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Infant Mortality and Its Underlying Causes of Death in Araraquara-SP, Brazil from 2007 to 2015

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Authors' contributions

This work was carried out in collaboration between all authors. Authors LCML and RTJ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors GCB, GPR, GBMJ, LCB and TFD managed the literature searches. All authors discussed the results, read and approved the final manuscript.

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ABSTRACT

Aim: This study was done to characterize the evolution of infant mortality rate in the period 2007-2015 in Araraquara- SP, Brazil and to identify the main causes of death.
Design: It was an exploratory cross-sectional epidemiological study.
Subjects: Data sources for live births and deaths of infants under 1 year were, respectively, SINASC and SIM. The study period was divided into three-years-period, aiming to identify statistically significant differences between two periods. Death´s causes were codified according to ICD-10.
Results: The infant mortality rate, between 2007 and 2015, was 11.7 per 1,000 live births, and was stable with no statistically significant differences between the three-year-period. Perinatal

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causes were the most common in the neonatal period (73.2%), followed by congenital malformations (21.4%). In the postneonatal period, congenital malformations accounted for 30.2% of deaths, followed by influenza and pneumonia, with 11.3%.
Conclusions: The infant mortality rates were stable from 2007 to 2015. The postneonatal mortality was the least of the components, so that the neonatal period was responsible for 80.9% of the deaths. The perinatal causes accounted for 60.6% of the deaths among children of less than one year of age, and were the main cause of mortality.

Keywords: Infant mortality; epidemiology; causes of death.

1. INTRODUCTION

The infant mortality rate is an indicator used for the assessment of the health status of populations, being appropriate for comparisons in historical series in different societies. Because of its multi-causal character, infant mortality has unquestionable importance in the drawing up of health policies, especially in the planning and assessment of health programs [1].

The richness of this indicator arises from the fact that many of the deaths of children under one year of age are avoidable by means of interventions in various fields of social, economic and cultural life [2]. The prevention of infant deaths depends on interventions which vary from the improvement of prenatal attention and labor, policies which encourage breast-feeding, and vaccination programs, to the expansion of basic sanitation coverage, to the increase in the schooling of the parents, and the increase in family income.

The infant mortality rate (IMR) expresses the possibility of the child's dying before 1 year of age per 1,000 live births (‰ LB), permitting subdivision, according to the period in which the decease occurred, into neonatal period and postneonatal period, corresponding, respectively, to the periods "less than 28 days" and "between 28 and 364 days" from the date of birth. This division favors the understanding of the underlying causes of mortality, as it presents distinct characteristics according to the period of occurrence.

The presupposition which gives support to infant mortality as a good indicator of the health status of a community arises from the fact that the great majority of children's deaths – the exception being due to deaths from congenital malformations – are avoidable, and that they only occur by reason of systemic failures which allow these children to die prematurely. An aggravating factor is that, apart from the affective load which these deaths represent in family terms, there is also a considerable loss to society, arising from their demographic and economic implications. In the last 50 years, Brazil has presented a reduction in fecundity, and the country's population has been aging rapidly. Early deaths also affect other demographic indicators, such as life expectancy at birth and the size of the population at reproductive age in the following generations.

By virtue of these implications, the reduction of infant mortality figures in the Millennial Development Objectives (MDOs), an undertaking assumed by the member countries of the United Nations Organization, for the purpose of reducing the deaths of children under 5 years of age by two-thirds between 1990 and 2015 [3,4]. Of the 195 signatory countries of this undertaking, 62 have already attained the target, Brazil among them, as it had reduced its IMR by 73% even before the end of the stipulated deadline [5].

Since the 80s, infant mortality has been markedly reduced throughout Brazil, reflecting the regional inequalities present in other health and social indicators. Even as regards the MDOs, the regional iniquities are very severe: in 2015, of the approximately 5,500 Brazilian municipalities, 1,000 achieved an infant mortality of up to 5 deaths/1,000LBs, similar to that of the most highly developed countries on the planet, while 32 of the country's municipalities presented values that exceeded 82 [6].

