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EPIDEMIOLOGICAL PROFILE OF INFANT MORTALITY IN THE STATE OF CEARÁ, BRAZIL, FROM 2013 TO 2023

PERFIL EPIDEMIOLÓGICO DA MORTALIDADE INFANTIL NO ESTADO DO CEARÁ, BRASIL, DE 2013 A 2023

PERFIL EPIDEMIOLÓGICO DE LA MORTALIDAD INFANTIL EN EL ESTADO DE CEARÁ, BRASIL, DE 2013 A 2023

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ABSTRACT
Objective: To analyze the epidemiological situation of maternal and infant mortality in Ceará, Brazil, from 2013 to 2023. **Methods:** This is a descriptive epidemiological study, carried out in September 2024 on notifications of Infant Mortality in the State of Ceará, in the period from 2013 to 2023. Data collection was carried out by the Mortality Information System (SIM) and the Live Birth Information System (Sinasc). **Results:** 16,686 cases were reported, with a predominance of males (54.96%), age group under 24 hours (26.67%), brown race (61.97%), mothers' education level of 8 to 11 years (40.43%), mothers' age of 20 to 24 years (21.11%), mortality rate of 13.822 in 2013 and 11.722 in 2023. **Final considerations:** Finally, there was a reduction in infant deaths in the State of Ceará, where in 2013, the highest infant mortality rate was recorded.
Keywords: *Infant mortalit; Maternal and child mortality.*

RESUMO
Objetivo: Analisar a situação epidemiológica da mortalidade materno infantil do Ceará, Brasil, no período de 2013 a 2023. **Métodos:** Trata-se de um estudo epidemiológico do tipo descritivo, realizado em setembro de 2024 sobre as notificações da Mortalidade Infantil no Estado do Ceará, no período de 2013 a 2023. A coleta de dados foi realizada pelo Sistema de Informações sobre Mortalidade (SIM) e o Sistema de Informações sobre Nascidos Vivos (Sinasc). **Resultados:** Foram notificados 16686 casos, com a predominância do sexo masculino (54,96%), faixa etária de menor de 24 horas (26,67%), raça parda (61,97%), escolaridade de 8 a 11 anos das mães (40,43%), idade da mãe de 20 a 24 anos (21,11%), taxa de mortalidade de 13,822 em 2013 e 11,722 em 2023. **Considerações finais:** Por fim, houve uma redução nas mortes infantis no Estado do Ceará, onde no ano de 2013, foi registrada a maior taxa de mortalidade infantil.
Descritores: *Mortalidade infantil; Mortalidade materna e infantil*.

RESUMEN
Objetivo: Analizar la situación epidemiológica de la mortalidad materna e infantil en Ceará, Brasil, de 2013 a 2023. **Métodos:** Se trata de un estudio epidemiológico descriptivo, realizado en septiembre de 2024, sobre las notificaciones de Mortalidad Infantil en el Estado de Ceará, en el período de 2013 a 2023. La recolección de datos fue realizada por el Sistema de Información sobre Mortalidad (SIM) y el Sistema de Información sobre Nacidos Vivos (Sinasc). **Resultados:** Se reportaron 16.686 casos, con predominio del sexo masculino (54,96%), grupo etario de menos de 24 horas (26,67%), mestizo (61,97%), escolaridad de la madre de 8 a 11 años (40,43%), edad de la madre de 20 a 24 años (21,11%), tasa de mortalidad de 13.822 en 2013 y 11.722 en 2023. **Consideraciones finales:** Finalmente, hubo una reducción de las muertes infantiles en el Estado de Ceará, donde en 2013 se registró la mayor tasa de mortalidad infantil.
Descriptores: *Mortalidad infantil; Mortalidad materna e infantil.*

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INTRODUCTION

In the context of epidemiological surveillance, infant mortality can be understood and characterized as recommendations to improve the notification of potential causes of death and to determine preventability criteria. This strategy also helps to enhance mortality records and contributes to preventive measures and health promotion[1]. Infant deaths correspond to deaths occurring among live-born children up to one year of age, specifically 364 (three hundred sixty-four) days. The number of deaths in this age group is divided into the following subgroups: early neonatal (0 to 6 days), late neonatal (7 to 27 days), and post-neonatal (28 to 364 days). For each of these components, specific actions have been taken to reduce them[2].

