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# Population-based study on infant mortality

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**Abstract** *Although Brazil has reduced social, economic and health indicators disparities in the last decade, intra- and inter-regional differences in child mortality rates (CMR) persist in regions such as the state capital of Mato Grosso. This population-based study aimed to investigate factors associated with child mortality in five cohorts of live births (LB) of mothers living in Cuiabá (MT), Brazil, 2006-2010, through probabilistic linkage in 47,018 LB. We used hierarchical logistic regression analysis. Of the 617 child deaths, 48% occurred in the early neonatal period. CMR ranged from 14.6 to 12.0 deaths per thousand LB. The following remained independently associated with death: mothers without companion (OR = 1.32); low number of prenatal consultations (OR = 1.65); low birthweight (OR = 4.83); prematurity (OR = 3.05); Apgar ≤ 7 at the first minute (OR = 3.19); Apgar ≤ 7 at the fifth minute (OR = 4.95); congenital malformations (OR = 14.91) and male gender (OR = 1.26). CMR has declined in Cuiabá, however, there is need to guide public healthcare policies in the prenatal and perinatal period to reduce early neonatal mortality and further studies to identify the causes of preventable deaths.*

**Key words** *Child mortality, Information systems, Risk factors, Vital statistics*

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## Introduction

One of the goals proposed in the Millennium Development Goals (MDGs) in mother and child health was to reduce child mortality rate (CMR) to below 15.7 deaths per thousand live births (LB) by 2015[1]. Brazil achieved this mark in 2011, achieving a rate of 15.3[1,2].

Among the emerging countries of the BRICS (Brazil, Russia, India, China and South Africa), Brazil was the best performer in reducing child mortality between 1990 and 2010, followed by China[3]. However, compared to the other South American countries, Brazil has higher rates than Ecuador, Colombia, Argentina, Uruguay and Chile, with the latter two showing rates below 10/1,000 LB in 2013[1].

While Brazil has reduced social, economic and health indicators disparities in the last decade[4,5], intra- and interregional differences in child mortality rates persist[5]. In 2010, the North had rates ranging from 11.0 to 21.8 deaths/1,000 LB; in the Northeast, rates ranged between 11.9 and 17.8 deaths/1,000 LB; in the Southeast and South, rates had a lower variation, ranging between 9.1 and 13.2 deaths/1,000 LB. In turn, Midwest capitals have very similar rates, varying from 12.6 to 13.2 deaths/1,000 LB[2].

Midwest capitals emerge among those that showed the greatest drop in child mortality rates in the last two decades, following the significant improvement of social and economic indicators in this period[6]. However, child mortality has been little studied in this region[7,8].

The method such as linkage with the Live Births Information System (SINASC) and the Mortality Information System (SIM) has been widely used for studies of factors associated with child mortality[7,9]. Some of these factors are well known, such as low mother schooling, low number of prenatal consultations, mother's age, prematurity and low birthweight[4,5,9-13].

Linkage enables the identification of individuals or records that are part of two or more distinct databases[14]. This feature has the advantages of low operational cost, speed and feasibility, using data already recorded by health services[7,14]. Despite this facility, only one child mortality study was conducted in capital Cuiabá using this method[7].

Cuiabá has good SINASC and SIM coverage (over 90%)[15] and good variables completeness of both systems[16,17], essential for the linkage. Due to research gaps in the Midwest, we developed this study aiming at investigating factors associated with child mortality in the LB cohorts of mothers residing in Cuiabá from 2006 to 2010.

## Methodology

This is a retrospective population-based cohort study. The study population consisted of cohorts of born between January 1, 2006 and December 31, 2010, children of mothers living in the city of Cuiabá (MT), totaling 47,018 LB. The area of interest was capital Cuiabá (MT), with a population of 550,000 inhabitants in the last census, with a Human Development Index (HDI) of 0.785, Gini Index of 0.59, fertility rate of 1.79 children per woman in fertile age, and average per capita income of 1,161.49 Brazilian reais in 2010[6].

Included in the study were live births with a duly completed Live Birth Certificate (LBC), and child deaths not matched by the linkage method, without date of birth and the mother's name and not found after manual search were excluded.

Children included in the study were selected from the SINASC database and deaths were identified in the SIM database. Probabilistic linkage was performed after standardizing the two databases (capitalization, no semicolons), establishing a single database. The Registry Plus™ Link Plus, version 3.0 beta software (Centers for Disease Control and Prevention, CDC, http://www.cdc.gov) was used for linkage.