The reduction took place more rapidly among the postneonatal component of infant mortality, with the control of environmental variables and the offer of preventive care measures, such as, the encouragement of breast-feeding, programs of immunization, and also other primary childcare health assistance actions. Also, the neonatal deaths, whose causality is more closely associated with pre-natal attendance and labor, were also reduced, although at a slower rate. Today, there is a predominance of the deaths of

the neonatal period in infant mortality throughout Brazil [7,8].

While the countries of Europe and North America have presented a slow and continuous reduction in IMRs since the middle of the XIXth century, in the countries of Latin America the changes began as from 1945, as a result of the control of the infectious and endemic diseases [9]. In Brazil, in 1940, the IMR was 150‰ LB, has since presented a tendency to a slow decline, [2,9] thanks to the improvement in basic sanitation, the rise in parents' level of schooling and the reorganization of the programs addressing women's and child health, as from the implantation of the Unified Health System (SUS) [10].

In the State of São Paulo, a decline in IMR has been observed in recent decades, falling from 85.2‰ LB in 1975 to 50.9‰ LB in 1980 [11]. As a result of the above-mentioned policies which attempted to meet the demands made on public health, in 2015 the IMR in the State of São Paulo reached the lowest level in its history, i.e., 10.7‰ LB [11].

The central region of the State of São Paulo, in which the municipality of Araraquara is situated, presented a reduction of 19.1% in the IMRs between 2000 and 2015, reaching 11.4‰ LB at the end of that period, higher than that verified for the State as a whole on that date. Araraquara had an estimated population in 2016 of 221,205 inhabitants. The main economic activities of the municipality are the rendering of services and the farming industry. It presented a high MHDI (Municipal Human Development Index), of 0.815 in 2010, the eighth highest in the State of São Paulo, higher than the average for the State, which was of 0.783 on the same date [11].

In view of the importance of the measurement of IMR, so that health managers might monitor the prevailing conditions and establish future needs, the aim of this study was the characterization of the tendency of infant mortality in the municipality of Araraquara- SP, from 2007 to 2015, in accordance with its age components (neonatal and postneonatal mortality), as well as identifying its principal causes of death.

2. MATERIALS AND METHODS

This was a cross-sectional study, with an exploratory purpose. As sources of data, the information systems that the Ministry of Health makes available for the direct calculation of the IMR: the Information System on Births (SINASC) and the Information System on Mortality (SIM) [12]. The data from these systems were provided by the Municipal Health Secretariat of the Municipality of Araraquara- SP. These systems offer trustworthy coverage of this health information, validated by the Ministry of Health, which guarantees the quality of the calculation of the IMR [13].

The datafile was constructed on Excel, permitting that the authors might obtain the IMRs per ‰ LB and their age components, such as neonatal mortality (early neonatal mortality-ENN ‰ LB and late neonatal mortality LNN ‰ LB), and postneonatal mortality- PNN ‰ LB, for each year of the period from 2007 to 2015, as well as for each three-years period, for the municipality of Araraquara. The neonatal period was considered as consisting of early neonatal (from birth up to the 6th day) and late neonatal (from the 7th to the 28th day). It was adopted as a non-inclusion criterion the stillbirths, being excluded from the analysis.

The causes of deaths were codified in accordance with the groups of causes given by the International Statistical Classification of Diseases and Health Problems, in its 10th revision, ICD-10 [14]. Indeed, it was considered that the perinatal causes covers the period leading up to birth and the first week of life, and deaths occurring in this period are largely due to obstetric causes, and they are included in block P00-P96.

For the purpose of identifying tendencies in the evolution of the mortality rates by three-year periods, it was calculated the ratio between them, by point and by 95% confidence interval ($CI_{95\%}$). According to DEVER [15], to compare two independent rates (r_1 and r_2), it can be used the confidence interval of the ratio (R) between them, as follows:

$$R = r_1 / r_2,$$

where:

R= ratio
r_1= rate in Period 1
r_2= rate in Period 2

The 95% confidence interval of the ratio is defined as:

$$R \mp 1.96.R.\sqrt{\frac{1}{d1}+\frac{1}{d2}}$$

Where:

d1= number of deaths in Period 1
d2= number of deaths in Period 2

Thus if the confidence interval did not include the value 1, there was a significant difference between these rates; on the other hand, if the value 1 was included, the difference was explained as due only to random effects [15].