The Infant Mortality Rate (IMR) is a vital public health parameter, reflecting not only the socioeconomic conditions of an area but also the quality of maternal and child health services provided. The goal of global and national policies is to decrease infant mortality rates, particularly in the early neonatal, late neonatal, and post-neonatal aspects, as established by the Sustainable Development Goals (SDGs). These international targets, established by the United Nations (UN) in 2015, stipulate that by 2030, countries should reduce the neonatal mortality rate to less than 12 deaths per 1,000 live births, emphasizing the importance of preventive measures and health promotion to achieve this goal[3].

In Brazil, Ceará stands out as a significant setting for assessing infant mortality conditions, owing to its wide social diversity and structural obstacles in the healthcare system. It is crucial to monitor infant mortality between 2013 and 2023 to evaluate the effectiveness of public policies implemented and to recognize the most vulnerable regions. Furthermore, this assessment allows for a deeper understanding of the preventable causes of infant deaths and the creation of more precise disciplines.

In this context, considering the importance of infant mortality as a public health issue, this epidemiological bulletin aims to analyze the epidemiological situation of maternal and infant mortality in Ceará, Brazil, during the period from 2013 to 2023.

METHODS

This is a descriptive, retrospective epidemiological study with a quantitative approach, conducted in September 2024 by faculty and students from the Medical Course at the State University of Ceará (UECE), Crateús Campus, Ceará.

Data collection was carried out using two public databases: SIM and Sinasc, both publicly accessible and managed by the Brazilian Ministry of Health. The data were analyzed by macroregion and municipality, with a special focus on infant mortality in the municipality of Crateús, Ceará, from 2013 to 2023.

The information utilized in this study encompasses socioeconomic variables (gender, color/race, children's education, and mother's age), health-related variables (birth weight, number of deaths, age group of infant mortality, major diseases causing death and perinatal infections) and demographic variables (macroregions and municipalities of Ceará). For the categorization of causes of death, codes from the International Classification of Diseases, 10th Revision (ICD-10) and the ICD list of causes of death were employed.

The data were organized and tabulated using the program Excel, initially conducting a descriptive analysis to identify the number of infant deaths throughout the study period.

The IMR was calculated using the formula: number of deaths of residents under one year of age X 1000 / number of live births to resident mothers. The descriptors (Infant mortality) AND (Infant mortality, Brazil, Ceará) AND (Maternal and child mortality) were used in the databases "Lilacs" and "MedLine" to find the theoretical references.

Inclusion criteria considered studies that directly contained the previously described socioeconomic, health-related and demographic variables. Calculations were made through absolute frequency, relative frequency and incidence calculation.

All ethical procedures were respected, ensuring data confidentiality and responsible use of information. The research adhered to the ethical principles established for studies involving publicly available secondary data.

RESULTS

SOCIOECONOMIC VARIABLES RELATED TO IMR IN CEARÁ

In Ceará, from 2013 to 2023, 16,686 infant deaths were recorded in the Mortality Information System (SIM). From this number, we can make the following associations with socioeconomic variables: gender, color/race, mother's education and age, according to the tables provided below.

According to Table 1, it is observed that male infants accounted for 9,171 (54.96%) of infant deaths, while female infants accounted for 7,364 (44.13%) of infant deaths. In the state of Ceará, there was a higher percentage of infant deaths among male children, with 1,803 (10.83%) more cases compared to females. The "ignored" category recorded 151 cases (0.91%).

Table 1 – Children's gender, Ceará 2013 a 2023.

Gender	N	%
Male	9171	54,96%
Female	7364	44,13%
Ignored	151	0,91%
Total	16686	100,00%

Source: Mortality Information System – SIM.

According to Table 2, it is observed that the white color/race category accounted for 3,224 (19.32%) of infant deaths, the black color/race category accounted for 111 (0.67%), the yellow color/race category accounted for 46 (0.28%), the brown color/race category accounted for 10,341 (61.97%) and the indigenous color/race category accounted for 42 (0.25%). The number of infant deaths in the State of Ceará was highest among children of the brown color/race, with 7,117 (42.65%) more cases than the second most common, the white color/race. The ignored category presented 2,922 (17.51%), being the third highest percentage.

Table 2 – Children's color/race, Ceará 2013 a 2023.

