Infant Mortality: An Analysis of Avoidable Deaths in a Municipality in the Northeast of Brazil, 2008 to 2016

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ABSTRACT

Introduction: *The plan "Every Newborn: an action plan to end preventable deaths" developed by the World Health Organization and the United Nations Children's Fund has the goal of ending preventable child deaths.* ***Objective:*** *Analyze infant mortality rates in the municipality of Sobral, Ceará, between 2008 and 2016.* ***Methods:*** *This was an observational, cross-sectional study to analyze and compare mortality rates in a middle-sized municipality. This study was made up of all infant deaths less than 1 year of age registered in the Mortality Information System. The deaths were revised and classified as preventable, ill-defined causes and other causes according to the List of Preventable Deaths through Interventions from the Unified Health System.* ***Results:*** *During the study period, the mortality rate varied between 8.36 and 18.93 per 1000 live births, with most infant deaths occurred during the early neonatal period (<7 days of life). Furthermore, most infant deaths were classified as preventable, between 60.0 and 78.3%. Most of the deaths were classified as preventable through adequate assistance to women during pregnancy; adequate assistance during labor; or adequate assistance to the newborn.* ***Conclusion:*** *It was concluded that most of the deaths on infants under 1 year of age in the municipality were preventable with adequate assistance to women during pregnancy; adequate assistance during labor; or adequate assistance to the newborn. The approach used in this study may assist in the development of health plans and programs directed to the health of women during pregnancy and to the newborn.*

Keywords: Infant mortality, Underlying cause of death, Child health services, Pregnant women, Epidemiology

INTRODUCTION

Infant mortality is an important indicator of a country's health, as it is associated with several factors, including access and quality of health care, socioeconomic conditions, disease rates, health programs for women of childbearing age, and health practices public [1,2]. In the last decades, there has been a change in the mortality indicators of the Brazilian population with the reduction of infant mortality [3]. According to the National Monitoring Report on the Millennium Development Goals [4], prepared by the United Nations, Brazil has already gone beyond the established goal of up to 15.7 deaths per thousand live births by 2015, the rate decreased from 47.1 in 1990 to 13.25 in 2014 [5].

However, it is still far from the figures presented in Finland (2.3 deaths per 1000 live births), Japan (2.3), Portugal (2.5), Sweden (2.5) and Czech Republic (2.7) [6]. In addition, there are large discrepancies between the rates in the different regions of Brazil, while the south and southeast regions present rates of 10.1/1000 and 12.6/1000, respectively; the northeast presents the highest rate in the country with 23.0/1000, and in the state of Ceará (a state in the northeast region) this rate is 19.7/1000 [7].

The "The Every Newborn Action Plan", developed by the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), launched in Johannesburg in July 2014, guidelines on how to eliminate preventable

neonatal deaths. The main goal of the plan is for all countries in the world to have infant mortality rates of less than 10/1000 live births by 2035, continue to reduce death and disability and close subnational equity gaps, ensuring that no newborn is left unattended [8].

Infant mortality rates are expressed in numbers only. For there to be a real reduction it is necessary to look closely at the composition of these rates, identify each cause, to understand if, and how each death could be avoided. As far as it was possible to identify in the literature, there are few studies conducted in the northeast of Brazil that discriminate the causes of death of children under 1 year of age. Based on this premise, the objective of this study is to investigate the causes of death of infants under 1 year of age in the municipality of Sobral, Ceará, from 2008 to 2016. Based on the results, health policy managers may elaborate policies and programs to reduce infant mortality, identifying the causes of death that are possibly avoidable.

METHODS

Study Design

To address the purpose of the research, an observational cross-sectional study was developed and programmed. The study was composed of all the deaths of children up to one year of age registered in the Information System on Mortality-SIM (instrument of data collection: Declaration of Death-DO) in the municipality of Sobral, Ceará, between 2008 and 2017.

Study Setting

Sobral is a municipality belonging to the state of Ceará, whose economy occupies the fourth position, with a GDP of R $ 2,348,207,000 or R $ 12,472 49 per capita. With a population of 197 663 inhabitants and population density of 93.11 inhabitants per km², the urbanization rate of the municipality is 88.35% [9].

Inclusion Criteria

To be included in the study sample, deaths had to be recorded in the SIM, residing in the municipality of Sobral, Ceará, and aged up to one year, with the respective ICD-10 codes identifying the underlying cause of death [10,11]. Individuals with incomplete data in the records, or residing outside the municipality, were excluded.