This research project was submitted to the Ethics in Research Committee of the University of Araraquara (UNIARA) and approved, according to Report nº 1.554.315.

3. RESULTS

From 2007 to 2015, there were 277 deaths of children under 1 year of age, resident in Araraquara, so that, 164 (59.2%) occurred in the early neonatal period, 60 (21.7%) in the late neonatal period and 53 (19.1%) in the post-neonatal period. The IMR for the period was of 11.7‰ LB.

For the time series, stability was observed in the IMRs from year to year with the exception of the years 2008 and 2013, which diverged from the pattern, with higher values, of 14.5‰ LB and 13.7‰ LB, respectively.

The analysis of the infant mortality of the whole period, subdivided into three-year periods, resulted in the data presented in Table 1.

Table 1. Deaths in children under 1 year of age, number of libe born (LB) and IMR (‰ LB). Araraquara-SP, Brazil, 2007-2009, 2010-2012 and 2013-2015

Three-year period	Deaths in childrenunder 1 year old	LB	IMR (‰ LB)
2007-2009	88	7,274	12.1
2010-2012	88	7,840	11.2
2013-2015	101	8,583	11.8
Total	**277**	**23,697**	**11.7**

The three-year IMRs were seen to be stable and the comparison between them enables one to observe that, as between successive three-year periods, R~1, seeing that, for the comparison between 2007-2009 and 2010-2012, it was obtained $CI_{95\%}$: 0.775-1.425 and between 2010-2012 and 2013-2015, it was obtained $CI_{95\%}$: 0.786-1.414, thus characterizing a statistically non-significant difference. For the last three-year period, the IMR presented a 2.5% decline as compared with the first one, though of no statistical significance.

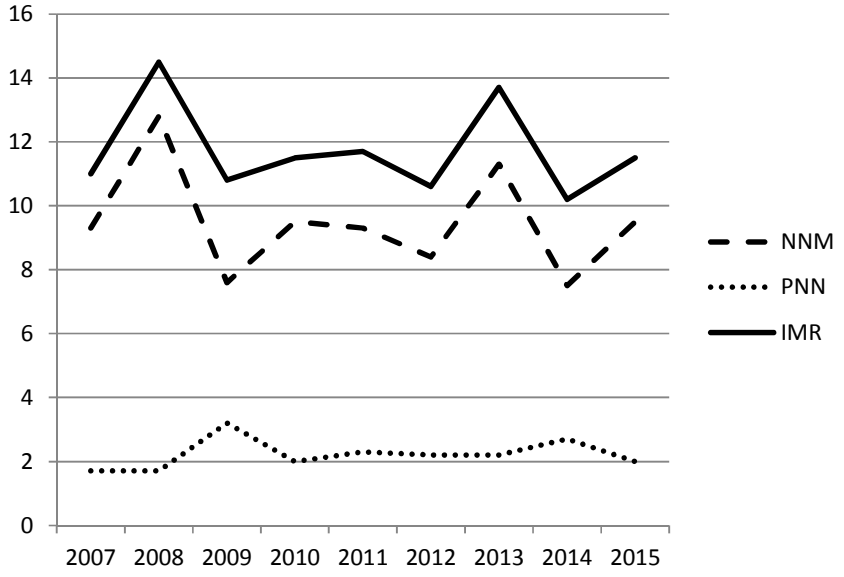

Fig. 1. Mortality rates per 1,000 live births (‰ LB): infant mortality (IMR), neonatal (NNM), and postneonatal (PNN). Araraquara- SP, Brazil from 2007 to 2015

The infant mortality data, separated into their components: early neonatal, late neonatal and postneonatal deaths, for the three- year periods, are presented in Table 2.