Color/race	N	%
White	3224	19,32%
Black	111	0,67%
Yellow	46	0,28%
Brown	10341	61,97%
Indigenous	42	0,25%
Ignored	2922	17,51%
Total	16686	100,00%

Source: Mortality Information System – SIM

According to Table 3, it can be observed that mothers with no education accounted for 461 (2.76%) of cases, mothers with 1 to 3 years of education accounted for 1,021 (6.12%), those with 4 to 7 years accounted for 3,366 (20.17%), mothers with 8 to 11 years of education accounted for 6,746 (40.43%) and mothers with 12 years or more accounted for 1,658 (20.58%) of infant deaths. The highest percentage of infant deaths in the state of Ceará was among mothers with 8 to 11 years of education, with 3,312 (19.85%) more cases compared to the second largest group, which were the cases with unspecified education levels. The unspecified category represented 3,434 (20.58%).

Table 3 – Mother's education, Ceará, 2013 a 2023.

Education	N	%
No one	461	2,76%
1 to 3 years	1021	6,12%
4 to 7 years	3366	20,17%
8 to 11 years	6746	40,43%
12 years or more	1658	9,94%
Ignored	3434	20,58%
Total	16686	100,00%

Source: Mortality Information System – SIM.

According to Table 4, it is observed that the age of mothers under 10 years presented 1 (0.005%), from 10 to 14 years presented 261 (1.57%), from 15 to 19 years presented 2672 (16.01%), from 20 to 24 years presented 3522 (21.11%), from 25 to 29 years presented 3168 (18.99%), from 30 to 34 years presented 2712 (16.26%), from 35 to 39 years presented 1669 (10.00%), from 40 to 44 years presented 663 (3.97%), from 45 to 49 years presented 49 (0.29%) and from 50 to 54 years presented 1 (0.005%) infant deaths. The highest percentage of infant deaths in the state of Ceará was found among mothers aged 25 to 29 years, with 456 (2.73%) more cases compared to mothers aged 30 to 34 years, who ranked second. Ignored cases accounted for 1968 (11.79%).

Table 4 – Mother's age, Ceará 2013 a 2023.

Mother's age	N	%
Under 10 years	1	0,005%
10 to 14 years	261	1,57%
15 to 19 years	2672	16,01%
20 to 24 years	3522	21,11%
25 to 29 years	3168	18,99%

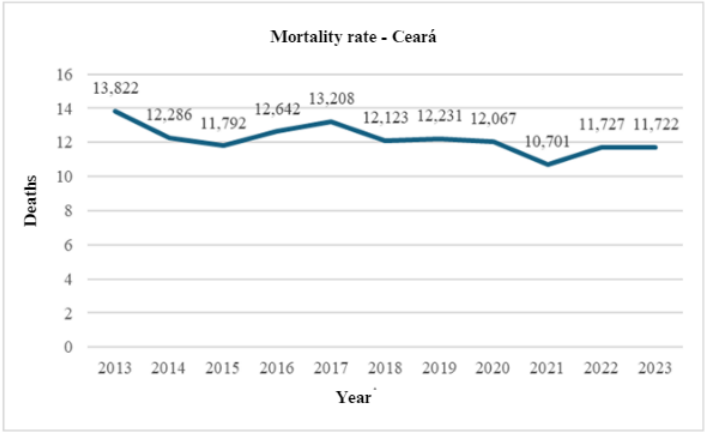
30 to 34 years	2712	16,26%
35 to 39 years	1669	10,00%
40 to 44 years	663	3,97%
45 to 49 years	49	0,29%
50 to 54 years	1	0,005%
Ignored	1968	11,79%
Total	16686	100,00%

Source: Mortality Information System – SIM.

