Original article

Magnitude and determinants of neonatal and postneonatal mortality in Goiânia, Goiás, Brazil: a retrospective cohort study, 2012*

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Abstract

Objective: To estimate magnitude and determinants of neonatal and postneonatal mortality rates in Goiânia, Brazil, 2012. **Methods:** This was a retrospective cohort study based on data linkage of the Live Birth Information System and the Mortality Information System. Logistic regression was used to evaluate factors associated with neonatal and postneonatal death. **Results:** Neonatal mortality (0-27 days of life) was 9.4 deaths per 1,000 live births; while postneonatal mortality (28-364 days of life) was 3.0 deaths per 1,000 live births. Neonatal mortality associated factors were: 0-3 prenatal care visits (OR=13.10 – 95%CI 7.48;22.96), 19-34-week pregnancy (OR=6.25 – 95%CI 2.26;17.29), birth weight <1,500g (OR=62.42 – 95%CI 22.72;171.48) and cesarean delivery (OR=0.54 – 95%CI 0.37;0.79). Postneonatal mortality associated factors were: 0-3 prenatal care visits (OR=4.16 – 95%CI 1.51;11.43) and birth weight <1.500g (OR=18.74 – 95%CI 4.04;87.00). **Conclusion:** A low number of prenatal care visits, premature childbirth and low birth weight were the main risk factors for neonatal and postneonatal mortality.

Keywords: Child Health; Infant Mortality; Neonatal Mortality; Health Services; Information Systems; Cohort Studies.

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Introduction

Infant mortality is an indicator of a population's health status and quality of life. Monitoring infant mortality serves to inform Public Health policies aimed at the well-being of women and children.[1,2] Globally, the infant mortality rate (IMR) fell from 63 to 35 deaths per 1,000 live births between 1990 and 2012.

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Geographic inequalities become clear when noting that in high-income countries IMR fell from 12 to 5 deaths per 1,000 live births between 1990 and 2012, while in low-income countries the rate decreased from 104 to 56 deaths per 1,000 live births in the same period.[3] According to more recent United Nations Children's Fund (UNICEF) data, there was an additional reduction in global IMR from 35 to 29 deaths per 1,000 live births in the period 2012-2018.[4] In the municipality of Goiânia, capital of the state of Goiás, there has been a reduction in both the absolute number of deaths and in mortality rates. IMR fell from 17.8 (1996) to 12.9 (2012) and then to 10.5 deaths per 1,000 live births in 2018, being lower than the national average in 2012 and 2018: 13.5 and 12.2 deaths per 1,000 live births, respectively.[5]

The neonatal component of infant mortality – infant deaths occurring between 0 and 27 days of life – is strongly influenced by the quality of health care provided, while the postneonatal component – infant deaths occurring between 28 and 364 days of life – is strongly influenced by socioeconomic and environmental determinants. In the 1970s, the main causes of infant deaths were communicable diseases and nutritional diseases. With effect from the early 1990s, there was a change in this predominance which until then had been attributed to perinatal illnesses. The determinants of the new configuration of infant deaths include reduced fertility rates, the scaling up of Primary Health Care, improved maternal schooling and expansion of immunization coverage.[6-8] Brazil met the Millennium Development Goal of reducing infant mortality by two thirds by 2015, taking the rate in 1990 as the reference;[9] however, current levels of infant mortality in Brazil, comparatively, remain higher than those of high-income countries,[10] suggesting that Brazil should set a more ambitious target for reducing this indicator.

One of the main challenges to reducing infant mortality, in view of current levels, is to reduce intra-urban inequality. Two studies that assessed likelihood of infant death in live birth cohorts in Goiânia's health districts between 1992 and 1996,[11,12] identified a heterogeneous spatial pattern of occurrence, reporting neonatal mortality in high-risk areas distributed over all health districts, while greater risk of postneonatal mortality was concentrated in the Northwestern and Northern health districts. Two decades later, however, there are no new studies dedicated to assessing the intra-urban profile of infant mortality in Goiânia's health districts.

The main objective of this study was precisely that of estimating the magnitude of the neonatal and postneonatal components of infant mortality, as well as associated factors, in the cohort of live born babies of mothers resident in Goiânia in 2012.

