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Infant mortality: surveillance, epidemiological characteristics and spatial distribution pattern in Recife, Brazil

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ABSTRACT. To describe the occurrence and spatial distribution of infant deaths investigated by surveillance in Recife, state of Pernambuco, Brazil, in 2014. This is an exploratory ecological study investigating 183 infant deaths. Data from the confidential records of surveillance investigation of the infant death and the Mortality Information System were used. In order to detect spatial distribution patterns, the kernel estimation of infant, neonatal and post-neonatal mortality was used. Deaths were mainly of the neonatal type (n = 144; 78.69%), with gestational age below 37 weeks (n = 147; 80.3%) and birth weight lower than 2500 g (n = 143; 78.1%). The main causes of infant deaths were the disorders originating in the perinatal period, with emphasis on maternal hypertensive disorders (n = 31; 16.9%). The kernel map showed a higher density in 12 neighborhoods of the North (4), Northwest (2), West (3) and South (3) regions of the municipality. It was found a heterogeneous pattern in the occurrence and distribution of deaths in the territory; spatial clusters were observed in several areas of Recife with similar geographic spaces between types of death.

Keywords: infant mortality; vital statistics; health information systems; spatial analysis; healthcare disparities.

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Introduction

Infant mortality is an important indicator of living conditions, which reflects social inequalities, and reveals weaknesses in access to and quality of healthcare services for women and children (Van Minh et al., 2016).

Worldwide, an estimated 4.5 million deaths occur among children under one year old (World Health Organization [WHO], 2015). There is a trend towards a reduction in the infant mortality rate (IMR) from 63 per thousand live births (LB) in 1990 to 32 in 2015 (United Nations, 2015). The target of the Sustainable Development Goals (SDGs) of United Nations (UN) is to eliminate by 2030 the preventable deaths of newborns and children under five years old (WHO, 2015). Brazil reduced the IMR by 70%, from 47.1 deaths per thousand LB in 1990 to 14.2 in 2014 (Goretti et al., 2016), while in the state of Pernambuco (PE), the decline was 80.9% in this period, from 77 to 14.7 per thousand LB (Goretti et al., 2016). In Recife (PE), the IMR was 47.1 per thousand in 1990 and decreased to 12.2 in 2012, accounting for a decline of 74.1% (Oliveira, Bonfim, Guimarães, Frias, & Medeiros, 2016).

In Brazil, the reduction in infant mortality was the result of several actions and strategies related to the improvement of living conditions and health care (Oliveira et al., 2017). Child mortality surveillance, instituted by the Ministry of Health throughout the country in 2010, is one of the strategies that can contribute to reducing mortality among children under one year old (Oliveira et al., 2016). In Recife, death surveillance was implemented in 2003, with the objective of identifying failures in healthcare that contributed to deaths, improving information systems (Oliveira et al., 2017) and using data in the development of measures to reduce infant mortality (Marques, Oliveira, & Bonfim, 2016).

Some methodologies can be used to assist the surveillance of infant death and subsidize the direction of health actions (Marques et al., 2016; Oliveira et al., 2017). Among these, the spatial analysis allows to identify the deaths in the territory, and to integrate them the georeferenced epidemiological, socioeconomic, environmental and demographic information (MacQuillan, Curtis, Baker, Paul, & Back, 2017).

Spatial analysis can be performed using visualization methods, exploratory analysis, or georeferenced data modeling (Ladusingh, Gupta, & Yadav, 2016). The tool that enables its operationalization is geoprocessing, defined as a set of techniques for collecting, processing, manipulating and presenting information without dissociating them from geographic space (MacQuillan et al., 2017).

In research on infant mortality, spatial analysis has been used to detect risk factors, to verify patterns of distribution in space, and to identify priority areas for health sector interventions (Ladusingh et al., 2016; MacQuillan et al., 2017). This study aimed to describe the occurrence and spatial distribution of infant deaths investigated by surveillance in Recife, state of Pernambuco, Brazil, in 2014.

Material and methods

This is an exploratory ecological study performed in Recife, capital of Pernambuco, Northeastern Brazil, with 1,608,563 inhabitants (2014) (Brasil, 2014) distributed in 218.5 km², with heterogeneous occupation pattern, in which highly valued areas coexistwith others with relevant structural problems (Recife, 2014). The 94 neighborhoods, at the time of the study, were arranged in six Political-administrative Regions, Central (10 neighborhoods), North (17), Northwest (29), West (12), Southwest (16) and South (8) (Recife, 2014). The study was performed in 2014.