VARIABLES RELATED TO HEALTH AND IMR IN CEARÁ

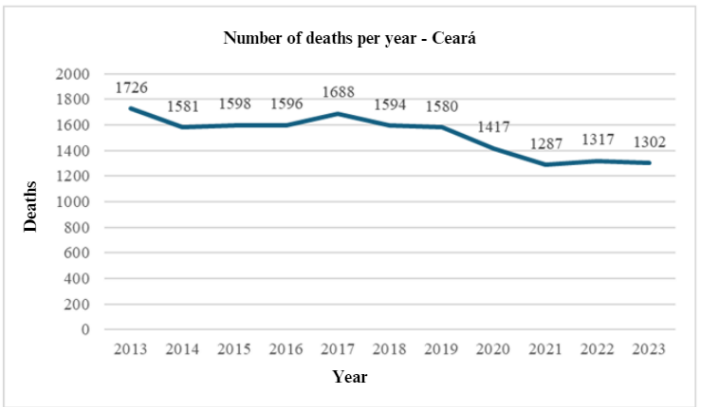
Regarding the Infant Mortality Rate (IMR) from 2013 to 2023 in Ceará, it remained within a maximum rate of 13.822 and a minimum of 11.722 (Graph 1). The highest raw number of infant deaths occurred in 2013, with approximately 1,726 deaths and the lowest in 2023 (Graph 2). This trend reveals that, despite fluctuations over this period, there was an overall decline in the IMR and consequently in the number of deaths in this social group. It is worth noting that the total raw number of deaths in the state amounted to 16,686. Below is a graph showing the infant mortality rate and the raw number of infant deaths over the years from 2013 to 2023.

Graph 1 - Mortality rate - Ceará



Source: Mortality Information System – SIM

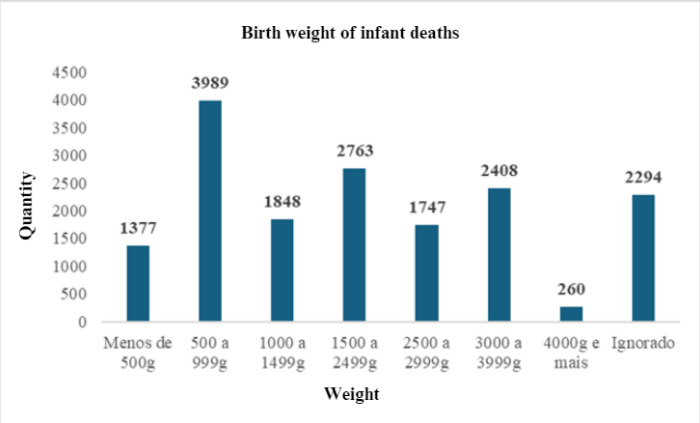
Graph 2 - Number of deaths per year - Ceará



Source: Mortality Information System – SIM

A fundamental data point related to health variables is the birth weight of infants who passed away in Ceará (Graph 3), as it directly correlates with the newborn's development. According to the Mortality Information System (SIM), the highest number of deaths is concentrated in the weight range of 500 to 999g, indicating that most infant mortality occurred in newborns classified as extremely low birth weight (LBW). Below are the graph and table that show this relationship between infant mortality and birth weight, as well as the age range of infant deaths, respectively.

Graph 3 - Birth weight of infant deaths - Ceará



Source: Mortality Information System – SIM

Tabela 5 – Age group of infant deaths - Ceará 2013 a 2023.

Age group	N	%
Under 24 hours	4617	26,67%
1 day	1429	8,56%
2 to 6 days	2998	17,96%
7 to 13 days	1430	8,60%
14 to 27 days	1244	7,45%
28 days to 1 month	1676	10,04%
2 to 11 months	3301	19,70%

Source: Mortality Information System – SIM

DEMOGRAPHIC VARIABLES RELATED TO IMR IN CEARÁ

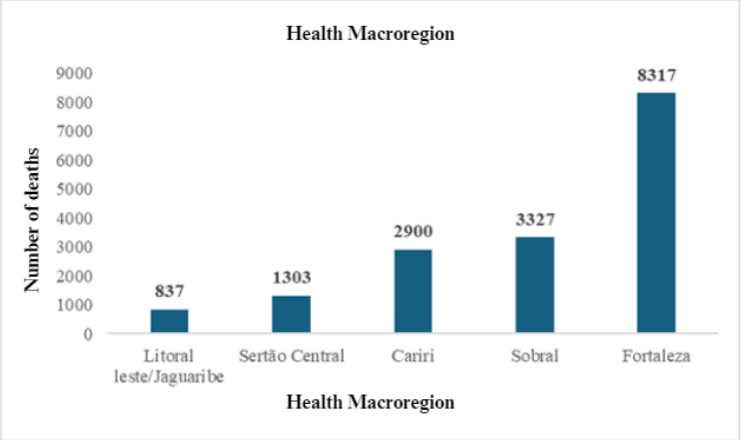
Health Macroregions of Ceará

The state of Ceará is divided into five health macroregions (Fortaleza, Sobral, Cariri, Sertão Central, and Litoral Leste/Jaguaribe). These are large territorial areas that facilitate the organization and provision of health services in a regionalized and integrated manner. The goal of these macroregions is to ensure equitable access to health services at different levels of complexity, from primary care to high-complexity care.

