0.33 + (-0,087x)	Decreasing	0,027

it possible to indirectly evaluate possible primary and secondary prevention measures for the health problem being studied.[22] This is an ecological study and allows a given population to be studied broadly, without focusing on particular subjects. Thus, data from ecological studies reflect phenomena at a collective level. However, these studies are biased by their dependence on secondary data, provided by third parties to the consulted banks, and there may be underreporting and/or inadequate input.[23] Therefore, this study is influenced by the quality and flow of information. Another limitation is the non-inclusion of hospitalizations in the private network, which could underestimate the rates found.

The results of this study showed that, in line with the national trend, hospitalization and death rates from ADD in children under-five have been falling in the State of Piauí, in the city capital of Teresina and in the health macro-regions between 2000 and 2019, which can be

credited to socioeconomic, structural and health changes over the last few years, made possible by initiatives such as the *Programa Bolsa Família* (PBF) (Family Welfare Program), *Estratégia Saúde da Família* (ESF) (Family Health Strategy) and improved sanitary conditions in the cities in the State of Piauí. Despite this, the stability of the trend in some macro-regions, especially for mortality, reinforces the necessity to expand and strengthen surveillance services and continuous monitoring of the ADD in children**.**

Acknowledgements

We would like to thank the *Programa de Políticas Públicas* (Public Policies Program), *Modelos de Atenção e Gestão do Sistema e Serviços de Saúde da Fundação Oswaldo Cruz* (PMA/FIOCRUZ), (Models of Care and Management in the Health System and Services at the Oswaldo Cruz Foundation) and FIOCRUZ-PI for their financial and institutional support.

Funding

This study is linked to the FIOCRUZ-PI project "*Fortalecimento da Vigilância em Saúde na APS: a implantação de unidades sentinelas para vigilância da morbimortalidade por Doenças Diarreicas Agudas na Estratégia da Saúde da Família no Piauí*"(Strengthening Health Surveillance in PHC: the implementation of sentinel units for the surveillance of morbidity and mortality from Acute Diarrheal Diseases in the Family Health Strategy in Piauí), which was funded by PMA/FIOCRUZ, in accordance with the FIOCRUZ/VPPCB/PMA 2020 (Application No: 46401342676846).

Authors' contribution

Costa REAR, Visgueira ARL, Sousa RFV: data collection, processing and analysis and writing of the manuscript. Monteiro KJL, Horta MAP, Oliveira BFA: conception and design of the study and revision of the original manuscript. All the authors have approved the final version of the article and declare no conflicts of interest.

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Received on April 10, 2023
Final version presented on September 5, 2023
Approved on September 12, 2023

Associated Editor: Karla Bomfim