Ciência & Saúde Coletiva
cienciaesaudecoletiva.com.br
ISSN 1413-8123. v.29, n.1
DOI: 10.1590/1413-81232024291.17462022EN

Near miss neonatal in the capital of the Brazilian Midwest: a case-control study

Priscilla Shirley Siniak dos Anjos Modes (https://orcid.org/0000-0003-2039-4505) [1]
Maria Aparecida Munhoz Gaíva (https://orcid.org/0000-0002-8666-9738) [2]
Amanda Cristina de Souza Andrade (https://orcid.org/0000-0002-3366-4423) [3]
Elizabeth Fujimori (https://orcid.org/0000-0002-7991-0503) [4]

Abstract *We aimed to analyze factors associated with neonatal near-miss in Cuiabá, State of Mato Grosso, Brazil by performing a case-control study of live births in a capital city of central-western Brazil from January 2015 to December 2018 that included 931 cases and 1,862 controls. Data were obtained from the Live Births Information System and the Mortality Information System and variables were organized according to the hierarchical model. Association was analyzed by logistic regression with a 5% significance level. Data were expressed as crude and adjusted odds ratio (OR) and respective confidence intervals (95%CI). The following factors were associated with neonatal near miss: mothers with two (OR = 1.63; 95%CI: 1.01-2.63) or three or more previous pregnancies (OR=1.87; 95%CI: 1.09-3.21), without any live children (OR = 2.57; 95%CI: 1.56-4.24) or one live child at birth (OR = 1.53; 95%CI: 1.04-2.26), multiple pregnancy (OR = 4.57; 95%CI: 2.95-7.07), fewer than six prenatal consultations (OR = 2.20; 95%CI: 1.77-2.72), whose deliveries took place in public/university hospitals (OR = 2.25; 95%CI: 1.60-3.15) or philanthropic hospitals (OR = 1.62; 95%CI: 1.16-2.26), with non-cephalic presentation (OR = 2.71 95%CI: 1.87-3.94) and uninduced labor (OR = 1.47; 95%CI: 1.18-1.84).*
Key words *Near miss, Newborn, Morbidity, Information systems*

[1] Programa de Pós-Graduação em Enfermagem, Faculdade de Enfermagem, Universidade Federal de Mato Grosso. Av. Alexandre Ferronato 1200. Bairro Residencial Cidade Jardim. 78550-728 Sinop MT Brasil. priscilladosanjos@yahoo.com.br
[2] Universidade Federal de Mato Grosso. Cuiabá MT Brasil.
[3] Programa de Pós-Graduação em Saúde Coletiva, Instituto de Saúde Coletiva, Universidade Federal de Mato Grosso. Cuiabá MT Brasil.
[4] Departamento de Enfermagem em Saúde Coletiva, Escola de Enfermagem, Universidade de São Paulo. São Paulo SP Brasil.

Introduction

Despite a noteworthy decrease in infant mortality rates over the past 30 years, in 2019 more than 5 million children under five years of age died all over the world. Almost half of these deaths occurred in the first 28 days of life, i.e., in the neonatal period[1].

These deaths in the neonatal period are part of an greater problem, i.e., neonatal morbidity. Its full extent and the factors that prevented death still need to be fully understood. In this sense, it is important to examine, reflect and study the process involved in identifying the characteristics of newborns who escaped death so that future deaths may be avoided. Newborns who survive despite complications are called "near miss" cases[2]. The concept of neonatal near miss (NNM) refers to newborn children with a life-threatening condition at birth or an organ dysfunction during the neonatal period, who almost died but eventually survived[3].

It is estimated that the worldwide NNM rate is 2.6 to 8 times higher than that of neonatal deaths[4]. Therefore, analysis of these cases has been recommended to understand health system failures in comparison with neonatal mortality studies[2]. However, few studies have been developed in Brazil that focus on factors potentially associated with NNM[5].

To date, it is known that the following factors are associated with the outcome of NNM or may increase its risk: advanced maternal age[5-6], black maternal skin color[7], twins and multiparity[6], lack of prenatal or inadequate prenatal care[6-10], breech presentation[11], cesarean delivery[10-12], type of hospital doing the delivery[12] and fetal malformation[10].

Despite advances in research on this topic, there are still few epidemiological studies[7] and factors associated with NNM[11]. Therefore, this study aimed to analyze the factors associated with neonatal near miss in live births in Cuiabá, State of Mato Grosso, Brazil.

Method

We performed a case-control study with live births in the city of Cuiabá, capital of the state of Mato Grosso (MT), central-west region of Brazil from January 2015 to December 2018 and used data from the Born-Alive Infant Information System (SINASC) and the Mortality Information System (SIM).

"Cases" were defined as hospital-delivered newborns, from mothers residing in Cuiabá, who survived the first 27 days of life despite having presented one of the NNM criteria , adapted according to the definition by Silva et al (2017)[12]: birth weight < 1,500g, 5-minute Apgar < 7, gestational age < 32 weeks and congenital malformation, excluding mechanical ventilation, which is not available in the SINASC database (Table 1). "Controls" consisted of infants who were born alive at hospitals in Cuiabá, whose mothers resided in the city, who did not present any of the adapted pragmatic NNM criteria and who survived the first 27 days of life.