According to Graph 4, it is observed that the deaths occurring in the state's macroregions from 2013 to 2023 were distributed as follows: 8317 (49.8%) in the Fortaleza Macroregion, 3327 (19.9%) in the Sobral Macroregion, 2900 (17.4%) in the

Cariri Macroregion, 1303 (7.8%) in the Sertão Central Macroregion and 837 (5.1%) in the Litoral Leste/Jaguaribe Macroregion.

Graph 4 - Health Macroregion - Ceará

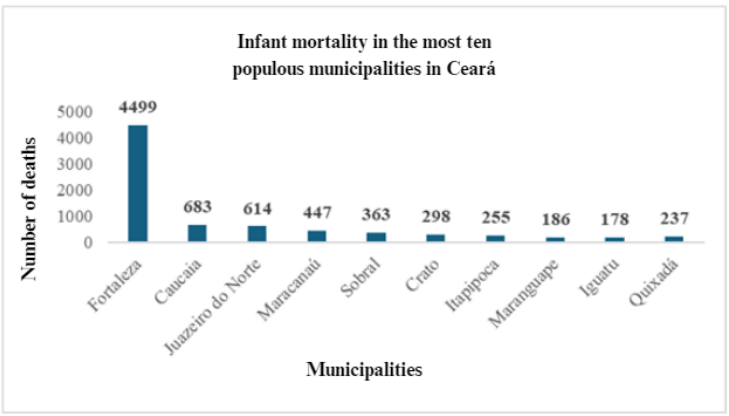


Source: Mortality Information System – SIM

Municipalities of Ceará

According to data from IBGE, the 10 most populous municipalities in Ceará are: Fortaleza, Caucaia, Juazeiro do Norte, Maracanaú, Sobral, Itapipoca, Crato, Maranguape, Iguatu and Quixadá[4].

Graph 5 - Infant mortality in the most populous municipalities in Ceará



Source: Mortality Information System – SIM

The state of Ceará recorded a total of 16,684 infant deaths from 2013 to 2023. In this context, an analysis of the number of deaths in the ten most populous municipalities reveals 4,499 (27%) in Fortaleza, 683 (4%) in Caucaia, 614 (3.7%) in Juazeiro do Norte, 447 (2.7%) in Maracanaú, 363 (2.2%) in Sobral, 298 (1.8%) in Crato, 255 (1.5%) in Itapipoca, 186 (1.1%) in Maranguape, 178 (1%) in Iguatu and 237 (1.4%) in Quixadá. In this scenario, it is noteworthy that these ten municipalities account for 46.4% of infant deaths in Ceará. Another noteworthy point is that the municipality of Quixadá, despite being less populous than Itapipoca, Maranguape, and Iguatu, has a higher number of

infant deaths, highlighting the fact that other intrinsic factors in public health impact these statistics.

DISCUSSION

Infant mortality is a crucial indicator for assessing the quality of life and public health advancements in a country or region, measuring the number of deaths of children under one year of age for every thousand live births.

Since 1990, IMRs have decreased by nearly 60% worldwide. However, the COVID-19 pandemic may reverse some currently positive indicators due to the interruption of essential health services. This is highlighted in the annual report of the UN inter-agency group for infant mortality estimates, which directly influences several countries, particularly developing nations like Brazil. The text of the UN report evaluates indices across all countries and provides projections for the future, such as the estimate that 48 million children under five may die between 2020 and 2030, with half of these deaths occurring in newborns[5].

In Ceará, the IMR has shown a significant reduction over the past decades. Thanks to investments in public health, basic sanitation and programs focused on maternal and child health, such as the Family Health Program (PSF), Ceará has managed to achieve notable declines in IMR. However, rates still vary between urban and rural areas and are influenced by socioeconomic factors and access to health services. In poorer areas, infant mortality tends to be higher, mainly due to conditions such as malnutrition, lack of sanitation and difficulties in accessing neonatal care[5].