Variables

According to the records of the deaths, a standardized form was filled out, containing the date of death, ICD-10 code, age (>7 days=early neonatal mortality, 7>28 days=late neonatal mortality, 28>365 days=post-neonatal mortality) and the gender of the child. Deaths were reviewed and classified as avoidable, ill-defined causes and other causes according to the List of Causes of Deaths Avoidable by Interventions of the Unified Health System (avoidable: reducible by immune prevention actions, reducible by adequate attention to the woman during pregnancy, which are reducible by adequate attention to the woman in childbirth, reducible by adequate attention to the newborn, reducible by actions of diagnosis and appropriate treatment, and reducible by actions of health promotion linked to attention actions; not clearly avoidable) [12-15].

Methods of Data Collection

Data on deaths were collected at the headquarters of the Secretariat of Health and Social Action located in Sobral, Ceará of the Information System on Live Births (SINASC)/Mortality Information System (SIM/MS), then released on a data sheet standardized by a previously trained professional.

Statistical Analysis of Data

Epi Info, version 6.04, and SPSS software version 17.0 for Windows (SPSS Inc., Chicago, IL, USA) were used for the tabulation and analysis of the data. The research project was conducted following the ethical principles established by the Research Ethics Committee (CEP), as defined in the National Health Council Resolution #466/2012.

RESULTS

Table 1 shows the distribution of live births and the number of non-fetal deaths up to the age of 1 year occurred in the municipality of Sobral, Ceará between 2008 and 2016. The number of deaths was 43 in 2008, 60 in 2009, 42 in 2010, 58 in 2011 and 46 in 2012; 55 in 2013, 46 in 2014, 29 in 2015 and 30 in 2016 with a mortality rate ranging from (13.87

to 9.12) per thousand live births (Table 1).

Table 1 Live births, number of deaths up to 1 year of age and the infant mortality rate in the municipality of Sobral, Ceará, from 2008 to 2016

Year	Live Births	Number of deaths>1 year of age	Mortality Rate†
2008	3.1	43	13.87
2009	3.169	60	18.93
2010	3.084	42	13.62
2011	3.193	58	18.16
2012	3.156	46	14.58
2013	3.269	55	16.82
2014	3.471	46	13.25
2015	3.468	29	8.36
2016	3.287	30	9.12
Source: Live Birth Information System (SINASC)/Mortality Information System (SIM/MS) †/1000 live births			

Table 2 shows the distribution of infant deaths according to age. Infant deaths were categorized as follows: <7 days=early neonatal mortality; $7 \geq 28$ days=late neonatal mortality; and $28 \geq 365$ days=post-neonatal mortality. In 2008 and 2009, most of the infant deaths were in the category of early neonatal mortality, being 65.1% and 63.3%, respectively; in 2011 the majority of deaths (39.7%) were classified as post-natal mortality (Table 2).

Table 2 Distribution of infant deaths according to age in the municipality of Sobral, Ceará, from 2008 to 2016

Age	2008	2009	2010	2011	2012	2013	2014	2015	2016
<7 days	28 (65.1)	38 (63.3)	24 (57.1)	22 (37.9)	22 (47.8)	33 (58.9)	26 (57.7)	15 (50.0)	10 (34.5)
$7 \geq 28$ days	8 (18.6)	12 (20.0)	9 (21.4)	13 (22.4)	13 (28.3)	11 (19.7)	10 (22.3)	5 (16.7)	8 (27.5)
$28 \geq 365$ days	7 (16.3)	10 (16.7)	9 (21.4)	23 (39.7)	11 (23.9)	12 (21.4)	9 (20.0)	10 (33.3)	11 (38.0)
Source: Live Birth Information System (SINASC) /Mortality Information System (SIM/MS) All numbers are absolute except numbers in parentheses, which represent percentages									

According to the categorization of causes of death according to the List of Predictable Causes of Tabulation of Causes [15], based on the ICD-10, in all the years of the study most of the deaths were classified as preventable: 76, 7% in 2008; 71.7% in 2009; 73.8% in 2010; 63.8% in 2011; 78.3% in 2012; 67.8% in 2013; 60.0% in 2014; 73.3% in 2015; 69.0% in 2016 followed by other causes (not clearly avoidable), the percentages of which ranged from 16.3 to 37.7; finally came the ill-defined causes, in which no deaths were registered in 2010, 2012, 2015 and 2016 (Table 3).

Table 3 The categorization of the primary cause of death according to the Tabulation List of Preventable Causes from the Ministry of Health based on the ICD-10 in the municipality of Sobral, Ceará, from 2008 to 2016

Category	2008	2009	2010	2011	2012	2013	2014	2015	2016
Avoidable	33 (76.7)	43 (71.7)	31 (73.8)	37 (63.8)	36 (78.3)	38 (67.8)	27 (60.0)	22 (73.3)	20 (69.0)
Poorly defined causes	3 (7.0)	4 (6.7)	--	4 (6.9)	--	1 (1.78)	1 (2.2)	--	--
Other causes: not clearly avoidable	7 (16.3)	13 (21.7)	11 (26.2)	17 (29.3)	10 (21.7)	17 (30.3)	17 (37.7)	8 (26.6)	9 (31.0)
Source: Live Birth Information System (SINASC)/Mortality Information System (SIM/MS) All numbers are absolute except numbers in parentheses, which represent percentages									