The Mortality Information System (MIS) recorded 280 infant deaths in the capital in that year. Of these, 73 were excluded from the analysis because of congenital malformation, exclusion criteria for the investigation due to the limited potential of avoidability, and 24 that were not investigated due to inconsistency of residence address, non-localized records and refusal of the family. The analysis included a population of 183 infant deaths investigated.

The source of data collection was the confidential records of investigation of infant deaths of Recife and the MIS. This self-contained investigation record of the municipality contemplates the variables recommended by the Ministry of Health, besides adding others, being composed of variables related to the identification of the child, the mother and characteristics of the family, data on gestation, prenatal care, birth, child care, outpatient and hospital care for the pregnant woman and the child, and the occurrence of death (Oliveira et al., 2017).

Variables of the confidential investigationrecord were usedrelated to: identification of the child, the mother; prenatal data, birth and death. 70 variables with missing data above 20% were excluded. For the purposes of analysis, the deaths were divided according to the age group in infant, neonatal and post-neonatal. The basic cause of death was grouped according to the chapters of the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD 10).

The georeferencing of infant deaths according to maternal residence address was performed. The cartographic base of the addresses and the digital meshes used are available on the website of the Municipality of Recife (http://www.recife.pe.gov.br/ESIG/documentos/Informacao/InformacaoManualArquivos.htm) and present a system of references of coordinates SIRGAS 2000/UTM zone 25S. Georeferencing consists of assigning geographic coordinates to addresses (Magalhães, Matos, & Medronho, 2014). For this, the following procedures were performed: adequacy of the MIS database; the georeferencing itself and the verification of its quality (the points identified as geometric center and approximate were manually checked); and the recovery of the initially undetected addresses (the points not found were manually entered).

The data were coded, typed with double entry and validated in the Epi Info® program version 6.04d. The R®software version 3.0.1 was used for descriptive statistics. For analysis of spatial data, the QGis® version 2.14.3 software was used. The address of each event was searched in the MIS database and compared to the ones contained in the Google Maps® address base, identifying their geographic coordinates. In order to estimate the intensity of the event, a kernel with an adaptive radius of 1500m and quartic function was used. The kernel estimation analyzes the spatial patterns of point processes through statistical smoothing, being able to describe the influence of one point in relation to others in nearby areas (MacQuillan et al., 2017).

The research was approved by the Research Ethics Committee of the Research Center Aggeu Magalhães of the Oswaldo Cruz Foundation (CAAE: 07336313.6.0000.519).

Results

Figure 1 illustrates the kernel density maps with spatial clusters, in areas with higher concentration of points. The color gradient shows a high-intensity kernel of infant, neonatal and post-neonatal deaths distributed in 12 Recife neighborhoods in the North (4), Northwest (2), West (3) and South (3) regions. It shows a heterogeneous pattern in the distribution of the clusters of investigated deaths, with similarities between the types of deaths.

Of the 183 infant deaths investigated, the majority occurred in the neonatal period (n = 144; 78.7%), the highest proportion of deaths was for males (n = 85; 59.0%), while in the post-neonatal period the female sex predominated (n = 24; 61.5%). Mothers were mainly between 19 and 34 years old (n = 128; 69.9%) and had less than 12 years of schooling (n = 152; 83.1%) (Table 1).