In Brazil, IMR decreased from 62 deaths per thousand live births in 1980 to approximately 13.4 per thousand in 2021. This progress has been driven by public health policies aimed at expanding vaccination coverage, improving prenatal care and investing in basic sanitation and housing conditions[3].

However, significant regional disparities persist in Brazil, with states in the North and Northeast regions exhibiting higher rates of infant mortality compared to those in the Southeast and South regions. Income redistribution programs and improvements in access to health services are helping to reduce this inequality[3,6].

The evaluation of IMR in Ceará from 2013 to 2023 reveals significant disparities between genders. Males accounted for 54.96% of infant deaths, while females represented 44.13%. This difference, with an increase of 10.83% in the number of deaths among boys, reflects a pattern frequently identified in epidemiological studies, indicating greater biological vulnerability among male newborns compared to their female counterparts[6].

Factors such as the inexperience of the immune system, higher predisposition to perinatal complications, and increased incidence of respiratory illnesses may influence this disparity. Furthermore, the percentage of unreported deaths, though modest (0.91%), underscores the need to enhance the quality of mortality records to obtain more accurate information for effective interventions[6].

Regarding color or race, infant mortality in Ceará was predominantly linked to the mixed-race population, which accounted for 61.97% of deaths. This figure is considerably higher compared to the white population (19.32%) and black population (0.67%), suggesting a strong correlation between color/race and social vulnerability. The

elevated death rate among mixed-race children may be associated with socioeconomic disparities impacting this population, such as limited access to high-quality health services, inadequate housing conditions and low maternal education[7].

Certainly, maternal educational attainment emerged as a crucial element: the majority of infant deaths occurred among mothers with 8 to 11 years of education (40.43%), demonstrating that the level of education directly affects the ability to access and appropriately use health services. Conversely, mothers with no education, who accounted for 2.76% of deaths, highlight the importance of policies that promote education and social support for pregnant women and newborns[7].

In addition to the highlighted variables, another aspect studied in this epidemiological analysis was the IMRs during the period from 2013 to 2023. The IMR is a reliable indicator of both the health of a population and the efficiency of health systems, allowing for the measurement of the degree of social inequality and access to health among different population groups. In this perspective, these rates are essential for supporting the planning and creation of public policies aimed at prenatal care, childbirth, and the health of newborns[9].

In this regard, a reduction in IMRs was observed over the analyzed time frame, where in 2013 the rate was 13.822 and in 2023 it was 11.722. It is noteworthy that this reduction did not occur in a linear and progressive manner, as there were fluctuations during this period. Thus, the decrease in IMRs observed in Ceará aligns with similar trends in Brazil, where there has been a significant reduction in IMRs in recent years[10].

Another essential variable studied in this work was birth weight in infant deaths. The epidemiological analysis revealed that the majority of deaths occurred within the weight range of 500 to 999 grams, which indicates a weight significantly below the normal. LBW referring to infants weighing less than 2,500 grams, is a significant public health issue, as it is strongly linked to infant mortality, in addition to increasing the risk of diseases in the future. When LBW is associated with prematurity or fetal growth restriction, the risk of death for the newborn is even greater. Thus, the lower the birth weight and gestational age, the higher the likelihood of death, differing from LBW newborns with appropriate gestational age[10].

A direct consequence of LBW is a drastic reduction in the survival capacity of preterm infants. As a result, the age range for infant deaths tends to occur shortly after birth, within the first days of life. Table 5 shows that the majority of deaths (26.67%) occur within less than 24 hours of the child's life during the perinatal period, with nearly 80% occurring within the first month after birth[8].

Perinatal-related conditions remain one of the leading causes of mortality in Brazil, often resulting from maternal factors and complications during pregnancy, labor, and delivery. This reflects failures in the care and attention provided to women during gestation and childbirth. Perinatal mortality is strongly associated with obstetric causes and is thus considered largely preventable, serving as an indicator of the quality of prenatal and childbirth assistance. In addition to these factors, issues such as infectious diseases, chromosomal anomalies and congenital malformations may also contribute to premature births and, consequently, increase the risk of infant death[10].