With regard to linkage, a blocking strategy for variable gender and matching in which pairs were made (a SINASC record with a SIM record) was used: the mother's name and the date of birth[18]. The established cutoff point was six to find the largest possible number of pairs[18]. In case of divergence of data between the Death Certificate (DC) and Live Birth Certificate (LBC), the information contained in the LBC was considered a golden standard because it was of good quality and with a low percentage of information ignored[7]. Non-electronically related deaths were processed manually by examining SINASC and the original LBC records.

Data source of this research was the Birth and Death Surveillance Management of the Municipal Health Secretariat of Cuiabá (MT) and the State Health Secretariat of Mato Grosso. Univariate analyzes and logistic regression were processed in Stata, version 13.0.

After linkage, infant mortality rates were estimated, taking as numerator deaths among children under one year and as denominator the number of LB, multiplied by one thousand. The

calculation method for child mortality components considered the early neonatal periods – deaths from 0 to 6 days of life; late neonatal – 7 to 27 days of life and postneonatal – deaths from 28 to 364 days of life as numerator and LB as denominator, multiplied by one thousand.

The dependent variable was the probability of death in the first year of life, whereas the independent variables were the potential factors associated with death, divided into determinants for the investigation of the factors associated with child mortality.

Gross odds ratios (OR) were estimated and adjusted with the respective 95% confidence intervals, using hierarchical multiple logistic regression[19]. The Hosmer-Lemeshow test was used to verify significance of the final model.

For the analysis of the hierarchical model, we took as distal determinants the socioeconomic variables: mother marital status and schooling – in years of study. The variables of intermediate determinants (care-related) were number of prenatal consultations, location of birth, hospital type, and type of delivery. Proximate determinants were mother biological variable (age) and child biological variables: pregnancy type, gestational age in weeks, birthweight in grams, gender, race/skin color, Apgar index at the first and fifth minute and congenital malformation.

The hierarchical statistical analysis is based on a conceptual model that describes the relationship between risk factors[19]. In this study, the hierarchical analysis followed the distal-proximate direction, using as a starting point block 1variables, which join block 2 variables and, finally, block 3 variables, thus forming the final hierarchical model. Within each block, variables with a value of $p < 0.20$ in the univariate analysis were included in the assembly of the respective block model, using the stepwise forward procedure. Variables with a value of $p<0.05$ and those with biological plausibility remained within each block.

This study was approved by the Research Ethics Committee of the Júlio Müller University Hospital, of the Federal University of Mato Grosso.

## Results

Of the initial total of 698 deaths related to the five birth cohorts (2006 to 2010), two deaths (0.3%) were excluded because they did not bear the mother's name nor the date of birth. After linkage between SINASC (47,018 LB) and SIM (696 deaths), 607 deaths were paired (87%), with 597 (98%) true pairs and 13 (2%) non-true pairs. After exclusion of the 13 non-true pairs and inclusion of the 23 true pairs resulting from the manual search, the final casuistry was 617 deaths (Figure 1).

The average CMR for the five-year period was 13.1 deaths/1,000 LB, and most deaths occurred in the neonatal period n = 414 (67.1%), especially in the early neonatal period, 48.1% (n = 297).

CMR increased from 11.4 deaths/1,000 LB in 2006 to 14.6 in 2008, followed by a decline to 12.0 deaths/1,000 LB in 2010. In the period under study, the main component responsible for child mortality was neonatal (Table 1).

Of live births, 6.85% (3,178 / 46,401) were born preterm, 7.20% (3,339 / 46,401) with low birthweight, 51.52% (23,905 / 46,401) were male, 35.85% (16,606 / 46,401) were of mothers who had less than seven prenatal consultations, 59.64% (27,675 / 46,401) were born by cesarean section and 67.22% (31,182 / 46,401) were of mothers without companion.

Of the newborns who died, 58.05% (357/617) were born preterm, 61.59% (380/617) with low birthweight, 57.21% (353/617) were males, 62.38% (383/617) were of mothers who had less than seven prenatal consultations, 52.51% (324/617) of deaths were of cesarean section and 75.53% (466/617) were of mothers without companion. In the univariate analysis, all variables analyzed were associated with death (Table 2).