In the analysis of avoidable causes, the majority of deaths were categorized as: reducible through adequate attention to women during pregnancy 39.4% in 2008, 37.2% in 2009, 22.6% in 2010, 24.3% in 2011, 25.0% in 2012, 14.3% in 2013, 24.4% in 2014, 22.6% in 2015 and 12.9% in 2016; reducible through adequate care for women at childbirth 18.2% in 2008, 20.9% in 2009, 19.4% in 2010, 16.2% in 2011, 11.1% in 2012, 10.7% in 2013, 1.2% in 2014, 9.7%

in 2015 and 3.2 in 2016; reducible through adequate attention to the newborn-33.3% in 2008, 32.6% in 2009, 45.2% in 2010, 43.2% in 2011, 52.8% in 2012, 10.7% in 2013 , 22.2% in 2014, 6.5% in 2015 and 22.6% in 2016 (Table 4).

Table 4 The distribution of avoidable causes of death according to the List of Preventable Causes from the Ministry of Health based on the ICD-10 in the municipality of Sobral, Ceará from 2008 to 2016

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016
Avoidable causes									
Reducible through immunoprevention actions	1 (3.0)	--	--	--	--	--	--	--	1 (3.2)
Reducible through adequate attention to the woman during pregnancy	13 (39.4)	16 (37.2)	7 (22.6)	9 (24.3)	9 (25.0)	8 (14.3)	11 (24.4)	7 (22.6)	4 (12.9)
Reducible through adequate attention to women at childbirth	6 (18.2)	9 (20.9)	(19.4)	6 (16.2)	4 (11.1)	6 (10.7)	1 (1.2)	3 (9.7)	1 (3.2)
Reducible through proper attention to the newborn	11 (33.3)	14 (32.6)	14 (45.2)	16 (43.2)	19 (52.8)	6 (10.7)	10 (22.2)	(6.5)	7 (22.6)
Reducible through appropriate diagnostic and treatment actions	2 (6.1)	3 (7.0)	2 (6.5)	3 (8.1)	3 (8.3)	3 (5.4)	2 (4.4)	4 (12.9)	3 (9.7)
Reducible through actions of health promotion linked to health care actions	--	1 (2.3)	2 (6.5)	3 (8.1)	1 (2.8)	2 (3.6)	3 (6.7)	6 (19.4)	4 (12.9)
Source: Live Birth Information System (SINASC) /Mortality Information System (SIM/MS) All numbers are absolute except numbers in parentheses, which represent percentages									

In most of the study years, except for 2012 and 2013, the cause of death with the highest prevalence was unspecified bacterial septicemia of the newborn (ICD-10 P36.9), in 2008 there were 9 cases, or 20.9% of all the basic causes of death; in 2009 there were 13 cases, or 21.7%; in 2010 there were 10 cases, or 23.8%; in 2011 there were 9 cases, or 15.5%; in 2012 there were 16 cases, or 34.7%; in 2013 there were 8 cases, or 14.5%; in 2014 there were 11 cases, or 23.9%; in 2015 there were 8 cases, or 27.5%; and in 2016 there were 9 cases, or 30%. In 2012 and 2013, the most prevalent cause was extreme immaturity (ICD-10 P07.2), with 23 cases (50%) in 2012 and 13 cases (23.6%) in 2013 (Data not shown).

DISCUSSION

From the results of this study, we identified the following characteristics in the deaths of children up to the age of one year living in the municipality of Sobral between 2008 and 2016:

- The infant mortality rate ranged from 8.36 to 18.93 per 1,000 live births

- The majority of deaths occurred within the first seven days of life

- The majority of deaths (between 60.0 and 78.3%) were classified as preventable

- Between 1.78 and 7.0% of deaths were classified as ill-defined causes, in 2010, 2012, 2015 and 2016 there were no deaths in this category

- Deaths due to other causes: not clearly avoidable varied between 16.3 and 37.7%

- The most prevalent avoidable causes were categorized as: reducible through adequate attention to the newborn, reducible through adequate attention to women during pregnancy, reducible through adequate attention to women during childbirth

- During the study period two deaths were reduced by immunoprevention actions

- The cause of death with the highest prevalence was unspecified bacterial septicemia of the newborn (ICD-10 P36.9)

The classification of infant mortality according to WHO is more comprehensive including children up to five years of age. According to the WHO [16] 6.3 million children under 5 died in 2013, and more than half of these deaths were preventable. The risk of death of a child is greater in the first 28 days of life, or in the neonatal period, and it is during this period that 44% of deaths are noted. In June 2014, WHO, UNICEF and partners published a comprehensive plan to eliminate preventable deaths of newborns by 2035. The plan calls for all countries to take steps to provide

basic and cost-effective health services, especially during childbirth, and to improve the quality of health care [8]. The Millennium Development Goals 2013 are to reduce child and maternal deaths globally; the fourth Millennium Development Goal is to reduce the under-five mortality rate among children under five by two-thirds (between 1990 and 2015); and infant mortality has a very close link to the fifth Objective, which is to improve maternal health and reduce the maternal mortality ratio (between 1990 and 2015) by three-quarters [4].