This table shows that early neonatal mortality is the main component of infant mortality, with an increasing tendency. In the passage of the three-year periods, there is a tendency for the late neonatal mortality to diminish, whereas the postneonatal mortality remains stable. In the comparison between the three-year periods it can be seen that as from 2007-2009 and from 2013-2015 there was a more accentuated fall in the late neonatal mortality rate, from 3.4 to 2.1 ‰ LB, which resulted in R=1.6 ($CI_{95\%}$: 0.66-2.54), with no statistical significance.

The causes of mortality which occupied the first positions in the 277 deaths of children below 1 year of age, between 2007 and 2015, are shown in Table 3.

The group of perinatal diseases (P00 a P96) became the principal cause of death in the neonatal period, accounting for 73.2% of the deaths in this period, followed by congenital malformations of the circulatory system and chromosomal anomalies (Q00-Q99), with 21.4% of the total. In the postneonatal period, the congenital malformations of the circulatory system and the chromosomal anomalies (Q00-Q99) had great impact among the causes of death (30.2%), followed by influenza and pneumonia (11.3%), and there was a lower

Table 2. Number of live-births (LB), deaths (D), infant mortality rate (rate per ‰ LB) in the periods early neonatal (ENN), late neonatal (LNN), and postneonatal (PNN). Araraquara-SP, Brazil, 2007-2009, 2010-2012 and 2013-2015

Three-year period	LB	ENN		LNN		PNN	
		D	Rate	D	Rate	D	Rate
2007-2009	7,274	47	6.5	25	3.4	16	2.2
2010-2012	7,840	54	6.9	17	2.2	17	2.2
2013-2015	8,583	63	7.3	18	2.1	20	2.3

Table 3. Main groups of causes of infant mortality in their age components: neonatal period (ENN, LNN), and postneonatal period (PNN). Araraquara- SP, Brazil, 2007 to 2015

Code	Description	Neonatal period		PNN
		ENN	LNN	
P00-P04	Newborn affected by maternal factors and by complications of pregnancy, labor, and delivery.	71	18	1
P05-P08	Disorders related to lenght of gestation and fetal growth.	9	-	-
P20-P29	Respiratory and cardiovascular disorders specific to perinatal period.	39	9	1
P35-P39	Infections specific to the perinatal period.	3	8	-
P50-P61	Hemorrhagic and hematological disorders of newborn.	-	2	-
P70-P74	Transitory endocrine and metabolic disorders specific to fetus and newborn.	1	-	-
P75-P78	Digestive system disorders of fetus and newborn	-	4	2
Q00-Q07	Congenital malformations of the nervous system	4	-	1
Q20-Q28	Congenital malformations of the circulatory system.	10	9	8
Q30-Q34	Congenital malformations of the respiratory system.	19	4	3
Q90-Q99	Chromosomal abnormalities, not elsewhere classified.	-	2	4
J09-J18	Influenza and pneumonia.	-	-	6
R95-R99	Ill-defined and unknown causes of mortality.	-	-	3
A00-A09	Intestinal infectious disease.	-	-	2
A30-A49	Other bacterial diseases.	-	-	2
Other causes		8	4	20
Total		164	60	53

Source: SIM, SINASC. Araraquara-SP, Brazil

participation of intestinal infectious diseases (3.8%).

Of the total number of deaths of children of up to 1 year of age, perinatal causes (168) were responsible for 60.6% and the congential malformations (64) for 23.1%.

For the early neonatal period the malformations accounted for 20.1% of the total deaths in this period, in the late neonatal period for 25.0% and, in the postneonatal period, for 30.2%.

The causes of death related to the fetus and the new-born affected by maternal factors and by complications of the pregnancy, labor and delivery predominated in the neonatal period. When chapter XVI of the ICD (Some diseases arising in the perinatal period) is considered as a whole (P00-P96), it accounts for 75% of the deaths in the early neonatal period, 68.3% in the late neonatal period and 7.5% in the post-neonatal period.