Table 3 shows the result of the model applied for each block in the first column. In the second column, we observe the intermediate model, composing block 1 (distal determinants) with block 2 (intermediate determinants). The third column shows the final model, by adding to the two previous blocks to block 3 (proximate determinants). Since it is hierarchical, results can be read horizontally (a given variable along the adjustment) and diagonally (adjustment between blocks), as indicated in bold in Table 3.

In block 1 (distal determinants), the mother's marital status without companion and low schooling were associated with child death, however, only mother without companion remained independently associated in the final model. In block 2 (intermediate determinants), the low number of prenatal consultations and non-private hospitals were associated with the outcome, however, only the low number of prenatal consultations remained independently associated with death in the final model. In block 3 (proximate determinants), post-term gestational age was not associated with death, not remaining in the final

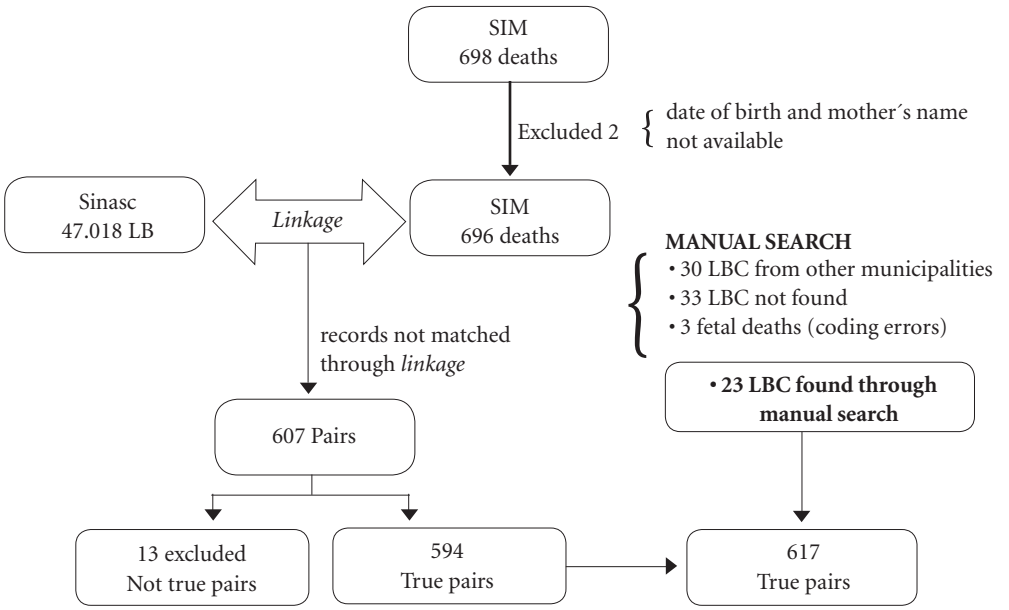


**Figure 1.** Linkage between the Live Births Information Systems (SINASC) and Mortality Information System (SIM), 2006-2010.

**Table 1.** Distribution of numbers of deaths and child mortality rates of live birth cohorts by year, Cuiabá-MT.

| Deaths | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|---|
| Neonatal period (n) | 74 | 87 | 86 | 90 | 77 | 414 |
| Early neonatal period (n) | 58 | 66 | 63 | 55 | 55 | 297 |
| Late neonatal period (n) | 16 | 21 | 23 | 35 | 22 | 117 |
| Postneonatal period (n) | 34 | 35 | 54 | 45 | 35 | 203 |
| First year of life (n) | 108 | 122 | 140 | 135 | 112 | 617 |
| Number of live births (LB) | 9.443 | 9.284 | 9.601 | 9.351 | 9.339 | 47.018 |
| NCMR | 7,8 | 9,4 | 9,0 | 9,6 | 8,2 | 8,8 |
| ENCMR | 6,1 | 7,1 | 6,6 | 5,9 | 5,9 | 6,3 |
| LNCMR | 1,7 | 2,3 | 2,4 | 3,7 | 2,4 | 2,5 |
| PNCMR | 3,6 | 3,8 | 5,6 | 4,8 | 3,7 | 4,3 |
| CMR | 11,4 | 13,1 | 14,6 | 14,4 | 12,0 | 13,1 |

Captions: NCMR = Neonatal Child Mortality Rate; ENCMR = Early Neonatal Child Mortality Rate; LNCMR = Late Neonatal Child Mortality Rate; PNCMR = Postneonatal Child Mortality Rate; CMR: Child Mortality Rate.

model. The race / skin color black + brown was associated in isolation, but lost significance after adjusting the model.