An odds ratio of 1.8 was used to make up a sample, which required two controls for each case (2:1), including power of 80%, alpha error of 5% and relative frequency of 10% of a given exposure factor, considering the number of analyzed variables, some with unknown frequency in the studied population[13].

SINASC and SIM data were obtained from the Municipal Health Department of Cuiabá in form of an Excel file and were pre-processed to correct and standardize variables before selection of cases and controls[14]. Next, we checked double registration and absence of data. In the SIM database, we found six duplicate records and 13 lacking information on the birth certificate number (DN), all of which were excluded. After that, using the DN number as an identification variable,

Table 1. Distribution of criteria for defining cases of neonatal near miss. Cuiabá, State of Mato Grosso, Brazil, 2015-2018 (n = 931).

Variables	n (%)
Birth weight	
< ,1500 g	379 (40,71)
≥ 1,500 g	552 (59,29)
Five-minute Apgar score	
< 7	260 (27.93)
≥ 7	669 (71.86)
No information available	2 (0.21)
Gestational age	
< 32 weeks	400 (42.96)
≥ 32 weeks	524 (56.28)
No information available	7 (0.75)
Congenital malformation	
Yes	187 (20.09)
No	744 (79.91)

Source: Authors.

a deterministic linkage was performed between the SINASC and SIM banks[15].

During the analyzed period, 40,741 children were born, of which 306 (0.75%) died within the first month of life and were excluded from the study. Of the 40,435 survivors, 931 (2.30%) presented at least one of the criteria adapted from NNM at birth and made up the "cases". Of the 39,504 eligible subjects, 1,862 "controls" were randomly selected, resulting in a final sample of 2,793 live births (931 cases and 1,862 controls).

The NNM was the dependent variable. For the analysis of variables taken from SINASC associated with NNM cases, a hierarchical model[7] was adapted, which was based on the conceptual theoretical model proposed to investigate factors associated with neonatal death[10]. In epidemiological studies using multivariate techniques, it is suggested that the complex hierarchical interrelationships between determinants be considered to avoid underestimating the effects of distal (socioeconomic) determinants, which may directly or indirectly affect all other variables, except sex and age[16].

Figure 1 shows the independent variables, which are organized into three hierarchical levels. Considering that the sex of the newborn is an important predictor of neonatal mortality[10], this variable was included in the final model, despite the fact that it was not included in any of the levels[7].

The variables of this study were obtained from SINASC and the categorization of maternal sociodemographic variables at the distal level were: years of education completed (no schooling, elementary school I and II, high school, full and partial higher education, unknown) in years of schooling (≤ 8, 9-11, ≥ 12); professional occupation according to the Brazilian Classification of Occupations (CBO, 2002), i.e., currently working (yes/no), but the categories student, housewife, unemployed, retired and pensioners were classified as "not working" and all the others occupations as "currently working", and; race/color (white, brown, black, yellow and indigenous). At the intermediate level, variables were categorized into: mother's age in years (< 20, 20-34, ≥ 35 years); marital status (lives with a partner [married, common-law marriage], without a partner [single, widowed, separated/divorced]); number of previous pregnancies (0, 1, 2, 3 or more), number of live births (0, 1, 2 or more); number of fetal losses and abortions (0, 1, 2 or more); number of previous vaginal and cesarean deliveries (0, 1, 2 or more); type of current pregnancy (single, double or more). Variables related to health care during pregnancy and delivery were characterized at the proximal level by: quarter in which prenatal care began (first, second, third), depending on gestational age; number of prenatal consultations (< 6, ≥ 6) ; health establishment where the delivery took place, i.e., type of hospital (private hospital, private hospital associated with the Public Health System (SUS), philanthropic hospital, and public hospital that merged with a university hospital); fetal presentation (cephalic, non-cephalic ([frank breech/complete breech/transverse lie]); type of delivery (vaginal, cesarean); induced labor (yes/no). The only characteristics of newborns analyzed was their sex and year of birth.

Literature shows that the determinants of neonatal mortality and near miss morbidity are quite similar, including in twins.[6] However, few studies have investigated the relationship between the type of pregnancy (single, double, triple or more) and NM so far[6,12]. As the similarity between mortality and risk of complications was understood, we decided to keep twins in the analysis as an explanatory variable of the study.

Results of the descriptive analysis were presented in absolute and relative frequencies. The association between NNM cases and independent variables was analyzed using univariate and multiple logistic regression. Crude and adjusted odds ratio (OR) and the respective 95% confidence intervals (CI) were used to measure association. Variables with a p-value < 0.20 in the univariate analysis were included in the multiple model, following the proposed hierarchical levels.