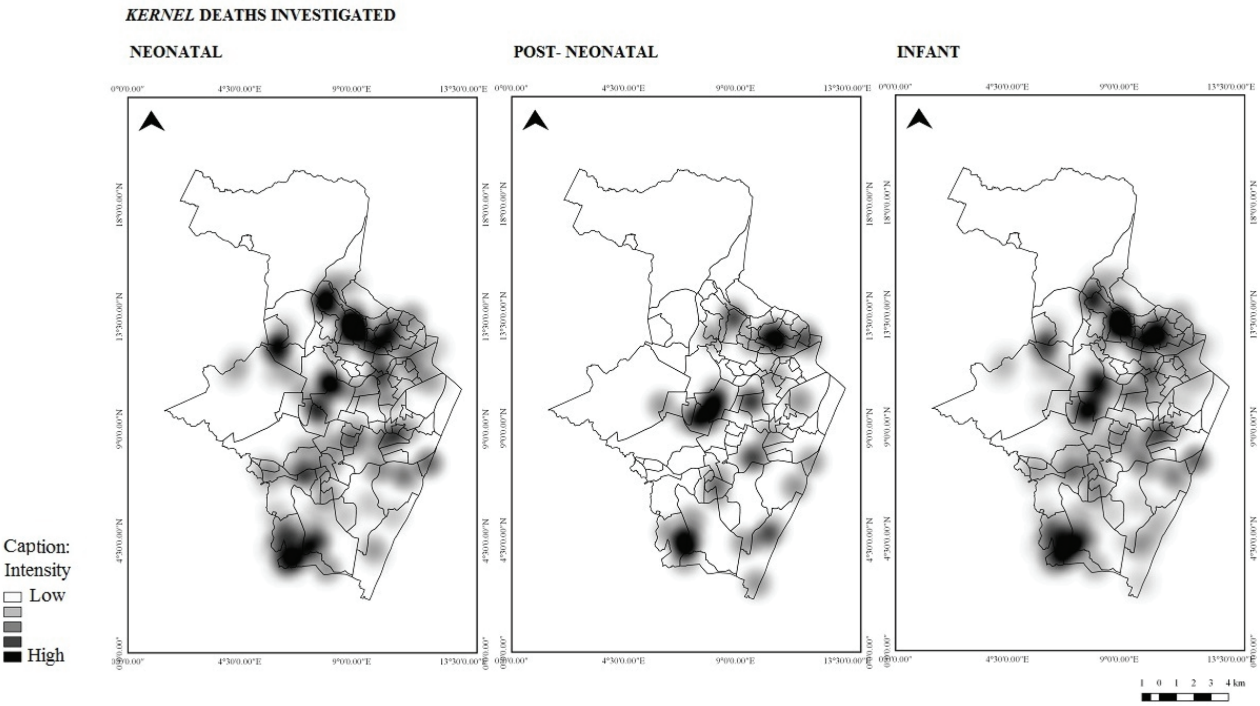

Figure 1. Kernel density maps of infant deaths investigated according to age group. Recife, state of Pernambuco, Brazil, 2014.

Table 1. Identification of the mother and infant deaths investigated. Recife, state of Pernambuco, Brazil, 2014.

Variables	Neonatal (n = 144)		Post-neonatal (n = 39)		Infant (n = 183)	
	n	%	n	%	n	%
Sex						
Male	85	59.0	15	38.5	100	54.6
Female	59	41.0	24	61.5	83	45.4
Race/color of the child [n = 176(a)]						
White	23	16.0	9	23.1	32	17.5
No white	115	79.9	29	74.4	144	78.7
Age of the mother (years old)						
< 19	25	17.4	4	10.3	29	15.8
19-34	98	68.1	30	76.9	128	69.9
> 34	21	14.6	5	12.8	26	14.2
Race/color of mother [n = 170(b)]						
White	22	15.3	7	17.9	29	15.8
No white	112	77.8	29	74.4	141	77.0
Years of schooling [n = 180(c)]						
≤ 12	118	81.9	34	87.2	152	83.1
> 12	24	16.7	4	10.3	28	15.3
Marital status [n = 181(d)]						
With partner	77	53.5	14	35.9	91	49.7
Without partner	65	45.1	25	64.1	90	49.2

*Number/percentage of ignored: (a) 7/3.8; (b) 13/7.1; (c) 3/1.6; and (d) 2/1.1%.

In relation to the characteristics of prenatal healthcare, there was prenatal care (n = 154; 84.2%), which started in the first trimester (n = 100; 54.6%), with less than six consultations (n = 109; 59.6%). There was a higher occurrence of pregnancies below 37 weeks (n = 147; 80.3%) (Table 2).

Birth weight was mainly below 2500 g (n = 143; 78.1%). At the 5th minute, there was a close relationship between Apgar proportions for the neonatal (n = 82; 44.8%) and post-neonatal (n = 93; 50.8%), being, especially, less than 7 among the neonatal deaths (n = 78; 54.2%), and equal or above 7 for post-neonatal deaths (n = 32; 82.1%). The highest number of deaths occurred in hospitals (n = 172; 94.0%) in the intensive care unit (ICU) (n = 128; 69.9%), without transfer of other health units (n = 146; 79.8%) (Table 3).

The main causes of infant deaths were disorders originating in the perinatal period, with emphasis on maternal hypertensive disorders (n = 31; 16.94%), especially in the neonatal period (n = 26; 18.1%), and maternal urinary tract infections (n = 22; 12.0%), especially in neonatal deaths (n = 18; 12.5%). In the post-neonatal period, external causes (probably bronchoaspiration) were among the highest frequencies (n = 6; 15.4%), followed by whooping cough (n = 5; 12.8%), which is in the chapter on infectious and parasitic diseases. Despite the low frequency (n = 4; 2.2%), congenital syphilis also stood out out (Table 4).