Methods

This was a retrospective cohort study using nominal data from the Live Birth Information System (SINASC) database for the year 2012 and from the Mortality Information System (SIM) database for 2012 and 2013 – i.e. data on babies born alive in 2012 who died in 2012 or 2013.

The study site was Goiânia, GO, in the Midwest region of Brazil. In 2012 the municipality had an estimated population of 1,333,767 inhabitants. According to 2019 data, Goiânia has a *per capita* oss domestic product of R$ 28,343.10.[13] The municipality is divided into 65 urban planning districts defined in 1992 following socioeconomic homogeneity criteria.[14] These districts currently form seven geographical health regions, referred to as the Southern, Campinas-Central, Eastern, Northern, Western, Southwestern and Northwestern health districts.

In Goiânia the Family Health Strategy covers 68,351 families and the city has three public maternity hospitals. One of them is a reference hospital for high-risk cases managed by the Goiás state government, while another of them is a federal service located in

the Federal University of Goiás *Hospital das Clínicas*. In addition to public services, there are also obstetric and neonatal beds paid for by the Brazilian National Health Service (SUS) in private and charity hospital maternity units.[13]

The nominal databases were provided by the Goiás State Health Department.

The study database was comprised of all the 21,346 live born babies of mothers resident in the municipality of Goiânia in 2012 who had Live Birth Certificates registered on the SINASC system in 2012. Neonatal and postneonatal deaths occurring in the 2012 live born baby cohort were identified on the SIM system by linking the two databases.

The outcomes of the study were infant deaths – defined as deaths of live born babies under 1 year old – divided into neonatal deaths (0-27 days of life) and postneonatal deaths (28-364 days of life).

In order to analyze determinant factors of infant mortality, the variables were categorized as distal determinants, intermediate determinants and proximal determinants of infantile death, as per the classification proposed by Mosley & Chen:[15]

a) Distal determinants
   - level of schooling (complete higher education; high school/incomplete higher education; complete elementary education; incomplete elementary education or no schooling);
   - mother's race/skin color (white; brown; black; other [indigenous and yellow]); and
   - mother's marital status (married/common law marriage; single/separated/widowed).

b) Intermediate determinants
   - mother's age (in years: 20-34; 35 and over; 10-19);
   - delivery type (vaginal; cesarean); and
   - number of prenatal care visits (7-14; 15-20; 4-6; 0-3).

c) Proximal determinants
   - weeks of pregnancy (37-45; 34-36; 19-34);
   - birth weight (2,500g and over; 1,500 to 2.499g; under 1.500g); and
   - sex of the newborn (female; male).

d) Mother's health district of residence (Southern; Campinas-Central; Eastern; Northern; Western; Southwestern; Northwestern).

In order to identify deaths in the 2012 live birth cohort, a probabilistic linking procedure was performed between the databases using the OpenRecLink 3.1 computer program. This procedure was comprised of the following stages:

i) standardization – standardization of variables and checking for phonetic and spelling mistakes that could interfere with record matching;
ii) blocking – creation of logical blocks of files, done by the computer program, taking the name of the mother of the live born baby held on each record;
iii) matching – definition of the linkage variables (name; date of birth; mother's name) and the comparison variables used in the next stage (name; date of birth; mother's name; sex; municipality of residence), based on the sensitivity and specificity parameters adopted, according to the matrix generated by the computer program for the dataset;
iv) manual inspection – final stage classifying each pair of records as a true or false match, by categories defined by probability scores given at the end of the matching stage; and
v) merging – retrieval of the original variables present in the complete databases.

IMRs in the neonatal and postneonatal periods were estimated by taking neonatal deaths (0-27 days of life) and postneonatal deaths (28-364 days of life) for the years 2012 and 2013 belonging to the 2012 live birth cohort as the numerator, and live born babies of mothers resident in Goiânia in 2012 as the denominator:

$$\text{IMR} = \frac{\textit{Total number of deaths of babies under 1 year old born alive in 2012}}{\textit{Total number of live births in 2012}} \text{ X } 1{,}000$$

$$\text{neonatal IMR} = \frac{\textit{Number of deaths at 0-27 complete days of life of babies born alive in 2012}}{\textit{Total number of live births in 2012 x 1,000}} \text{ X } 1{,}000$$

$$\text{postneonatal IMR} = \frac{\textit{Number of deaths at 28-364 complete days of life of babies born alive in 2012}}{\textit{Total number of live births in 2012 x 1,000}} \text{ X } 1{,}000$$

Infant deaths and live-born babies were georeferenced in Goiânia's health districts, in order to estimate the neonatal and postneonatal mortality rates for each district.