A hierarchical analysis was performed in blocks according to the conceptual model (Figure 1). Newborn variables sex and year of birth were inserted in the first model and variables of the distal level were included in the second model, as well as sex and year of birth of the newborn, which were used as an adjustment. The significant variables (p ≤ 0.05) of the distal level were kept in the model and used to adjust the intermediate level block (model 3). The same procedure was repeated until the proximal variables were adjusted with the intermediate and distal ones (model 4). Those selected by the level of statistical significance at a certain level remained in the subsequent models, even if the inclusion of hierarchically inferior variables altered their level of significance. A model was adjusted for each hierarchical level by excluding variables with the highest pvalue and the model was re-evaluat-

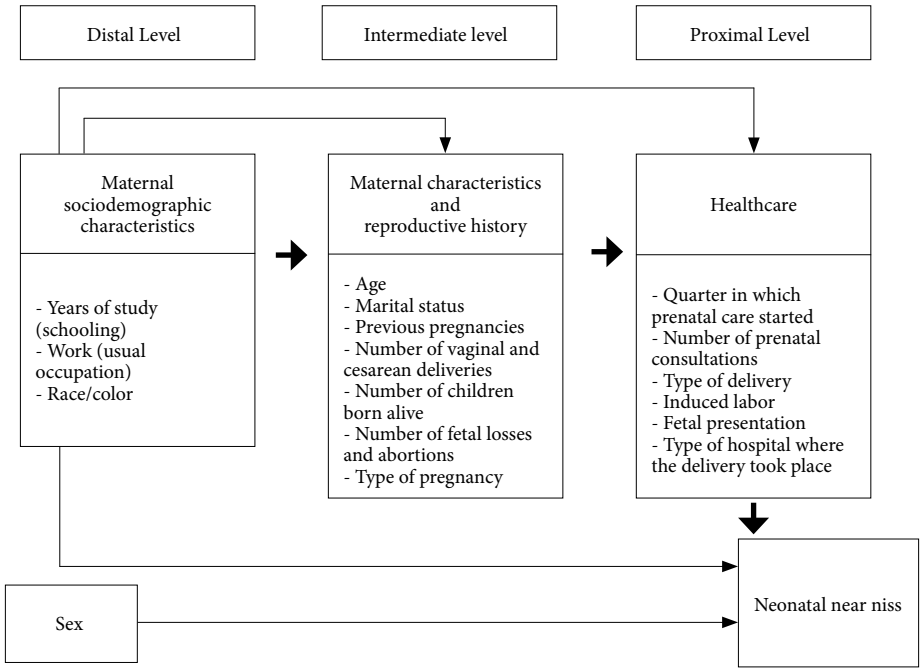

Figure 1. Conceptual hierarchical model* for analysis of factors associated with cases of neonatal near miss.

* Adapted from Kale et al., 2017.

Source: Authors.

ed after each exclusion until all variables of the same level remained significant. One model was adjusted for each hierarchical level and the variables at the most distal levels remained as adjustment factors for those at the hierarchically lower levels. All analyzes were performed using the STATA Software version 12. A significance level of 5% was adopted.

Our research project was assessed and authorized by the Ethics Committee by approval nº 3.734.141 and CAE 25558619.0.0000.5541.

Results

Tables 2 to 4 present the distribution of cases and controls by hierarchical level according to independent variables. Table 1 shows that more than half of the newborns were male in both groups (54.0% cases and 51.7% controls). There was a slightly higher percentage of NNM cases in 2016 (37.1%). Most mothers were brown (72.1%), had between 9 to 11 years of schooling (60.6%) and were currently working (51.0%). In the distal block, schooling and maternal race/color were associated with NNM (Table 2).

Regarding the intermediate level variables (Table 3), there was a higher proportion of mothers between 20 and 34 years old (70.4%) who lived with a partner (60.2%). There were more single pregnancies (95.0%), by women without any fetal loss or abortion (80.5%), without previous pregnancy (38.3%), who therefore had never had a normal delivery (65.3%) or cesarean section (70.6%) and no live births (43.6%). The univariate analysis of the intermediate block showed that mothers without a partner who had had two or more fetal losses/abortions in a previous pregnancy and who had had multiple pregnancies were statistically associated with NNM.

Health care analysis at the proximal block level showed that most mothers started prenatal care in the first quarter (80.7%) and had six or more consultations (80.1%), but that condition was statistically lower among cases (70.1%) compared to controls (85.1%). There was a higher proportion of births by cesarean delivery (55.8%), non-induced delivery (78.4%) and cephalic delivery (94.0%). Outcome was associated with mothers who had had less than six prenatal consultations, non-induced labor, non-cephalic fetal presentation and delivery in a private hos-

Table 2. Distribution of cases and controls according to year of birth and sex of newborns and variables of the distal hierarchical level (maternal sociodemographic characteristics). Cuiabá, State of Mato Grosso, Brazil, 2015-2018 (n = 2,793).