Discussion

The analysis of spatial data of the infant deaths investigated allowed the identification of a heterogeneous pattern of occurrence of mortality in children under one year old, with a higher concentration of cases in 12 out of 94 neighborhood sin Recife, with similar spatial clusters for neonatal and post-neonatal deaths. The detection of these areas reveals particularities in the distribution of deaths that may reflect inequalities in health and social conditions (Rodrigues et al., 2014; Nucci, Souccar, & Castilho, 2016; Faria, 2016; Leal, Bittencourt, Torres, Niquini, & Souza Jr, 2017) and indicates locations with greater need for investment in public policies directed at the health of women and children.

The signaled neighborhoods were also identified by previous research as areas with poor living conditions, degraded environmental conditions or that harbor significant socioeconomic inequalities (Oliveira & Silveira Neto, 2015). The punctual analysis of deaths by characterizing the territory in detail reveals areas with a higher concentration of deaths and indicates the presence of risk factors in certain localities (MacQuillan et al., 2017).

Table 2. Prenatal healthcare and pregnancy characteristics of the infant deaths investigated. Recife, state of Pernambuco, Brazil, 2014.

Variables	Neonatal (n = 144)		Post-neonatal (n = 39)		Infant (n = 183)	
	n	%	n	%	n	%
Prenatal						
Coverage of basic care area [n = 182(a)]						
With coverage	123	85.4	28	71.8	151	82.5
Non- covered	20	13.9	11	28.2	31	16.9
Prenatal [n = 180(b)]						
Yes	121	84.0	33	84.6	154	84.2
No	23	16.0	3	7.7	26	14.2
Start month [n = 152(c)]						
1st quarter	80	55.6	20	51.3	100	54.6
After the 1st quarter	39	27.1	13	33.3	52	28.4
Number of consultations [n = 154(d)]						
< 6	91	63.2	18	46.2	109	59.6
≥ 6	30	20.8	15	38.5	45	24.6
Characteristics of gestation						
Previous pregnancies [n = 180(e)]						
Primiparous	74	51.4	15	38.5	89	48.6
Multiparous	69	47.9	22	56.4	91	49.7
Gestational age (weeks)						
< 37	123	85.4	24	61.5	147	80.3
≥ 37	21	14.6	15	38.5	36	19.7
Type of pregnancy						
Unique	125	86.8	36	92.3	161	88.0
Double	19	13.2	3	7.7	22	12.0

*Number/percentage of ignored: (a) 1/0.5; (b) 3/1.6; (c) 31/16.9; (d) 30/16.4; and (e) 3/1.6%.

Table 3. Birth assistance, characteristics of the child and the occurrence of infant deaths investigated. Recife, state of Pernambuco, Brazil, 2014.

Variables	Neonatal (n = 144)		Post-neonatal (n = 39)		Infant (n = 183)	
	n	%	n	%	n	%
Birthplace						
Hospital	140	97.2	34	87.2	174	95.1
Residence	1	0.7	-	-	1	0.5
Others	3	2.1	5	12.8	8	4.4
Type of unit (birth) [n = 180(a)]						
Public	109	75.7	29	74.4	138	75.4
Non-public	33	22.9	9	23.1	42	23.0
Type of birth [n = 182(b)]						
Vaginal	92	63.9	20	51.3	112	61.2
Cesarean	52	36.1	18	46.2	70	38.3
Birth attendant [n = 172(c)]						
Doctor/Nurse	136	94.4	35	89.7	171	93.4
Others	-	-	1	2.6	1	0.5
Characteristics of the child						
Birth weight [n = 182(d)]						
< 2500 g	121	84.0	22	56.4	143	78.1
≥ 2500 g	23	16.0	16	41.0	39	21.3
Apgar 1 [n = 174(e)(a1)]						
<7	108	75.0	9	23.1	117	63.9
≥7	30	20.8	27	69.2	57	31.1
Apgar 5 [n = 175(f)(b1)]						
< 7	78	54.2	4	10.3	82	44.8
≥ 7	61	42.4	32	82.1	93	50.8
Occurrence of death						
Place of death						
Hospital	139	96.5	33	84.6	172	94
Residence	1	0.7	3	7.7	4	2.2
Others	4	2.8	3	7.7	7	3.8
Type of unit (death) [n = 179(g)]						
Public	109	75.7	29	74.4	138	75.4
Non-public	34	23.6	7	17.9	41	22.4
Sector of occurrence of death [n = 149(h)(c1)]						
Pediatric/neonatal ICU	97	67.4	31	79.5	128	69.9
Obstetric center	1	0.7	1	2.6	2	1.1
Others	19	13.2	-	-	19	10.4
Transfer [n = 173(i)(d1)]						
Yes	16	11.1	11	28.2	27	14.8
No	123	85.4	23	59	146	79.8