Bivariate and multivariate logistic regression was performed in order to analyze determinants of infant mortality. Crude and adjusted odds ratios (OR) and their respective 95% confidence intervals (95%CI) were calculated. Variables with a p-value of less than 0.20 in the bivariate analysis were included in the multivariate analysis, on each hierarchical level. Variables with $p<0.05$ in each hierarchical level and those found to be a confounding factor for the other variables on the same hierarchical level were kept in the model. The analysis was conducted according to hierarchical levels of determination: distal, intermediate and proximal. The distal level variables were adjusted only by the variables on the same level. The intermediate level variables were adjusted between each other and by the significant distal level variables. The proximal level variables were adjusted between each other and by the significant distal and intermediate level variables. The quality of the fit of the model was assessed using the Hosmer & Lemeshow test, with values between 0.9 and 1.0.

The reference categories for each variable were defined based on the literature we reviewed as well as on previous studies conducted in Goiânia, in order to enable comparability of the results in different years.

The OpenReclink 3.1 computer program was used for the probabilistic linkage between the databases and the IBM® SPSS Statistics 25 computer program was used to perform statistical analysis.

The Federal University of Goiás Research Ethics Committee approved the study project as per Opinion No. 1.058.681, issued on May 11th 2015

Results

The final database was comprised of a total of 21,346 live-born babies of mothers resident in the municipality of Goiânia in 2012. Data completeness quality was greater than 95% for the selected variables, with the exception of mother's race/skin color and weeks of pregnancy, with 80.9% and 86.0% respectively (Table 1). We identified 21,081 survivors and 265 infant deaths in the 2012 live birth cohort, with 201 deaths in the neonatal period and 64 deaths in the postneonatal period. The IMR was 12.4 deaths per 1,000 live births: neonatal IMR was 9.4 deaths per 1,000 live births, while postneonatal IMR was 3.0 deaths per 1,000 live births. In the early neonatal period (0-6 days of life), there were 6.6 deaths per 1,000 live births; while in the late neonatal period (7-27 days of life) there were 2.8 deaths per 1,000 live births.

With regard to the neonatal period and factors associated with mortality, no statistically significant determinant was found for the distal level. On the other hand, the following factors were found for the intermediate level: mothers who had 4-6 prenatal care visits (OR=4.57 – 95%CI 2.96;7.04) and 0-3 prenatal care visits (OR=13.10 – 95%CI 7.48;22.96). Cesarean delivery was found to be a protective factor (OR=0.54 – 95%CI 0.37;0.79) (Table 2). The following were risk factors for the proximal determinants: 34-36 weeks of pregnancy (OR=4.11 – 95%CI 1.92;8.76), 19-34 weeks of pregnancy (OR=6.25 – 95%CI 2.26;17.29), birth weight between 1,500 and 2,499g (OR=2.70 – 95%CI 1.21;6.07) and birth weight under 1,500g (OR=62.42 – 95%CI 22.72;171.48) (Table 2).

In the postneonatal period, the factor found to be associated with mortality was 0-3 prenatal care visits (OR=4.16 – 95%CI 1.51;11.43) (Table 3). On the proximal level the associated factors were: birth weight between 1,500 and 2.499g (OR=6.71 – 95%CI 2.58;17.51) and birth weight under 1,500g (OR=18.74 – 95%CI 4.04;87.00) (Table 3).

With regard to magnitude of mortality in Goiânia's health districts, the estimated mortality rate in the neonatal period varied between 6.45 deaths per 1,000 live births in the Northern district and 10.32 deaths per 1,000 live births in the Southwestern district. In the postneonatal period, mortality varied between 1.30 death per 1,000 live births in the Northern district and 4.23 deaths per 1,000 live births in the Western district. No statistically significant differences were found (Table 4).

Discussion

This study estimated magnitude of neonatal and postneonatal mortality in the municipality of Goiânia and its health districts. Mortality magnitude rates differed between districts, with greatest risk of neonatal mortality in the Southwestern district and least risk in the Northern district. The main factors associated with mortality in the neonatal and postneonatal periods were inadequate number of prenatal care visits, premature birth and low birth weight.