Variables	Total n (%)	Cases (%)	Controls n (%)	Gross OR (95%CI)	p-value
Of the newborn					
Year of birth					
2015	721 (25.8)	219 (30.4)	502 (69.6)	0.83 (0.66-1.03)	0.092
2016	668 (23.9)	248 (37.1)	420 (62.9)	1.12 (0.90-1.39)	0.312
2017	677 (24.2)	213 (31.5)	464 (68.5)	0.87 (0.69-1.09)	0.223
2018	727 (26.0)	251 (34.5)	476 (65.5)	1.00	
Sex					
Female	1,326 (47.5)	427 (46.0)	899 (48.3)	1.00	
Male	1,465 (52.5)	502 (54.0)	963 (51.7)	1.10 (0.94-1.28)	0.248
Distal level:					
Years of study					
≤ 8	411 (14.8)	169 (18.2)	242 (13.0)	1.36 (1.06-1.75)	0.016
9-11	1,688 (60.6)	525 (56.6)	1,163 (62.5)	0.88 (0.73-1.06)	0.190
≥ 12	688 (24.6)	233 (25.1)	455 (24.5)	1.00	
Work					
Yes	1,419 (51.0)	473 (51.1)	946 (50.9)	1.01 (0.86-1.18)	0.924
No	1,366 (49.0)	453 (48.9)	913 (49.1)	1.00	
Race/Color					
White	592 (21.3)	208 (22.5)	384 (20.7)	1.08 (0.97-12.02)	0.948
Brown	2007 (72.1)	653 (70.7)	1,354 (72.9)	0.96 (0.87-12.60)	0.977
Black	170 (6.1)	61 (6.6)	109 (5.9)	1.12 (0.99-14.34)	0.927
Yellow	10 (0.3)	1 (0.1)	9 (0.5)	0.22 (0.09-5.27)	0.352
Indigenous	3 (0.1)	1 (0.1)	2 (0.1)	1.00	

* Not obtained for cases and controls. OR: odds ratio; 95%CI: Confidence Interval. The distal model in which the variables were significant ($p \leq 0.05$) were retained in the model and included in the adjustment in the second block of the intermediary level.

Source: Authors.

pital affiliated with the Brazilian Public Health Care System (SUS), in a public/university hospital, or in a philanthropic hospital (Table 4).

In the multiple analysis, whose results are described in Table 4, the following variables showed a statistically significant association ($p < 0.05$) with NNM: gave birth to two (OR = 1.63; 95%CI: 1.01-2.63) or more children (OR = 1.87; 95%CI: 1.09-3.21) in previous pregnancies, where no child (OR = 2.57; 95%CI: 1.56-4.24) or one child was born alive (OR = 1.53; 95%CI: 1.04-2.26), multiple pregnancies (OR = 4.57; 95%CI: 2.95-7.07), less than six prenatal consultations (OR = 2.20; 95%CI: 1.77-2.72), delivery in public/university hospitals (OR = 2.25; 95%CI: 1.60-3.15) and philanthropic hospitals (OR = 2.25; 95%CI: 1.60-3.15) OR = 1.62; 95%CI: 1.16-2.26), non-cephalic presentation (OR = 2.71; 95%CI: 1.87-3.94) and non-induced labor (OR = 1.47; 95%CI: 1.18-1.84) (Table 5).

Discussion

In the present study, variables that showed an association with the NNM outcome were mothers who had already been pregnant twice or more, who had either not given birth or one live birth, who had had multiple gestation, less than six prenatal consultations, delivery in public/university hospitals and philanthropic hospitals, non-cephalic presentation and non-induced labor.

The findings of this study, in which women who attended less than six prenatal consultations had a greater chance of NNM are corroborated by a study performed in Gujarat, India, which shows that having had less than four prenatal consultations was associated with a greater risk of NNM[9], as well as by another study conducted in Ambo, Ethiopia[8]. Studies performed in Ethiopia[12] and in Brazil[7] show that inadequate and low-quality prenatal care contribute to unfavorable outcomes

Table 3. Distribution of cases and controls according to variables of the intermediate hierarchical level (maternal characteristics and reproductive history). Cuiabá, State of Mato Grosso, Brazil, 2015-2018 (n = 2,793).

Variables*	Total n (%)	Cases n (%)	Controls n (%)	Gross OR (95%CI)	p-value
Intermediate level					
Maternal age (years)					
< 20	398 (14.2)	134 (14.4)	264 (14.2)	1.00	
20-34	1967 (70.4)	628 (67.4)	1.339 (71.9)	0.92 (0.73-1.16)	0.498
≥ 35	428 (15.3)	169 (18.2)	259 (13.9)	1.28 (0.98-1.71)	0.083
Marital status					
with a partner	1,677 (60.2)	511 (55.2)	1,166 (62.6)	1.00	
without a partner	1,110 (39.8)	415 (44.8)	695 (37.4)	1.36 (1.16-1.60)	< 0.001
Previous pregnancies					
0	1,057 (38.3)	367 (39.9)	690 (37.5)	1.00	
1	880 (31.9)	275 (29.9)	605 (32.9)	0.85 (0.71-1.03)	0.106
2	430 (15.6)	140 (15.2)	290 (15.8)	0.91 (0.71-1.15)	0.425
≥ 3	393 (14.2)	138 (15.0)	255 (13.8)	1.02 (0.80-1.30)	0.889
Vaginal delivery					
0	1,803 (65.3)	603 (65.5)	1,200 (65.2)	1.00	
1	518 (18.8)	169 (18.4)	349 (18.9)	0.96 (0.78-1.19)	0.727
2 or more	440 (15.9)	148 (16.1)	292 (15.9)	1.01 (0.81-1.26)	0.939
Cesarean delivery					
0	1,950 (70.6)	668 (72.5)	1,282 (69.7)	1.36 (0.98-1.87)	0.062
1	609 (22.1)	197 (21.4)	412 (22.4)	1.25 (0.88-1.77)	0.219
2 or more	202 (7.3)	56	146 (7.9)	1.00	
Number of children born alive					
0	1,201 (43.6)	428 (46.6)	773 (42.0)	1.17 (0.95-1.43)	0.127
1	911 (33.0)	283 (30.8)	628 (34.2)	0.95 (0.77-1.18)	0.667
2 or more	645 (23.4)	207 (22.6)	438 (23.8)	1.00	
Fetal loss / abortion					
0	2,214 (80.5)	713 (77.8)	1,501 (81.8)	1.00	
1	412 (15.0)	152 (16.6)	260 (14.2)	1.23 (0.99-1.53)	0.063
2 or more	124 (4.5)	51 (5.6)	73 (4.0)	1.47 (1.02-2.13)	0.040
Type of pregnancy					
Single	2,649 (95.0)	823 (88.5)	1,826 (98.2)	1.00	
Two or more	141 (5.0)	107 (11.5)	34 (1.8)	6.98 (4.70-10.36)	< 0.001