4. DISCUSSION

For the study of infant mortality in Araraquara, between 2007 and 2015, it was used the direct calculation of the IMR, which expresses the number of deaths in children of less than 1 year of age per 1,000 LB. The number of infant deaths as also the number of live births are subject to various determining factors. Infant deaths are closely related to factors such as basic sanitation, educational level of their parents, the quality and coverage of the primary health assistance, especially of vaccination programs, access to pre-natal services, assistance during delivery, and puerperium and access to hospital services of high complexity for the treatment of complications arising during delivery and of congenital malformations, with the availability of units of intensive child therapy. On the other hand, the number of live births is dependent on the policies which address sexual education and family planning, as also on the general social and cultural changes experienced.

The historical series 2007-2015 for infant mortality in the municipality of Araraquara presented stability, with two peaks in the years 2008 and 2013, which resulted from the occurrence of a larger number of infant deaths in those years, 35 and 37, respectively. These peaks do not indicate a worsening of the mortality situation; they seem to have been the result of a bias intrinsic to the use of this indicator in communities with a small number of events, by the variation in the number of live births and deaths in children of less than 1 year of age. The same does not occur in the State of São Paulo as a whole, which has a much larger population, controlling the casual variations. Considering the final and initial three-year periods, between 2012-2015 and 2007-2009, there was a declining tendency in the IMR of 2.5%.

Research undertaken in the State of São Paulo in the 12 Regional Departments of Health, in a historical series from 2006 to 2013, presented the IMRs in successive reductions [4]. Information up to 2014 also indicated the continuation of this reduction in the State of São Paulo, though at a lesser rate in the last four years [16]. This pattern points to the correct approach of the public policies in facing up to infant mortality in the State. Infant mortality in the State of São Paulo between 1996 and 2012 fell by 22.5%, closing the period with 11.5‰ LB [17]. On the other hand, the city of Araraquara, in 2015, presented an IMR of 11.5‰ LB, an index 7.5% above that of the State in 2015, which was of 10.7‰ LB [11].

The neonatal mortality predominated throughout the period of the study, as the behavior of the early and late neonatal component was similar to the general Brazilian situation of the XXIst century. Factors related to the quality of pre-natal attendance and to that during delivery presented a direct association with infant mortality,[8] seeing that the control of factors associated with death during this period presented greater complexity. A detailed analysis, going beyond the scope of this study, would be necessary to identify those deficiencies in attendance which has hindered a greater reduction in the early neonatal and late neonatal components of infant mortality in Araraquara. In the State of São Paulo other indicators have also shown an association with the reduction in infant mortality, such as the greater population coverage of the attendance model of family health and the increase in income, as assessed by the *per capita* GDP (Gross Domestic Product) [18].

In the series studied, for Araraquara, postneonatal mortality was of 2.2‰ LB and was stable, as in the rest of the country [3] and the State of São Paulo as a whole [11,18]. The reduction in deaths from infectious causes, which in the past predominated in the postneonatal period, is associated mainly with the increase in the coverage of basic sanitation, which, in

Araraquara in 2010, attained 99.9% for garbage collection, 99.43% for water supply and 98.89% for sewage collection [19]. These indices are greater than the values observed for the State of São Paulo as a whole, and were certainly fundamental in the reduction of infant deaths in this period, permitting the reduction of deaths by diarrheic diseases, the main cause of death until the 70s throughout the country. In the period studied, diarrheas accounted for only 3.8% of the postneonatal deaths in Araraquara.

Beyond the increase in the coverage of basic sanitation, other improvements may be added in the primary health attendance of the infant population, especially those emphasized in programs undertaken by the Ministry of Health, such as immunization, encouragement of breast feeding and oral rehydration, as well as the increase in the coverage of family health programs [20,21].

Diseases which began in the perinatal period (ICD 10, Chap. XVI) accounted for 75% of the deaths which occurred in the early neonatal period, 68.3% of those of the late neonatal period and 7.5% of those of the post-neonatal period, in a pattern similar to that of the State of São Paulo, which presented respective indices of 77.9%, 72.6% and 12.8% [22]. In the measure in which there is a reduction in post neonatal deaths, the relative importance of neonatal mortality, whether early or late, tends to increase the relative importance of that mortality, whether it be early or late. And the reduction of the number of these deaths becomes more problematic than it is with those of post-neonatal mortality, requiring much more expensive interventions in the pre-natal period and at delivery as well as in the period immediately after the post-partum.