The marital status of mother without companion (OR = 1.32, $CI_{95\%}$ = 1.04;1.68) and low number of prenatal consultations (OR = 1.65, $CI_{95\%}$ = 1.34;2.03) of the distal and intermediate determinants, respectively, remained independently associated with child deaths. Variables of the biological determinants were the most strongly associated with the outcome, with OR = 4.83 ($CI_{95\%}$ = 3.70;6.31) for low birthweight, OR = 3.05 ($CI_{95\%}$ = 2.33;4.00) for prematurity, OR = 3.19 $CI_{95\%}$ = 2.52;4.05) for anoxia in the first minute, OR = 4.95 ($CI_{95\%}$ = 3.80;6.45), for anoxia in the fifth minute, OR = 14.91 ($CI_{95\%}$ = 10.46; 21.26) for congenital malformation and (OR = 1.26 $CI_{95\%}$ = 1.04;1.52) for male gender (Table 3).

**Table 2.** Univariate analysis of variables associated with child death by determinants (distal, intermediate and proximate), municipality of Cuiabá, 2006-2010.

| Variables | Deaths | | | | Gross OR | CI 95% | p-value |
|---|---|---|---|---|---|---|---|
| | Yes n = 617 | | No n = 46.401 | | | | |
| | N | % | N | % | | | |
| Distal determinants | | | | | | | |
| mother schooling (years of study) | | | | | | | |
| ≥ 8 | 448 | 72,85 | 36.883 | 79,50 | 1 | | |
| < 8 | 167 | 27,15 | 9.510 | 20,50 | 1,46 | 1,21;1,73 | <0,001 |
| Marital status | | | | | | | |
| With companion | 151 | 24,47 | 15.209 | 32,78 | 1 | | |
| Without companion | 466 | 75,53 | 31.182 | 67,22 | 1,51 | 1,25;1,81 | <0,001 |
| Intermediate determinants | | | | | | | |
| number of prenatal consultations | | | | | | | |
| ≥ 7 | 231 | 37,62 | 29.721 | 64,15 | 1 | | |
| < 7 | 383 | 62,38 | 16.606 | 35,85 | 2,97 | 2,52;3,50 | <0,001 |
| Birth location | | | | | | | |
| Hospital | 610 | 98,87 | 46.309 | 99,80 | 1 | | |
| Home | 7 | 1,13 | 92 | 0,20 | 5,78 | 2,67;12,51 | <0,001 |
| Type of hospital | | | | | | | |
| Private and/or linked to the SUS | 530 | 87,17 | 43.324 | 93,64 | 1 | | |
| Non Private | 78 | 12,83 | 2.943 | 6,36 | 2,17 | 1,70;2,76 | <0,001 |
| Delivery type | | | | | | | |
| C-Section | 324 | 52,51 | 27.675 | 59,64 | 1 | | |
| Vaginal | 293 | 47,49 | 18.726 | 40,36 | 1,34 | 1,14;1,57 | <0,001 |
| Mother proximate determinants | | | | | | | |
| Age (years) | | | | | | | |
| 20 - 34 | 403 | 65,32 | 33.899 | 73,06 | 1 | | |
| < 20 | 161 | 26,09 | 8.925 | 19,23 | 1,52 | 1,26;1,82 | <0,001 |
| ≥ 35 | 53 | 8,59 | 3.577 | 7,71 | 1,25 | 0,93;1,66 | |
| Child proximate determinants | | | | | | | |
| Pregnancy Type | | | | | | | |
| Single | 563 | 91,40 | 45.520 | 98,11 | 1 | | |
| Multiple | 53 | 8,60 | 876 | 1,89 | 4,89 | 3,66;6,53 | <0,001 |
| Gestational age (weeks) | | | | | | | |
| 37 - 41 | 256 | 41,63 | 42.937 | 92,57 | 1 | | |
| < 37 | 357 | 58,05 | 3.178 | 6,85 | 18,84 | 15,98;22,21 | <0,001 |
| ≥ 42 | 2 | 0,32 | 268 | 0,58 | 1,25 | 0,31;5,06 | |
| Birthweight (grams) | | | | | | | |
| ≥ 2.500 | 237 | 38,41 | 43.061 | 92,80 | 1 | | |
| < 2.500 | 380 | 61,59 | 3.339 | 7,20 | 20,68 | 17,51;24,41 | <0,001 |
| Gender | | | | | | | |
| Female | 264 | 42,79 | 22.496 | 48,48 | 1 | | |
| Male | 353 | 57,21 | 23.905 | 51,52 | 1,26 | 1,07;1,48 | 0,005 |