*Number/percentage of ignored: (a) 3/1.6; (b) 1/0.5; (c) 1/0.5; (d) 8/4.4; (e) 7/3.8; (f) 11/6.0; (g) 4/2.2; (h) 23/12.6; and (I) 7/3.8%. Number/percentage of not applicable: (a1) 1/0.5; (b1) 1/0.5; (c1) 4/2.2; and (d1) 3/1.6%.

Studies on the spatial analysis of infant mortality point to the usefulness of these approaches for the elaboration and development of policies aimed at coping with the determinants of these deaths, particularly those related to healthcare (Rodrigues et al., 2014; Faria, 2016; Rodrigues et al., 2016; Venâncio, Tuan, Vaz, & Nascimento, 2016; Leal et al., 2017). Likewise, the characterization of the epidemiological profile of infant deaths is recognized as an important tool for drawing strategies to deal with the problem, in particular, by investigating the events, because it allows a better understanding of the circumstances of their occurrence (Vanderlei & Navarrete, 2013).

Neonatal deaths were prevalent among those younger than one year old. The highest proportion of these deaths occurred in males, whose pulmonary maturity is late, when compared to females, generating a higher incidence of respiratory problems (Sanders et al., 2017).

The profile analysis showed a higher frequency of infant deaths among women with less than 12 years of schooling. Lower maternal schooling is associated with low adherence to prenatal care, and when performed, it is more difficult to understand the guidelines provided by health professionals during prenatal care (Borde et al., 2016), reflecting the care of women with gestation and the newborn, which increases the risk for infant death (Domingues et al., 2015; Cardoso, Ribeiro, Oliveira, Andrade, & Santos, 2016). In addition, low schooling interferes with employment and income conditions and family housing, contributing mainly to post-neonatal deaths (Viellas et al., 2014; Ladusingh et al., 2016).

The highest proportion of infant and neonatal deaths analyzed was found for mothers who attended less than six prenatal consultations and occurred among premature infants less than 37 weeks of gestational age. The inadequate number of consultations and the low quality of prenatal care contribute to unfavorable outcomes for the woman and the newborn, including premature birth, making it impossible to increase the number of consultations (Fiorati, Arcêncio, & Souza, 2016). The Ministry of Health recommends six or more prenatal visits beginning in the first trimester of pregnancy (Domingues et al., 2015; Cardoso et al., 2016) for the potential of promoting women's health and the fetus, constituting a factor to protect the mother-baby dyad (Smith, Portela, & Marston, 2017). Diagnosis and timely treatment of diseases accompanied by adequate management may prevent premature births, increased risk of neonatal death and unnecessary costs for the health system and for the family (Vidal, Samico, Frias, & Hartz, 2011; Botura et al., 2018).

In agreement with the literature, the highest proportion of infant deaths occurred in infants with low birth weight and in general with Apgar less than 7 at 5 min., a time of greater predictive capacity of the newborn vitality, in which low values are recognized as a risk factor for neonatal death (Lansky et al., 2014). Thus, adequate postpartum interventions have the potential to increase specialized care at birth and to minimize obstetric and neonatal complications (Miltenburg, Roggeveen, Roosmalen, & Smith, 2017).

As expected, most of the deaths occurred in neonatal intensive care units (NICUs), and without transfers between health units. In general, in metropolises that have a minimally structured maternal care network with more complex maternity facilities, pregnant women of greater risk come to health facilities that have NICUs and Conventional Intermediate CareUnits or Kangaroos for the possibility of indication of special attention to their newborns (Silva et al., 2014). The existence of NICUs and intermediate care units in maternity hospitals, despite allowing a greater chance of survival to the newborn, due to the availability of equipment required for intensive care (Silva et al., 2014) also defines a clientele profile, generally characterized by the presence of one or more risks, sometimes overlapping, which results in a high number of unfavorable outcomes compared to maternity units at normal risk (Viellas et al., 2014).