* Information was not available for all cases and controls. OR: odds ratio; 95%CI: confidence interval. In the intermediate hierarchical level model, the variables of the intermediate and distal model that had been significant ($p \leq 0.05$) were retained and included in the adjustment of the third block of the proximal level.

Source: Authors.

for neonatal health. Such results confirm the urgent need to improve access to qualified care for pregnant women and to address the issue of the number of consultations. Moreover, prevention and early detection of both maternal and fetal pathologies is fundamental to reduce life-threatening conditions in newborn children.

It is widely known that starting prenatal care early and performing follow-up appropriately ensures more beneficial health outcomes for both the mother and the baby, since consultations provide the opportunity to perform basic procedures, to follow the pregnancy periodically, to detect issues at an early stage and to treat health risk factors in time[17] to prevent neonatal deaths[18].

Regarding the number of pregnancies, an association was identified between NNM and mothers who had already had two or more children in their obstetric history, corroborating the findings of a study carried out in Ethiopia[11]. On the other hand, these findings differ from those found by a study performed in southeastern Brazil, in which primiparous mothers showed a higher risk of NNM[7]. That divergence may be

Table 4. Distribution of cases and controls according to variables of the proximal hierarchical level (health care). Cuiabá, MT, Brazil, 2015-2018 (n = 2,793).

Variables*	Total n (%)	Cases n (%)	Controls n (%)	Crude OR (95%CI)	p-value
Proximal level					
Quarter in which prenatal care started					
First	2,200 (80.7)	721 (80.0)	1,479 (81.0)	1.03 (0.63-1.70)	0.888
Second	452 (16.6)	156 (17.3)	296 (16.2)	1.12 (0.66-1.89)	0.671
Third	75 (2.7)	24 (2.7)	51 (2.8)	1.00	
Number of prenatal consultations					
< 6	553 (19.9)	276 (29.9)	277 (14.9)	2.43 (2.01-2.94)	< 0.001
≥ 6	2,225 (80.1)	647 (70.1)	1,578 (85.1)	1.00	
Type of delivery					
Vaginal	1,233 (44.2)	388 (41.7)	845 (45.38)	1.00	
Cesarean	1,560 (55.8)	543 (58.3)	1,017 (54.62)	1.16 (0.99-1.36)	0.063
Induced labor					
Yes	598 (21.6)	153 (16.6)	445 (24.1)	1.00	
No	2,167 (78.4)	769 (83.4)	1,398 (75.9)	1.60 (1.30-1.96)	< 0.001
Fetal presentation					
Cephalic	2,601 (94.0)	804 (88.3)	1,797 (96.9)	1.00	
Non-cephalic	165 (6.0)	107 (11.7)	58 (3.1)	4.12 (2.96 to 5.74)	< 0.001
Type of hospital					
Private	762 (27.4)	239 (26.2)	523 (28.1)	1.00	
Private/affiliated with SUS	1,353 (48.8)	369 (40.4)	984 (52.8)	0.82 (0.67-0.99)	0.046
Public/university	319 (11.5)	156 (18.1)	154 (8.3)	2.34 (1.79-3.06)	< 0.001
Philanthropic	341 (12.3)	140 (15.3)	201 (10.8)	1.52 (1.17-1.98)	0.002

* Not available for cases and controls. OR: odds ratio; 95%CI: confidence interval.

Source: Authors.

due to regional and cultural differences, socioeconomic inequalities, maternal preparation and adherence to prenatal care, different care systems, quality of prenatal care, professional qualification and accessibility.

Regarding the women's obstetric history, mothers who had had no or one live birth in a previous pregnancy were associated with the outcome. It should be noted that the relationship of this variable with NNM has been little studied so far. However, it is known that negative maternal and perinatal outcomes may be triggered by obstetric complications[19]. Thus, it is essential to pay more attention to women's health before pregnancy and help them get ready by means of health prevention and promotion actions and by properly diagnose and treat issues that may arise.