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**Tabela 2**. continuation

| Variables | Deaths | | | | Gross OR | CI 95% | p-value |
|---|---|---|---|---|---|---|---|
| | Yes n = 617 | | No n = 46.401 | | | | |
| | N | % | N | % | | | |
| Race/Skin Color | | | | | | | |
| White | 107 | 18,35 | 11.743 | 26,91 | 1 | | |
| Black + Brown | 476 | 81,65 | 31.899 | 73,09 | 1,64 | 1,33;2,02 | <0,001 |
| Apgar 1st minute | | | | | | | |
| 8 - 10 | 258 | 42,36 | 42.448 | 91,58 | 1 | | |
| 0 - 7 | 351 | 57,64 | 3.903 | 8,42 | 14,80 | 12,56;17,43 | <0,001 |
| Apgar 5th minute | | | | | | | |
| 8 - 10 | 393 | 64,32 | 45.564 | 98,31 | 1 | | |
| 0 - 7 | 218 | 35,68 | 784 | 1,69 | 32,24 | 26,93;38,59 | <0,001 |
| Congenital malformation | | | | | | | |
| No | 538 | 87,20 | 46.097 | 99,39 | 1 | | |
| Yes | 79 | 12,80 | 284 | 0,61 | 23,83 | 18,32;31,02 | <0,001 |

Note: Totals for some variables may vary because of blank values. OR = odds ratio; CI95% = 95% Confidence Interval.

## Discussion

The linkage was useful in the identification of live births that resulted into death in order to determine the factors associated with infant mortality, was operationally feasible and had a low cost (free software). Its use is a stimulus to work with secondary data, and it is possible to incorporate it into the routine of municipal health services[7,9].

There was variation of CMR in Cuiabá in the period studied. From 2006 to 2008, it increased, declining again in 2009 and 2010. Caution should be used when interpreting such results, since they do not necessarily mean that CMR has increased, but rather that there has been an improvement in the information systems over the years.

Between 2006 and 2010, CMR in Cuiabá stood below average for the Midwest and Brazil, ranging from 17.7 to 15.9 deaths per 1,000 LB and 19.4 to 16.2 deaths per 1,000 LB, respectively[11]. However, findings of this study are similar to those published in other Brazilian regions and in other countries[1-9,20].

This development was a reflection of public policies such as the *Bolsa Alimentação*[21] (food grant) and the *Bolsa Família* (family grant) Program[22] adopted in recent decades that have had a positive influence toward reducing child mortality, such as social policies, mainly in health, education and fight against poverty, making social, economic and health conditions indicators more favorable[5,21,22].

Factors associated with child death in Cuiabá were marital status without companion, low number of prenatal consultations, low birthweight, prematurity, Apgar ≤ 7 in the first minute, Apgar ≤ 7 in the fifth minute, congenital malformation and male gender. These factors corroborate those found by other authors[5,7-9,11,20].

Attention is drawn to the prevalence of congenital malformation that remained stable in the Midwest from 1990 to 2007, while decreasing in the South and Southeast and increasing the North and Northeast[4]. Mother's exposure to pesticides widely used in Mato Grosso was associated with the highest occurrence of congenital malformations in the state[23]. On the other hand, congenital malformations were associated with death, a result consistent with that of another study[8], again in the capital Cuiabá.