As regards mortality by congenital malformation, for the early neo-natal period it accounts for 20.1% of total deaths in this period; for the late neonatal period, 25.0% and for the post neo-natal period, 30.2% of the deaths of infants less than 1 year of age. One is here dealing with a pattern similar to that observed for the State of São Paulo, which in 2015 presented respective values of 21.1%, 22.6% and 26.5% [11].

Up to a few decades ago, deaths by congenital malformations presented short periods of survival time. The result was that deaths from these causes were concentrated in the early neonatal and late neonatal periods as a result of the lack of technological support in quantity and quality such as would have permitted the treatment of these new-born children. In recent decades the number of children who survive the various kinds of malformation or who have a longer survival time has been increasing, thus increasing the statistics of post-neonatal infant mortality.

In the total number of deaths occurring in the first year of life, they were the second most frequent cause of death, a pattern which has been repeated in studies of the same kind undertaken in Pernambuco [23,24]. It is difficult to prevent such deaths and the occurrence of malformations varies little over time. Their prevention is considered the last frontier for the reduction of infant mortality, as it hinders infant mortality from approximating to zero anywhere in the world. The reduction of this component of infant mortality is costly and calls for advanced technology, with access to out-patient services and high complexity hospital attendance. The 64 deaths due to malformations account for 23.1% of the total of deaths of children of up to 1 year of age (277), having great impact on the infant mortality in Araraquara, with the complicating factor that this is a situation which will be difficult to change on the short or medium term. The continuous monitoring of risk factors for death in children less than 1 year of age, particularly as regards pre-natal and delivery attendance, is indispensable for the reduction of infant mortality in Araraquara and other municipalities of similar epidemiological and demographic characteristics. The correct design of this indicator will make possible the assessment and revision of public policies adopted for the maternal and infant population, in such a way as to make the continuity of the reduction in the number of deaths of infants of less than 1 year of age possible.

In the last decades of the XXth century we witnessed a phase of the rapid reduction of infant mortality at the cost of the control of infectious diseases and infant undernourishment, associated with the control of environmental factors and the reduction of poverty, as well as the implantation of the Unified Health Service (SUS). Today, changes in the dimensions of the indicator will be more difficult and slower, seeing that infant mortality in the country as a whole, in the State of São Paulo and in Araraquara is concentrated in perinatal causes and congenital malformations. The reduction of these deaths depends on greater investment in the quality of attendance on pre-natal care and delivery.

The limitations of this study can be underreporting, that remains a problem in relation to the definitions of early deaths and stillbirths. Reliability of data depends on reliable reports and records of births and deaths, as also, codification of their causes.

5. CONCLUSIONS

The IMRs showed themselves stable in the municipality of Araraquara-SP, between 2007 and 2015. For the three-year periods (2007-2009, 2010-2012 and 2013-2015), they presented non-significant statistical differences between them.

The postneonatal infant mortality showed itself to be the least of the components of the indicator seeing that, for the period as a whole, it accounted for 19.1% of the deaths during the first year of life, while the deaths of the neonatal period (early plus late) accounted for 80.9% of the total, in a pattern similar to that of the State of São Paulo.

Considering the total deaths among children of less than 1 year of age, the perinatal causes were the principal cause of mortality. However, in the postneonatal period, the congenital malformations dominated among the causes of death (30.2%). As the congenital malformations were responsible for 23.1% of all infant deaths, it can be suggested to provide prevention opportunities such as: vaccination (especially against rubella virus), intake of folic acid, avoiding environmental exposure to heavy metals or pesticides during pregnancy, controlling diabetes prior and during pregnancy, and controlling the exposition to radiation (medical rays). Also, as they are important cause of death, studies on the etiology, diagnosis and prevention are needed.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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