Table 1 – Description and percentage completeness of the independent variables, by determinant levels, in Goiânia, 2012

Variable	Category	Completeness quality (%)	
		Neonatal	Postneonatal
Distal determinants			
Schooling	Complete higher education High school/incomplete higher education Complete elementary education Incomplete elementary education or no schooling	97.0	96.9
Mother's race/skin color	White Brown Black Other (indigenous and yellow)	80.9	80.9
Mother's marital status	Married/common law marriage Single/separated/widowed	97.6	97.6
Intermediate determinants			
Mother's age (years)	20 - 34 ≥35 10 - 19	99.9	99.9
Delivery type	Vaginal Cesarean	99.8	99.9
Number of prenatal care visits	7 - 14 15 - 20 4 - 6 0 - 3	95.3	95.3
Proximal determinants			
Weeks of pregnancy	37 - 45 34 - 36 19 - 34	86.0	86.0
Birth weight	≥2.500g 1.500 a 2.499g <1.500g	99.9	99.9
Sex of the newborn	Female Male	99.9	99.9
Mother's health district of residence	Southern Campinas-Central Eastern Northern Western Southwestern Northwestern	98.2	98.2

Infant mortality rates in the neonatal and postneonatal periods in Goiânia in 2012 were lower than those found by two studies that estimated probability of death in the neonatal and postneonatal periods in the 1992 to 1996 live birth cohorts. Comparison between the rates in 2012 with those of 1992 and 1996 showed a reduction in percentage change of 14.5% and 24.5% respectively, for the two periods.[11,12] Comparison of the rates found in Goiânia with those of other countries shows that they were higher than those found in high-income countries.[10]

Reduction in the neonatal period was less than in the postneonatal period; probably because of socioeconomic improvements and improvement in the level of schooling of mothers living in the poorer regions of the city. In the 1990s, the Northwestern health district had the highest risks of mortality and the worst socioeconomic indicators when compared to the other districts; it was also the district with the largest percentage reduction in infant mortality between 1996 and 2012, when Primary Health Care expanded to provide 100% coverage of the district's population and a maternity hospital was built operating with a humanized child delivery model, adequate physical structure and qualified health workers.[11,12,16-18]

The lower percentage reduction in the neonatal component may be due to early neonatal deaths of babies born to women resident in other municipalities

Table 2 – Determinants of neonatal deaths in the cohort of live born babies of mothers resident (n=21,346) in Goiânia, 2012

Category	Deaths	Total[a] (%)	Neonatal mortality rate	p-value	OR[b] (95%CI[c])
Determinantes distais					
Schooling				0.440	
Complete higher education	53	4,558 (22.1)	11.63	–	–
High school/incomplete higher education	97	11,641 (56.4)	8.33	–	0.75 (0.51;1.12)
Complete elementary education	42	3,886 (18.8)	10.81	–	0.87 (0.52;1.48)
Incomplete elementary education or no schooling	5	551 (2.7)	9.07	–	0.47 (0.11;1.97)
Total	**197**	**20,636**	**9.55**	–	–
Mother's race/skin color				0.570	
White	74	6,895 (40.0)	10.73	–	–
Brown	79	9,713 (56.4)	8.13	–	0.85 (0.60;1.21)
Black	2	461 (2.7)	4.34	–	0.47 (0.11;1.96)
Other (indigenous and yellow)	2	149 (0.9)	13.42	–	1.42 (0.34;5.87)
Total	**157**	**17,218**	**9.12**	–	–
Mother's marital status				0.660	
Married/common law marriage	133	14,196 (68.4)	9.37	–	–
Single/separated/widowed	61	6,568 (31.6)	9.29	–	0.92 (0.64;1.33)
Total	**194**	**20,764**	**9.34**	–	–
Intermediate determinants					
Mother's age (in years)				0.210	
10-19	36	2,891 (13.6)	12.45	–	0.99 (0.58;1.69)
20-34	132	15,819 (74.3)	8.34	–	–
≥35	33	2,567 (12.1)	12.86	–	1.55 (0.95;2.52)
Total	**201**	**21,277**	**9.45**	–	–
Delivery type				<0.001	
Vaginal	88	5,298 (24.9)	16.61	–	–
Cesarean	112	15,952 (75.1)	7.02	–	0.54 (0.37;0.79)
Total	**200**	**21,250**	**9.41**	–	–
Number of prenatal care visits				<0.001	
15-20	3	412 (2.0)	7.28	–	0.89 (0.22;3.69)
7-14	75	14,508 (71.6)	5.17	–	–
4-6	70	4,650 (22.9)	15.05	–	4.57 (2.96;7.04)
0-3	32	702 (3.5)	45.58	–	13.10 (7.48;22.96)
Total	**180**	**20,272**	**8.88**	–	–
Proximal determinants					
Weeks of pregnancy				<0.001	
37-45	30	16,147 (88.2)	1.86	–	–
34-36	27	1,630 (8.9)	16.56	–	4.11 (1.92;8.76)
19-34	110	523 (2.9)	210.33	–	6.25 (2.26;17.29)
Total	**167**	**18,300**	**9.13**	–	–