As of 2003 and 2004, low birthweight rates remained stable in all Brazilian regions, except in Midwest capitals, which increased by 0.87% per year[24]. Authors[5] have argued that low birthweight may be related to the increased prevalence of cesarean section. This may make sense for Cuiabá,

**Table 3.** Factors associated with child death by determinant block, in Cuiabá, 2006-2010.

| Model/Variable | Model I | | Model II n = 46,778 | | Model III n = 44,037 | |
|---|---|---|---|---|---|---|
| | Blocks 1, 2 and 3 on a stand-alone basis | | Blocks 1 + 2 | | Blocks 1 + 2 + 3 | |
| | $OR_a$ | CI 95% | **$OR_a$** | CI 95% | **$OR_a$** | CI 95% |
| 1. Block 1 (distal determinants) | | | | | | |
| Marital status | | | | | | |
| With companion | 1 | | 1 | | 1 | |
| Without companion | 1,42 | 1,18;1,72 | 1,12 | 0,92;1,36 | 1,32 | 1,04;1,68 |
| Mother schooling | | | | | | |
| ≥ 8 years of study | 1 | | 1 | | 1 | |
| < 8 years of study | 1,35 | 1,12;1,62 | 1,04 | 0,87;1,26 | 1,12 | 0,90;1,40 |
| 2. Block 2 (intermediate determinants) | | | | | | |
| Number of prenatal consultations | | | | | | |
| ≥ 7 consultations | 1 | | 1 | | 1 | |
| < 7 consultations | 2,93 | 2,48;3,46 | 2,82 | 2,38;3,36 | 1,65 | 1,34;2,03 |
| Type of hospital | | | | | | |
| Private and/or linked to the SUS | 1 | | 1 | | 1 | |
| Non Private | 2,12 | 1,66;2,70 | 2,11 | 1,66;2,69 | 1,15 | 0,86;1,54 |
| 3. Block 3 (proximate determinants) | | | | | | |
| Birthweight | | | | | | |
| ≥ 2,500 grams | 1 | | | | 1 | |
| < 2,500 grams | 5,30 | 4,07;6,90 | | | 4,83 | 3,70;6,31 |
| Gestational age | | | | | | |
| 37 to 41 weeks | 1 | | | | 1 | |
| < 37 weeks | 3,02 | 2,31;3,94 | | | 3,05 | 2,33;4,00 |
| ≥ 42 weeks | 1,32 | 0,31;5,64 | | | 1,30 | 0,31;5,45 |
| Apgar 1st minute | | | | | | |
| 8 to 10 | 1 | | | | 1 | |
| 0 to 7 | 3,20 | 2,53;4,04 | | | 3,19 | 2,52;4,05 |
| Apgar 5th minute | | | | | | |
| 8 to 10 | 1 | | | | 1 | |
| 0 to 7 | 5,01 | 3,86;6,50 | | | 4,95 | 3,80;6,45 |
| Congenital malformation | | | | | | |
| No | 1 | | | | 1 | |
| Yes | 15,16 | 10,69;21,50 | | | 14,91 | 10,46;21,26 |
| Gender | | | | | | |
| Female | 1 | | | | 1 | |
| Male | 1,26 | 1,05;1,52 | | | 1,26 | 1,04;1,52 |
| Race/Skin Color | | | | | | |
| White | 1 | | | | 1 | |
| Black + Brown | 1,58 | 1,25;2,00 | | | 1,21 | 0,94;1,55 |

Obs.: Pearson's (p = 0.96) and Hosmer-Lemeshow's (p = 0.19) adjustment tests indicate a good fit of the model. ORa = adjusted odds ratio; CI95% = 95% Confidence Interval; SUS = Unified Health System.

since the proportion of cesarean section among LBs in this study was approximately 60% and 52.5% among deaths.

The retrospective nature and the use of secondary data are the main methodological limitations of this study; however, there was a low

percentage of losses due to underreporting and coding errors that prevented matching at the time of linkage.

There was a decrease in child mortality in Cuiabá, with the neonatal period accounting for 67.1% of child deaths. Factors associated with child death in the city show that efforts are needed to increase the number of prenatal consultations, trained staff for resuscitation in delivery rooms and that intensive neonatal units equipped to attend premature babies are required, since according to the World Health Organization (WHO)[25], up to 75% of newborn deaths can be avoided if effective health measures are taken at birth and during the first week of life. Due to the important participation of the early neonatal component in almost half of child deaths, new studies are needed to identify the preventable causes that result in deaths in this subgroup to guide local managers in the implementation of public policies.

## Collaborations

JC Lima designed the project, participated in the interpretation of data and wrote the paper. AM Mingarelli participated of the linkage process and the building of databases. NJ Segri and AAZ Zavala conducted the statistical review and participated of the interpretation of data. OA Takano guided the work, participated of all stages, design and final text review.

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