Table 4. Basic causes of infant deaths investigated according to ICD chapters 10. Recife, Pernambuco, Brazil, 2014.

Chapters	Neonatal n = 144		Post-neonatal n = 39		Infant n = 183	
	n	%	n	%	n	%
Some infectious and parasitic diseases (A00-B99)						
Whooping cough (A37.0, A37.9)	1	0.7	5	12.8	6	3.3
Congenital syphilis (A50.0, A50.2)	3	2.1	1	2.6	4	2.2
Diarrhea of probable infectious origin (A09)	-	-	1	2.6	1	0.5
Some disorders originating in the perinatal period (P00-P96)						
Maternal hypertensive disorders (P00.0)	26	18.1	4	10.3	30	16.4
Maternal urinary tract infection (P00.1)	18	12.5	4	10.3	22	12.0
Incompetence of the uterine cervix (P01.0)	11	7.6	-	-	11	6.0
Premature rupture of membranes (P01.1)	11	7.6	2	5.1	13	7.1
Complications of the placenta and membranes (P02.2, P02.7)	9	6.3	1	2.6	10	5.5
Disorders related to gestation of short duration and low birth weight (P07.1, P07.2)	2	1.4	-	-	2	1.1
Placenta previa and placental abruption (P02.0, P02.1)	6	4.2	-	-	6	3.3
Hypoxia/perinatal asphyxia (P20.1)	1	0.7	-	-	1	0.5
Birth trauma (P15.9)	1	0.7	-	-	1	0.5
Respiratory disorders specific to the neonatal period (P22.9, P23.9, P27.1, P28.0)	9	6.3	2	5.1	11	6.0
Infections of the neonatal period (P36.9, P38, P39.3)	7	4.9	-	-	7	3.8
Other disorders (P00.2, P00.3, P00.8, P00.9, P04.1, P04.4, P05.9, P22.0, P02.5, P03.0, P03.8, P70.0, P70.1, P77, P78.0)	35	24.3	6	15.4	41	22.4
Other causes						
Respiratory infections (J21.9)	-	-	2	5.1	2	1.1
Urinary tract infection of unspecified location (N39.0)	-	-	1	2.6	1	0.5
External causes (Y21.0, Y34.9, W78.0, W78.9)	3	2.1	6	15.4	9	4.9
Poorly defined causes and other causes (Q25.0, R68.8, Q79.2, R99, B01.9, Q04.9, Q33.6)	1	0.7	4	10.3	5	2.7

Deaths in the neonatal period had as main underlying causes maternal hypertensive disorders and maternal urinary tract infections, disorders considered preventable by the adequate attention of the health services to pregnancy (Nascimento, Oliveira, Sposito, Ferreira, & Bonfim, 2014; Oliveira et al., 2016; Marques et al., 2018). Post-neonatal whooping cough and external causes were highlighted in the post-neonatal period. The whooping cough vaccine, in addition to integrating the basic immunization schedule of the child, was introduced in the pregnant woman schedule as an indirect prevention to the baby because it remains a cause of infant morbidity and mortality, even in municipalities with high vaccination coverage (Mançaneira, Benedetti, & Zhang, 2016).Unacceptable remains the situation of congenital syphilis in the municipality as an expression of the low effectiveness in the care for pregnant women, especially the most vulnerable women (Macêdo et al., 2017).

As limitations of the study it is highlighted that among the infant deaths eligible for research, 207, when excluding congenital malformations, there were losses corresponding to 11.6%, for various reasons, among them the non-location of residence address registered in the death certificate, an aspect that could influence the distribution of events in the municipal territory and alter, to some extent, the characteristics of the profile presented. However, the comparison of sociodemographic and epidemiological variables of the death certificate of the excluded with the others, showed similarity, suggesting that the possible changes would not be substantial if all the deaths was included in the analysis.

Conclusion

Infant deaths presented characteristics that may be caused by fragilities in prenatal care, pregnancy and birth. A heterogeneous pattern was found in the distribution of deaths in the territory, with spatial clusters in several areas, with similar geographic spaces for neonatal and post-neonatal deaths. Maternal hypertensive disorders and maternal urinary tract infections were the main causes, especially for neonates, the main component of mortality. The detection of spatial clusters of mortality and the characterization of deaths from information produced by death surveillance, besides helping to identify areas that require greater attention in health actions, add to the accuracy of the data, which are more closely related to the local reality.

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