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Table 2 – Determinants of neonatal deaths in the cohort of live born babies of mothers resident (n=21,346) in Goiânia, 2012

Birth weight				<0.001	
≥2.500g	48	19,454 (91.4)	2.47	–	–
1.500 a 2.499g	34	1,564 (7.3)	21.74	–	2.70 (1.21;6.07)
<1.500g	118	262 (1.2)	450.38	–	62.42 (22.72;171.48)
Total	**200**	**21,280**	**9.40**	–	–
Sex				0.640	
Female	81	10,541 (49.6)	7.68	–	–
Male	115	10,716 (50.4)	10.73	–	1.12 (0.69;1.82)
Total	**196**	**21,257**	**9.22**	–	–

a) Unknown/blank cases were excluded from the analysis.
b) OR: *adjusted odds ratio*.
c) 95%CI: 95% confidence interval.

who reported living in the municipality of Goiânia when they received health care: the state capital provides a neonatal intensive therapy unit (ITU) reference service equipped with 98 beds.[19] Availability of neonatal ITU beds in Goiânia is sufficient to meet the needs not only of the population resident in the municipality but also part of the municipalities comprising Goiás state's Integrated Programming Agreement. Indeed, Public Health in Goiânia receives at risk newborns from all over the state as well as from neighboring states. Another hypothesis for this demand from outside the municipality may be low quality prenatal care and absence of obstetric beds in public maternity services in health districts where population density has increased more recently, comprised of people of low socioeconomic level and at high risk of neonatal death.[16,18]

In 2012, magnitude of neonatal and postneonatal infant mortality was highest in Goiânia's Southwestern and Western health districts, where the low-income population grew rapidly, as a result of migration between neighborhoods in Goiânia, or from municipalities in the metropolitan region surrounding the capital. Other factors that contributed to this high risk may have been low Family Health coverage and absence of public maternity services in these two regions.[16-18]

Analysis of the factors associated with neonatal and postneonatal mortality showed that the inadequate number of prenatal care visits was statistically significant for both these components of infant mortality.[1,20] Quality prenatal care, with an adequate number of consultations, laboratory tests and paying due attention to intercurrences, reduces risk of complications during pregnancy and childbirth.[20] A study which assessed a population with characteristics similar to those of Goiânia found that neonatal mortality can be reduced by up to 34% by implementing quality prenatal monitoring.[21]

Low birth weight and premature birth were the determinants with the highest odds ratios in the neonatal period. Magnitude of both factors is high, due to their being situated on the most proximal level of the chain of infant mortality determinants.[6] Distal determinants, such as socioeconomic status, schooling, mother's race/skin color, access to quality health services, are hierarchically higher determinants in the low weight and prematurity causality chain, these being the proximal determinants of infant deaths.[6,15] The '*Nascer no Brasil*' survey[22] showed that low weight was the variable with strongest association with neonatal mortality, with prematurity present in almost one third of cases. According to that survey, the main causes of prematurity were increased pregnancy in women over 35 years old, improvement in measuring gestational age and changes in the limit of viability (improvement in recording live births with very low birth weight).