Double or more pregnancies were associated with NNM by the present study, which matches the findings of the "Nascer no Brasil" research that also identified that kind of association in multiparous and nulliparous women[6], in addition to another study based on data of the same research that used a hierarchical neonatal near miss model[20] and to a third study that showed an association with the outcome among adolescent mothers[21]. Thus, attention needs to be paid to multiple pregnancies and timely and essential care must be provided to this type of pregnancy, as studies show that it is not only associated with NNM, but also with neonatal death and a higher risk of prematurity and low birthweight[22].

In the present study, the largest number of births occurred in private hospitals associated with SUS, both among cases and controls. However, births in public/university and philanthropic hospitals were the ones significantly associated with the outcome. This suggests that the public assisted by these hospitals shows specific characteristics, such as social inequalities, which is revealed by patient profile and care service type offered to the population. That care service is specialized and a reference in assisting mothers and babies at risk. It relies on assistance protocols and trained professionals to provide care based on scientific evidence.

Table 5. Hierarchical multiple logistic regression model of factors associated with cases of neonatal near miss in Cuiabá, State of Mato Grosso, Brazil, 2015-2018 (n = 2,793).

Variables	Neonatal near miss		
	$OR_{Adjust.}$*	95%CI **	p-value***
Model 1 – Characteristics of the newborn			
Sex			
Male	1.13	0.95-1.35	0.153
Female	1.00	-	
Year of birth of the newborn			
2015	0.79	0.62-1.00	0.056
2016	1.11	0.87-1.41	0.405
2017	0.82	0.64-1.05	0.119
2018	1.00	-	
Model 2 – Distal*			
Education (years of study) (6 missings)			
0 to 8	1.22	0.87-1.72	0.232
9 to 11	0.87	0.67-1.11	0.273
12 or more	1.00	-	
Model 3 – Intermediate **			
Marital status (6 missings)			
Without a partner	0.99	0.82-1.20	0.958
With a partner	1.00	-	
Number of pregnancies (33 missing)			
0	1.00	-	
1	1.30	0.89-1.89	0.168
2	1.63	1.01-2.63	0.044
3 or more	1.87	1.09-3.21	0.021
Number of children born alive (36 missings)			
0	2.57	1.56-4.24	< 0.001
1	1.53	1.04-2.26	0.031
2 or more	1.00	-	
Type of pregnancy (3 missings)			
Single	1.00	-	
Two or more	4.57	2.95 to 7.07	< 0.001
Model 4 – Proximal ***			
Number of prenatal consultations (15 missings)			
< 6	2.20	1.77-2.72	< 0.001
≥ 6	1.00	-	
Type of Hospital (18 missings)			
Private	1.00	-	
Private affiliated with SUS	0.98	0.75-1.26	0.871
Public / University	2.25	1.60-3.15	< 0.001
Philanthropic	1.62	1.16-2.26	0.005
Fetal presentation (27 missings)			
Cephalic	1.00	-	
Non-cephalic	2.71	1.87-3.94	< 0.001
Induced labor (27 missings)			
No	1.47	1.18-1.84	< 0.001
Yes	1.00	-	

OR: odds ratio; 95%CI: confidence interval; * model adjusted by sex and year of birth of newborns; ** model adjusted by the variables of the distal block, sex and year of birth of newborns; *** model adjusted by the variables of the distal and intermediate block, sex and year of birth of newborns.

Source: Authors.

University hospitals are characterized by offering better obstetric and neonatal care, by qualified teams that follow protocols supported by scientific evidence and by using advanced medical technology[7], which may explain the association between the type of hospital and the identified NNM outcome in this study and which is therefore a protective factor against neonatal mortality due to their care features.

In this sense, findings on hospital type may be useful for the surveillance of neonatal care in institutions, even if evaluating different types of hospitals is a complex matter. Surveillance can be a monitoring tool for neonatal care in different institutions that support newborns at risk, as long as only establishments of similar complexity are compared among each other, considering institutional profile and assisted population, in addition to case severity and the different technologies used to identify alert situations that require taking action[23].

Although most deliveries showed a cephalic presentation, both among cases and controls, which was similar to the findings of the two studies performed in Ethiopia[8,11], non-cephalic presentation was associated with NNM in both studies. In the present study, this type of presentation had 2.71 chances of NNM compared to cephalic presentation.

Regardless of delivery type, breech presentation results in a greater risk of gestational complications[24, stillbirth] and neonatal death compared to the cephalic position[25] and is associated with obstetric risk factors that increase linearly as the gestational age is lower[26], in addition to a higher frequency of small-for-gestational-age births[25-27], episiotomy[27], and labor induction. Nevertheless, studies show that the pelvic position does not present a statistically significant difference in perinatal and maternal morbidity[27-28] and as long as qualified assistance is provided, this can be a safe option for rigorously selected cases[27].

In the present study, most deliveries were noninduced, both among cases and controls, and were associated with NNM, which shows that not inducing labor favors the outcome. Pros and cons of inducing labor has been discussed worldwide and involves several other issues, e.g., use of synthetic oxytocin, which is not recommended by the World Health Organization (WHO) to accelerate childbirth[29].