It is well known that quality prenatal care is fundamental for reducing maternal and infant morbidity and mortality, as it allows for the early detection of risks both during pregnancy and labor, as well as ensuring appropriate referrals when necessary. In this context, measures such as well-structured prenatal care, health promotion actions, prevention of adverse outcomes and the promotion of fetal development are essential to minimize complications during gestation, childbirth and the postpartum period. These initiatives also aid in the early identification of maternal, perinatal and neonatal health issues, which are crucial for preventing infant deaths. However, despite various programs and policies created to reduce infant mortality, challenges related to social and economic inequalities persist, along with a lack of equitable access to quality health services, which continues to be a constant obstacle for governments and managers[11].

The evaluation of IMR across the different health macroregions of Ceará, illustrated in Graph 4, indicates a marked concentration of deaths in the Macroregion of Fortaleza, which accounts for 49.8% of infant deaths in the state from 2013 to 2023. This data highlights the high population density and the number of births in the capital and the metropolitan region, along with the possible concentration of high-complexity health services in this area, which may attract more severe cases from across the state[9].

However, the presence of significant numbers in regions such as Sobral (19.9%) and Cariri (17.4%) indicates the need to intensify regional health planning, ensuring that access to essential care is effective across all macroregions. The disparity in deaths between regions indicates variations in the social health factors and access to services. More rural regions, such as Sertão Central (7.8%) and Litoral Leste/Jaguaribe (5.1%), show lower absolute numbers, which may indicate underreporting or barriers to access services. This context underscores the importance of a unified and regionalized strategy for monitoring and analyzing infant mortality, taking into account the specific characteristics and demands of each macroregion in the formulation of more effective and equitable public policies[12].

The assessment of IMR in the 10 most populous municipalities of Ceará reveals a notable concentration of deaths in Fortaleza, representing 27% of the state total, highlighting the impact of urban conditions and the high demand on health services in the capital. However, cities such as Caucaia, Juazeiro do Norte, and Maracanaú, despite being equally populous, exhibit lower percentages, which may suggest differences in access to and quality of health services[8,9].

The municipality of Quixadá warrants special attention, as it has a significantly higher IMR despite being less populous than Itapipoca, Maranguape and Iguatu. This data underscores the importance of considering factors beyond population density, such as the quality of health infrastructure, availability of essential services, socioeconomic conditions and access to prenatal and neonatal care. Consequently, IMR is directly influenced by social health factors, such as poverty, maternal education, basic sanitation and access to health services. When neglected, these factors elevate children's vulnerability across various scenarios, regardless of population size[12].

FINAL CONSIDERATIONS

The results presented indicate a reduction in infant mortality in the State of Ceará from 2013 to 2023. It is important to note that, in 2013, the highest infant mortality rate was recorded. Throughout the studied period, the majority of deaths occurred among premature infants weighing between 500g and 999g, with the causes of these deaths being directly related to the fetal and perinatal periods, as well as shortly after birth, resulting in nearly 90% of deaths occurring before the first month of life.

Regarding socioeconomic variables, it was observed that boys were more affected, and the most prevalent race/color among the victims was mixed-race. Concerning maternal characteristics, the most common age group was between 20 and 29 years, and the average education level varied from 8 to 11 years of schooling. The macroregion of Fortaleza stood out as the area with the highest number of infant deaths in Ceará. Finally, although reducing infant mortality remains a significant challenge, the gradual decline in this rate in recent years, despite fluctuations, demonstrates that it is possible to achieve substantial progress in Ceará.

The advantages of conducting research on infant mortality in Ceará primarily consist of the ability to recognize epidemiological patterns and socioeconomic and health factors that directly impact infant deaths. This can guide strategic actions and more effective public policies. Access to information from large systems, such as SIM and Sinasc, enables an extensive and thorough evaluation of the distribution of infant deaths, assisting in identifying the most susceptible populations and allocating resources to more vulnerable areas and groups.

Epidemiological studies on infant mortality in Ceará face some limitations that may affect the quality and applicability of the results, such as incomplete or inconsistent data. In Ceará, especially in more remote regions, underreporting or improper recording of causes of infant death is common. These incomplete data can lead to a distorted view of the actual causes and numbers of infant mortality.

Other restrictions relate to the lack of quality and precision in the information collected, evidenced by the absence of data on relevant variables, such as race/color and education level. Furthermore, the use of secondary public data limits the analysis to information that has already been gathered, preventing the examination of more specific aspects or real-time updates.

To overcome these limitations, it is necessary to improve health records and intensify joint epidemiological surveillance actions, particularly in regions with greater social vulnerability.

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