The protective effect of cesarean delivery found by this study, had also been identified in previous studies that also assessed infant mortality in Goiânia in the 1992 cohort and the 1992-1996 cohorts, as well as in analyses of determinants of infant mortality in other Brazilian capitals.[11,12,23,24] This protective effect of cesarean delivery may be related to the fact that in Goiânia 75% of childbirths were via cesarean section, performed in an operating theater, under the care of an obstetrician and with less risk of complications related to normal childbirth – such as amniotic fluid and meconium inhalation, macrosomia and infections.[25] For the purposes of comparison, a study conducted in Florianópolis, SC, found that cesarean sections

Table 3 – Infant deaths by health district of residence in the cohort of live born babies of mothers resident (n=21,346) in Goiânia, 2012

Category	Deaths	Total[a] (%)	Postneonatal mortality rate	p-value	OR[b] (95%CI[c])
Distal determinants					
Schooling				0.540	
Complete higher education	8	4,513 (22.0)	1.77	–	–
High school/incomplete higher education	39	11,583 (56.5)	3.37	–	1.61 (0.71;3.65)
Complete elementary education	13	3,857 (18.8)	3.37	–	1.04 (0.35;3.09)
Incomplete elementary education or no schooling	1	547 (2.7)	1.83	–	1.06 (0.13;8.89)
Total	**61**	**20,500**	**2.98**	–	–
Mother's race/skin color				0.620	
White	21	6,842 (40.0)	3.07	–	–
Brown	27	9,661 (56.5)	2.79	–	0.80 (0.43;1.49)
Black	2	461 (2.7)	4.34	–	1.39 (0.32;6.12)
Other (indigenous and yellow)	1	148 (0.9)	6.76	–	2.30 (0.31;17.37)
Total	**51**	**17,112**	**2.98**	–	–
Mother's marital status				0.100	
Married/common law marriage	34	14,097 (68.3)	2.41	–	–
Single/separated/widowed	28	6,535 (31.7)	4.28	–	1.65 (0.91;2.97)
Total	**62**	**20,632**	**3.01**	–	–
Intermediate determinants					
Mother's age (in years)				0.490	
10-19	9	2,864 (13.5)	3.14	–	0.85 (0.34;2.10)
20-34	47	15,734 (74.4)	2.99	–	–
≥35	8	2,542 (12.0)	3.15	–	1.59 (0.69;3.67)
Total	**64**	**21,140**	**3.03**	–	–
Delivery type				0.990	
Vaginal	8	5,228 (24.8)	1.53	–	–
Cesarean	46	15,886 (75.2)	2.90	–	1.00 (0.49;2.01)
Total	**64**	**21,114**	**3.03**	–	–
Number of prenatal care visits				0.050	
15-20	1	410 (2.0)	2.44	–	1.28 (0.17;9.52)
7-14	36	14,469 (71.8)	2.49	–	–
4-6	18	4,598 (22.8)	3.91	–	1.21 (0.58;2.50)
0-3	5	675 (3.3)	7.41	–	4.16 (1.51;11.43)
Total	**60**	**20,152**	**2.98**	–	–
Proximal determinants					
Weeks of pregnancy				0.160	
37-45	29	16,146 (88.8)	1.80	–	–
34-36	7	1,610 (8.9)	4.35	–	1.27 (0.42;3.90)
19-34	18	431 (2.4)	41.76	–	3.40 (0.95;12.11)
Total	**54**	**18,187**	**2.97**	–	–

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Table 3 – Infant deaths by health district of residence in the cohort of live born babies of mothers resident (n=21,346) in Goiânia, 2012

Birth weight				<0.001	
≥2.500g	33	19,439 (91.9)	1.70	–	–
1.500 a 2.499g	18	1,548 (7.3)	11.63	–	6.71 (2.58;17.51)
<1.500g	13	157 (0.7)	82.80	–	18.74 (4.04;87.00)
Total	**64**	**21,144**	**3.03**	–	–
Sex				0.520	
Female	36	10,496 (49.7)	3.43	–	–
Male	28	10,629 (50.3)	2.63	–	0.79 (0.39;1.60)
Total	**64**	**21,125**	**3.03**	–	–

a) Unknown/blank cases were excluded from the analysis.
b) OR: *adjusted odds ratio.*
c) 95%CI: 95% confidence interval.

accounted for 53% of childbirths, with no statistically significant difference in relation to the 'infant death' outcome.[1] A case-control study of determinants of infant mortality in 27 Brazilian state capitals, which also has as its study population infant deaths occurring in 2012, found that cesarean delivery was a protective factor in its analysis of the capital cities of Brazil's Midwest region and for all the Brazilian state capitals.[23] Studies conducted in the United States show that there is low mortality among high-risk babies born alive in hospitals that have neonatal ITU beds, including those with extremely low birth weight.[21,26]

There was no difference in the likelihood of death in relation to the 'schooling', 'mother's race/skin

Table 4 – Determinants of postneonatal deaths in the cohort of live born babies of mothers resident (n=21,346) in Goiânia, 2012

Health district	Deaths	Total[a] (%)	Infant mortality rate	p-value	OR[b] (95%CI[c])
Neonatal death				**0.630**	
Southern	29	3,191 (15.7)	9.09	–	–
Campinas-Central	21	2,921 (14.4)	7.19	–	0.79 (0.45;1.39)
Eastern	18	2,682 (13.2)	6.71	–	0.74 (0.41;1.33)
Northern	15	2,327 (11.4)	6.45	–	0.71 (0.38;1.32)
Western	19	2,373 (11.7)	8.01	–	0.88 (0.49;1.57)
Southwestern	37	3,587 (17.6)	10.32	–	1.14 (0.70;1.85)
Northwestern	29	3,255 (16.0)	8.91	–	0.98 (0.58;1.64)
Total	**168**	**20,336**	**8.26**	**–**	**–**
Postneonatal death				**0.580**	
Southern	8	3,170 (15.7)	2.52	–	–
Campinas-Central	7	2,907 (14.4)	2.41	–	0.95 (0.35;2.63)
Eastern	7	2,671 (13.2)	2.62	–	1.04 (0.38;2.87)
Northern	3	2,315 (11.4)	1.30	–	0.51 (0.14;1.94)
Western	10	2,364 (11.7)	4.23	–	1.68 (0.66;4.26)
Southwestern	13	3,563 (17.6)	3.65	–	1.45 (0.60;3.50)
Northwestern	8	3,234 (16.0)	2.47	–	0.98 (0.37;2.62)
Total	**56**	**20,224**	**2.77**	**–**	**–**

a) Unknown/blank cases were excluded from the analysis.
b) OR: *adjusted odds ratio.*
c) 95%CI: 95% confidence interval.

color', 'marital status' and 'mother's age' variables. A systematic review[26] studying determinant factors of infant death showed that statistical analysis methods have limitations with regard to assessing determinants of infant mortality found on different hierarchical levels of determination. Proximal factors have greater statistical significance, when compared to distal and intermediate determinants, which may explain the stronger association of more proximal factors, such as low birth weight and prematurity, and absence of statistical significance of schooling and mother's race/skin color.[26] Cross-sectional studies that assessed determinants of neonatal near misses in Joinville, SC,[27] and in Teresina, PI,[28] also did not find statistically significant association between mother's race/skin color or marital status and infant death.

Standing out among the limitations of this study is the use of secondary SIM and SINASC data, which may have quality-related problems in terms of the filling in of some of the variables. SIM can have shortcomings in data processing and in the filling in of death certificates not in keeping with the standard recommended by the Ministry of Health. SIM and SINASC coverage was 90% in the state of Goiás in 2012,[29] with 97.9% variable completeness in the period 2006-2010.[30] The Ministry of Health, in partnership with state and municipal health departments, has made progress with increasing death certificate coverage and completeness quality; although there are still limitations in relation to infant mortality, so that indirect estimates need to be used in states with a high percentage of underreporting.[29,30]

The results of this study can inform municipal management of the Brazilian National Health System (SUS) and social health policy watchdog efforts in Goiânia, to achieve greater knowledge of infant mortality magnitude and its main risk factors. The results enable identification of infant mortality inequalities between Goiânia's health districts, as well as the main factors associated with mortality in the neonatal and postneonatal periods. Their use is also recommended for guiding, expanding and qualifying prenatal, childbirth and newborn care in Goiânia's health districts.

Authors' contributions

Saloio CA and Morais Neto OL contributed to the study concept and design, data acquisition, analysis and interpretation, drafting and critically reviewing the contents of the manuscript. Gonçalves DA, Bessa HEM and Coelho Junior JP contributed to data acquisition, analysis and interpretation, drafting and critically reviewing the contents of the manuscript. Carvalho SR and Afonso MSM contributed to the study concept and design, drafting and critically reviewing the contents of the manuscript. All the authors have approved the final version of the manuscript and are responsible for all aspects thereof, including the guarantee of its accuracy and integrity.

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