However, there are appropriate indications for its use for labor induction, e.g., in the first 24 hours of premature membrane rupture[30]. On the other hand, when synthetic oxytocin is used inappropriately to induce labor, it may put the safety of maternal and fetal health[31] at risk and cause serious issues, such as uterine hyperstimulation and rupture, fetal distress, very painful uterine contractions, hyponatremia, fetal hypoxia and acidemia, which contribute to an increase in the cesarean delivery rate[32].

Since the concept of NNM is rather recent and still being discussed, the present research contributes to the field of health by assuming an adapted definition of the pragmatic criteria that threaten life at birth (gestational age less than 32 weeks, birthweight below 1,500g, 5-minute Apgar score < 7, in addition to including congenital malformation as an NNM criterion and excluding mechanical ventilation, as it is not included in the Information Systems (IS) used.

Moreover, the study provided an expressive assessment of the local context by analyzing the entire neonatal period and by using information provided by SIS, whose data is largely available. In turn, the fact that some variables are incomplete may be considered a limitation of the present study. However, using a hierarchical modeling strategy avoided weakening associations with factors at distal levels by incorporating more proximal ones in the model. Thus, the theoretical model based on literature improved our analysis and helped integrate and interpret variables and their respective statistical associations[8].

Based on these findings, we may claim that care quality has to be improved, including prenatal care, delivery and birth, correction of deficiencies, planning and organization of improvements, definition of priorities regarding actions that have contributed most to "near deaths", identification and tackling of issues at the intermediate and proximal hierarchical levels by highlighting the significance of qualified prenatal care, considering obstetric history, paying thorough attention to multiple pregnancies and deliveries, investing in training of professionals who assist newborns at risk at all levels of care, especially those who work in public/university hospitals and are a reference in their field to avoid cases of neonatal near miss. Further, these findings may contribute to the development of management strategies to reduce neonatal mortality and long-term sequelae.

Conclusion

The results of this study point out that being a mother who had had two or more pregnancies,

no or one live child at birth, multiple pregnancies, less than six prenatal consultations, deliveries in public/university and philanthropic hospitals, non-cephalic presentation and non-induced labor was associated with NNM. Investing in improving care during the gestational period and delivery would favor care quality of this population and help avoid this outcome.

The results of this investigation are intended to contribute to an initial reflection process on factors associated with life-threatening conditions in neonates, especially NNM, a topic that still lacks epidemiological studies.

Collaborations

All authors contributed fundamentally to this study.