In Brazil, with the aim of reducing infant mortality, several studies have already been conducted to obtain a comprehensive description of the causes of death of children under 1 year. In the city of Londrina, Paraná, an exploratory and comparative study, using the SINASC database, was conducted on preventable infant deaths in two biennia, 2000/2001 and 2007/2008. Regarding infant deaths, in the biennium of 2000/2001, 71.6% were considered preventable by SUS interventions and 65.5% in 2007/2008. The predominant categories of avoidable deaths were 'reducible by adequate attention to women in gestation', 'reducible by adequate attention to women at childbirth', and 'reducible by adequate attention to the newborn' [17].

In a cross-sectional descriptive study conducted at the General Pediatric Hospital of the Instituto Materno Infantil de Pernambuco in Recife, PE, in the year 2000, it was identified that both early and late neonatal deaths presented a higher proportion of diagnosis and treatment. In the analysis of avoidable deaths, it was found that of the 263 deaths in the first month of life, 75% could have been avoided [18]. Another cross-sectional study conducted in Recife, PE, between 2000 and 2009, found a reduction in the infant mortality rate from 20.4 to 12.1 per 1000 live births. During the study period, 3743 deaths were recorded, of which 2681 (76.4%) were classified as preventable, most of these deaths were reducible by 'adequate attention to women in gestation' [19].

A study conducted in three municipalities in the state of Paraná (Maringá, Sarandi, and Paiçandú) between 2004 and 2008, concluded that of the 284 deaths of children under 1 year of age, 68.7% were considered avoidable, and the main causes of death were diseases originated during the perinatal period (73.8%), external causes (11.3%), and diseases of the respiratory system (5.1%) [20].

Drumond, et al., evaluated the causes of infant mortality according to the tabulation list of the Ministry of Health according to race/color in Belo Horizonte, MG between 2001 and 2009 [21]. The researchers identified that the rate of preventable deaths was higher among non-white children; low quality of care during pregnancy and delivery was more likely among non-white women. It was concluded that to reduce infant mortality, we should identify non-white children as a risk group and increase the efficiency of health services to prevent preventable deaths.

According to Vargas, the infant mortality rate in Brazil reduced from 85.6 to 37.5 per 1000 live births between 1980 and 1996 [22], although this rate hides large differences between urban and rural areas and between socioeconomic classes, it has been identified that economically disadvantaged people are excluded from adequate maternal and childcare.

This was one of the first municipal studies conducted in a medium-sized city (with a population of almost 200,000) in the northeastern region of Brazil to investigate the causes of death of children under 1 year of age during a period of five years. Another advantage is that this study was carried out with data from the SINASC/SIM MS, and with this, all relevant data were counted for the municipality and its inhabitants, covering all hospitals, emergency services, and other health services. The results obtained in this study present an epidemiological profile of infant deaths between 2008 and 2012 and based on these results, specific public policies can be developed to reduce infant mortality. If other municipalities conducted similar studies, it would be a step in the right direction to meet WHO and UNICEF's goal to ensure that no newborn is left unattended.

Some limitations need to be acknowledged and addressed regarding this study. Many confounding factors may affect the outcome of the study. These include errors in identifying the cause of death, typos in the databases, absence of identification document of the deceased that proves the date of birth, naturalness, and affiliation or address of residence. It would be interesting to conduct this study with more variables such as details on the care provided during gestation, delivery and the newborn. However, despite these limitations, our study was able to identify differences in the results obtained.

The infant mortality rate in Sobral, Ceará ranged from 8.36 to 18.93 deaths per thousand live births between 2008 and 2016. From this study, we identified that the majority of deaths of children under 1 year of age in the municipality between 2008 and 2016 could have been avoided with adequate attention women at delivery, adequate attention

to women during pregnancy, and adequate attention to the newborn. In addition, special attention should be given to children up to seven days of age, as this represents an important risk group. Another item that should be better investigated is unspecified bacterial septicemia of the newborn, as this basic cause constitutes the main cause of death.

CONCLUSION

From this study, we conclude that the municipality of Sobral needs programs and health care plans for pregnant women and newborn, with professionals previously trained to reduce these unnecessary deaths. The researchers recommend that all municipalities conduct similar studies to better understand the infant mortality rate, thus enabling the country to reach the goals established in the "The Every Newborn Action Plan".

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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