References

1. United Nations Children's Fund (UNICEF), World Health Organization (WHO). *Levels & trends in child mortality: report 2019. Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME)*. New York: UNICEF; 2019.
2. Surve S, Chauhan S, Kulkarni R. Neonatal near miss review: tracking its conceptual evolution and way forward. *Curr Pediatr Res* 2017; 21(2):264-271.
3. Pileggi C, Souza JP, Cecatti JG, Faúndes A. Neonatal near miss approach in the 2005 WHO Global Survey Brazil. *J Pediatr (Rio J)* 2010; 86(1):21-26.
4. Santos JP, Pileggi-Castro C, Camelo Jr JS, Silva AA, Duran P, Serruya SJ, Cecatti JG. Neonatal near miss: a systematic review. *BMC Pregnancy Childbirth* 2015; 15:320.
5. Kale PL, Jorge MHPM, Laurenti R, Fonseca SC, Silva KS. Critérios pragmáticos da definição de near miss neonatal: um estudo comparativo. *Rev Saude Publica* 2017; 51:111.
6. Martinelli KG, Gama SGN, Almeida AHV, Pacheco VE, Neto ETS. Advanced maternal age and factors associated with neonatal near miss in nulliparous and multiparous women. *Cad Saude Publica* 2019; 35(12):e00222218.
7. Kale PL, Mello-Jorge MHP, Silva KS, Fonseca SC. Neonatal near miss and mortality: factors associated with life-threatening conditions in newborns at six public maternity hospitals in Southeast Brazil. *Cad Saude Publica* 2017; 33(4):e00179115.
8. Yohannes E, Assefa N, Dessie Y. Determinants of neonatal near miss among neonates admitted to Ambo University Referral Hospital and Ambo General Hospital, Ethiopia, 2019. *J Preg Child Health* 2020; 7:1.
9. Shroff BD, Ninama NH. A call for eminence obstetrics care by way of "Neonatal Near Miss" events (NNM): a hospital-based case-control study. *J Obstet Gynaecol India* 2019; 69(1):50-55.
10. Lima THB, Katz L, Kassar SB, Amorim MM. Neonatal near miss determinants at a maternity hospital for high-risk pregnancy in Northeastern Brazil: a prospective study. *BMC Pregnancy Childbirth*. 2018; 18:401.
11. Mersha A, Bante A, Shibiru S. Factors associated with neonatal near-miss in selected hospitals of Gamo and Gofa zones, southern Ethiopia: nested case-control study. *BMC Pregnancy Childbirth* 2019; 19:516.
12. Silva GA, Rosa KA, Saguier ESF, Henning E, Mucha F, Franco SC. Estudo de base populacional sobre a prevalência de *near miss* neonatal em município do Sul do Brasil: prevalência e fatores associados. *Rev Bras Saude Matern Infant* 2017; 17(1):169-177.
13. Almeida SDM, Barros MBA. Atenção à saúde e mortalidade neonatal: estudo caso-controle realizado em Campinas, SP. *Rev Bras Epidemiol* 2004; 7(1):22-35.
14. Oliveira GP, Bierrenbach ALS, Camargo Júnior KR, Coeli CM, Pinheiro RS. Accuracy of probabilistic and deterministic record linkage: the case of tuberculosis. *Rev Saude Publica* 2016; 50:49.
15. Brustulin R, Marson PG. Inclusão de etapa de pós -processamento determinístico para o aumento de performance do relacionamento (*linkage*) probabilístico. *Cad Saude Publica* 2018; 34(6):e00088117.
16. Victora CG, Huttly SR, Fuchs SC, Olinto MTA. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. *Int J Epidemiol* 1997; 26:224-227.
17. Brito LME, Mesquita KKCB, Melo JS, Santos TP. A importância do pré-natal na saúde básica: uma revisão bibliográfica. *Res Soc Develop* 2021; 10:15.
18. Saloio CA, Morais Neto OL, Gonçalves DA, Bessa HEM, Coelho Júnior JP, Afonso MSM, Carvalho SR. Magnitude e determinantes da mortalidade neonatal e pós-neonatal em Goiânia, Goiás: um estudo de coorte retrospectivo, 2012. *Epidemiol Serv Saude* 2020; 29(5):e2020132.
19. Moura BLA, Alencar GP, Silva ZPD, Almeida MF. Internações por complicações obstétricas na gestação e desfechos maternos e perinatais, em uma coorte de gestantes no Sistema Único de Saúde no Município de São Paulo, Brasil. *Cad Saude Publica* 2018; 34(1):e00188016.
20. Pereira TG, Rocha DM, Fonseca VM, Moreira MEL, Gama SGN. Factors associated with neonatal near miss in Brazil. *Rev Saude Publica* 2020; 54:123.
21. Assis TSC, Martinelli KG, Gama SGN, Santos Neto ET. Associated factors of neonatal near miss among newborns of adolescent mothers in Brazil. *Rev Esc Enferm USP* 2022; 56:e20210359 .
22. Demitto MO, Gravena AAF, Dell'Agnolo CM, Antunes MB, Pelloso SM. Gestação de alto risco e fatores associados ao óbito neonatal. *Rev Esc Enferm USP* 2017; 5:e03208.
23. França, KEX, Vilela BR, Frias PG, Chaves MA, Sarinho. Near miss neonatal em hospitais de referência para gestação e parto de alto risco: estudo transversal. *Cad Saude Publica* 2021; 37(6):e00196220.
24. Fonseca A, Nogueira-Silva C, Silva IS, Casal Es, Pinto L, Clode N. Vaginal breech delivery: *guidelines*/normas de orientação clínica. *Acta Obstet Ginecol Port* 2021; 15(1):75-83.
25. Bjellmo S, Andersen GL, Martinussen MP, Romundstad PR, Hjelle S, Moster D, Vik T. Is vaginal breech delivery associated with higher risk for perinatal death and cerebral palsy compared with vaginal cephalic birth? Registry-based cohort study in Norway. *BMJ Open* 2017; 7(4):e014979.
26. Toijonen AE, Heinonen ST, Gissler MVM, Macharey G. A comparison of risk factors for breech presentation in preterm and term labor: a nationwide, population-based case-control study. *Arch Gynecol Obstet* 2020; 301(2):393-403.
27. Valente MP, Afonso MC, Clode N. O parto pélvico vaginal ainda é uma opção segura? *Rev Bras Ginecol Obstet* 2020; 42(11):712-716.
28. Gaillard T, Girault A, Alexander S, Goffinet F, Le Ray C. Is induction of labor a reasonable option for breech presentation? *Acta Obstet Gynecol Scand* 2019; 98(7):885-893.
29. World Health Organization (WHO). *Evaluating the quality of care for severe pregnancy complications: the who near-miss approach for maternal health*. Geneva: WHO; 2011.

30. Ministério da Saúde (MS). Secretaria de Ciência, Tecnologia e Insumos Estratégicos. Departamento de Gestão e Incorporação de Tecnologias em Saúde. *Diretrizes nacionais de assistência ao parto normal: versão resumida*. Brasília: MS; 2017.
31. Schincaglia CY, Santos GC, Ribeiro JA, Figueiredo RY, Menezes S, Maia JS, Maia LFS. As consequências do uso de ocitócitos durante o parto. *Rev Recien* 2017; 7(19):75-82.
32. Santos KLA, Farias CRBL, Cavalcante JS, Santos EA, Silva JM, Duarte APRSD. Ocitocina sintética no trabalho de parto induzido e suas repercussões materno-fetais. *Diversitas J* 2020; 5(3):1787-1804.

Article submitted 29/10/2022
Approved 17/04/2023
Final version submitted 19/04/2023

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva