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Neonatal near miss and mortality and associated factors: cohort study of births in the city of Rio de Janeiro, RJ, Brazil

Near miss e mortalidade neonatal e fatores associados: estudo de coorte de nascimentos do município do Rio de Janeiro, RJ

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ABSTRACT

Objective: The aim of this study was to investigate factors associated with neonatal near miss and mortality of the live birth cohort in the city of Rio de Janeiro, Brazil, in 2015.

Methods: Population-based retrospective cohort of live births (LB) of single pregnancy with 0–27 days of follow-up. Data were obtained from the Brazilian Live Birth and Mortality Information Systems. Logistic regressions with the analytical strategy of hierarchical determination were used for cases of near miss and deaths separately.

Results: The cohort was composed of 85,850 LB. For every one thousand LB, about 16 were cases of near miss and six died. Maternal level of education, skin color, and age and adequacy of prenatal care were associated with neonatal near miss; for deaths, presentation of LB at delivery, birth weight, gestational age, and five-minute Apgar score are added.

Conclusions: Besides confirming the effect of low birth weight, prematurity, and asphyxia on neonatal death, socioeconomic vulnerability markers – low education level and brown or black skin colors – were associated with neonatal death and near miss. Absent or inadequate prenatal care showed a strong association with both outcomes, being stronger for neonatal death. Investments in the quality of prenatal care and reduction of disparities in health care are necessary in Rio de Janeiro.

Keywords: Near miss; Neonatal mortality; Prenatal care; Information systems; Maternal and child health.

RESUMO

Objetivo: Investigar fatores associados aos *near miss* e óbito neonatais na coorte de nascidos vivos do município do Rio de Janeiro (RJ), 2015.

Métodos: Coorte retrospectiva de base populacional de nascidos vivos de gravidez única com seguimento de até 27 dias. Dados obtidos dos Sistemas de Informações sobre Nascidos Vivos e sobre Mortalidade. Foram usadas regressão logística e estratégia analítica de determinação hierárquica separadamente para casos de *near miss* e óbitos.

Resultados: Coorte composta de 85.850 nascidos vivos. Para cada mil nascidos vivos, 16 foram casos de *near miss* e seis evoluíram para óbito. Escolaridade, cor da pele e idade maternas e adequação do pré-natal estiveram associadas ao *near miss* neonatal; para óbitos, acrescenta-se apresentação do NV no parto, peso, idade gestacional e Apgar no 5º minuto.

Conclusões: Além de confirmar o efeito do baixo peso, da prematuridade e da asfixia no óbito neonatal, variáveis marcadoras de vulnerabilidade socioeconômica — baixa escolaridade e cor da pele parda ou preta — mostraram-se associadas ao óbito e ao *near miss* neonatal. Pré-natal ausente ou inadequado mostrou forte associação com ambos os desfechos, mais intensa para o óbito. Investimentos na qualificação do pré-natal e na redução das desigualdades na saúde são necessários no Rio de Janeiro.

Palavras-chave: Near miss; Mortalidade neonatal; Cuidado pré-natal; Sistemas de informação; Saúde materno-infantil.

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INTRODUCTION

Neonatal death and near miss, severe negative outcomes, are related to pregnancy, delivery, and newborn conditions, reflecting the quality of health care.[1,2] There are still few studies evaluating sociodemographic conditions, with discordant results, especially regarding the maternal level of education and skin color.[3-7]

In a national meta-analysis of factors associated with neonatal death, the following maternal variables stand out: absence of a partner, age ≥35 years, multiple pregnancy, absence or inadequacy of prenatal care, complications during pregnancy, and cesarean delivery. The following factors are related to newborns: male sex, congenital malformation, perinatal asphyxia, low birth weight, and prematurity.[3]

Neonatal near miss (NNM), defined as the situation of being born with life-threatening conditions and surviving, has been studied,[1,2,8] but still without a universal definition.[9-12] Strong predictors of neonatal death are used as criteria to define life-threatening conditions.[9] Birth weight (BW), gestational age (GA), and five-minute Apgar score are present in different NNM definitions, and are considered pragmatic criteria, as they correspond to easily measured and available information. These criteria, alone or accompanied by clinical, laboratory, and management criteria, compose the definition of NNM, validated in national studies.[1,10,11,13]

Although there are still few national studies on factors associated with NNM, the results are similar. Maternal age ≥35 years,[5-7] black skin color and absence of a partner,[7] morbidities in pregnancy – such as hemorrhage, hypertensive diseases,[5-7] diabetes,[5,6] urinary tract infection,[6] and syphilis –,[7] smoking habit,[6] use of illicit drugs,[7] inadequate prenatal care,[5,7] delivery in a public hospital,[4] pilgrimage for delivery,[14] and cesarean delivery,[4,5] among others, are important determinants of NNM cases.

The present study aimed to investigate factors associated with neonatal near miss and death in the population-based cohort of live births in the municipality of Rio de Janeiro, state of Rio Janeiro (RJ), Brazil, in 2015.

METHOD

This is a retrospective cohort of live births (LB), children of residents of Rio de Janeiro, in 2015. The follow-up time corresponded to the neonatal period (27 full days), and negative outcomes were NNM cases and deaths.

Data on live births were obtained from the Brazilian Live Birth Information System (*Sistema de Informações sobre Nascidos Vivos* – SINASC), in 2015; and data on neonatal deaths (which occurred from January 1, 2015 to January 27, 2016 and those who were born in 2015) were obtained from the Brazilian Mortality Information System (*Sistema de Informações sobre Mortalidade* – SIM) of the Municipal Health Department of Rio de Janeiro (*Secretaria Municipal de Saúde do Rio de Janeiro* – SMSRJ). The linkage of the respective databases was deterministic when information on the number of the LB certificate was completed on the death certificate; and, in its absence, it was probabilistic, considering the date and institution of the newborn's birth and maternal name and date of birth.

All LB weighing ≥500g and with GA ≥22 weeks were eligible for the study. Multiple-pregnancy LB were excluded due to differentiated risks of morbidity and mortality[15] and with inconsistencies between BW and GA information (values other than those of the following ranges of the lowest 3rd percentile value and the highest 97th percentile value of weight for GA): 22 weeks (500–930g); 23 weeks (500–1030g); 24 weeks (500–1160g); 25 weeks (500–1260g); 26 weeks (500–1380g); 27 weeks (580–1520g); 28 weeks (620–1670g); 29 weeks (670–1840g); 30 weeks (740–2070g); 31 weeks (860–2420g); 32 weeks (1100–2830g); 33 weeks (1180–3220g); 34 weeks (1350–3500g); 35 weeks (1550–3500g); 36 weeks (1790–3820g); 37 weeks (2040–4000g); 38 weeks (2250–4350g); 39 weeks (2400–4600g); 40 weeks (2490–4875g); 41 weeks (2560–5000g); and 42 weeks (2600–5000g).[16,17]

LB were classified according to life-threatening conditions at birth: presence of at least one of the pragmatic criteria of the NNM definition according to the *Nascer no Brazil* (Birth in Brazil) study:[10] GA<32 weeks or BW<1500g or five-minute Apgar score<7. Life-threatening births and neonatal survivors corresponded to the valid definition of NNM cases solely based on pragmatic criteria.[11]

The following aspects were estimated: proportion of life-threatening births at birth, rates of NNM per one thousand LB (NNMR: quotient between the number of NNM cases and total LB), neonatal mortality (NMR: total, early, up to six days, and late – from seven to 27 days), and severe outcomes (quotient between the sum of NNM cases and neonatal deaths by total LB) and respective 95% confidence intervals (95%CI). In addition, the mortality rate (%) (quotient between neonatal deaths of LB with life-threatening conditions and the total number of LB with life-threatening conditions) and the ratio between NNM cases and deaths (quotient between NNM cases and neonatal deaths per one hundred) were calculated.

The maternal variables (SINASC) were grouped into:

- sociodemographic (age group: <20, 20–34, and ≥35 years; ethnicity/skin color: white, black, brown, and others; level of education: <4, 4–11, and ≥12 years of formal education; have a partner: yes *vs.* no);
- reproductive (number of deceased children: 0 *vs.* ≥1; number of living children: 0, 1–3, and ≥4);

- pregnancy and delivery (prenatal care: no prenatal care, onset at the ≤3rd month or >3rd month; presentation of the newborn: cephalic, breech, and transverse; type of delivery: vaginal *vs.* cesarean delivery);
- newborn (sex: male *vs.* female; BW: <1500g, 1500–2499g, 2500–3999g, and ≥4000g; GA: <32, 32–36, 37–39, and ≥ 40 weeks; five-minute Apgar score<7 *vs.* ≥7).

As most NNM cases met the pragmatic criterion of GA<32 weeks, the proposal of adequacy of access to prenatal care of the Brazilian Ministry of Health was adapted:[18] the number of consultations was not considered, only if the pregnant woman received prenatal care and, in this case, the onset trimester. Likewise, considering the independent effect of GA on breech presentation during delivery in preterm infants,[12] this variable was not evaluated for NNM, only for mortality.

Factors associated with each outcome were investigated separately, based on theoretical models of hierarchical determination – distal, intermediate, and proximal factors – of the severity of the newborn's condition,[7] adapted according to the availability of information.

In the model for NNM, the distal hierarchical level comprised the maternal variables ethnicity/skin color (white, black, and brown, with "others" being excluded due to the low frequency of LB) and level of education (<8 *vs.* ≥8 years of formal education). These variables were adjusted between each other and followed to the intermediate level without being adjusted for the other variables. The intermediate level included maternal age (<20, 20–34, and ≥35 years), having a partner (yes *vs.* no), and parity (primiparous *vs.* multiparous). Subsequently, they were adjusted between each other and for those at the distal level, which were significant, following to the proximal level. Finally, the proximal level comprised prenatal care adequacy (no prenatal care, onset at the first trimester and after the first trimester), which was adjusted for all variables that were previously significant.

In the model for neonatal death, the maternal variables ethnicity/skin color (white, black, and brown) and level of education (<8 *vs.* ≥8 years of formal education) composed the distal level. The intermediate level was divided into two subgroups:

- intermediate I: maternal age (<20, 20–34, and ≥35 years), having a partner (yes *vs.* no), and parity (primiparous *vs.* multiparous).
- intermediate II: prenatal care adequacy (no prenatal care, onset at the first trimester and after the first trimester), and newborn presentation at delivery (cephalic: yes *vs.* no).

The proximal level was composed of newborn variables: prematurity (<37 weeks: yes *vs.* no), low birth weight (<2500g: yes *vs.* no), and five-minute Apgar score<7 (yes *vs.* no). The hierarchical approach followed the same steps described for the NNM.

For the outcomes, the variable "sex of the live birth," which does not belong to hierarchical levels, was independently addressed, without adjustments. The variable "type of delivery" was not included due to the possibility of indication bias in the associations studied with severe neonatal outcomes.

To describe the cohort, proportions were calculated for categorical variables, according to severe negative outcome. Pearson's chi-square or Fisher's exact tests were used to test the homogeneity of the population.

For the analysis of factors associated with the outcomes, binary logistic regression models were employed. After performing crude analyses, covariates with p<0.20 were selected for the multiple regression model of the respective hierarchical level. Only variables with p <0.05 of the multiple regression were maintained in the final model. Covariates of the same hierarchical and previous levels were deemed as possible confounding factors.

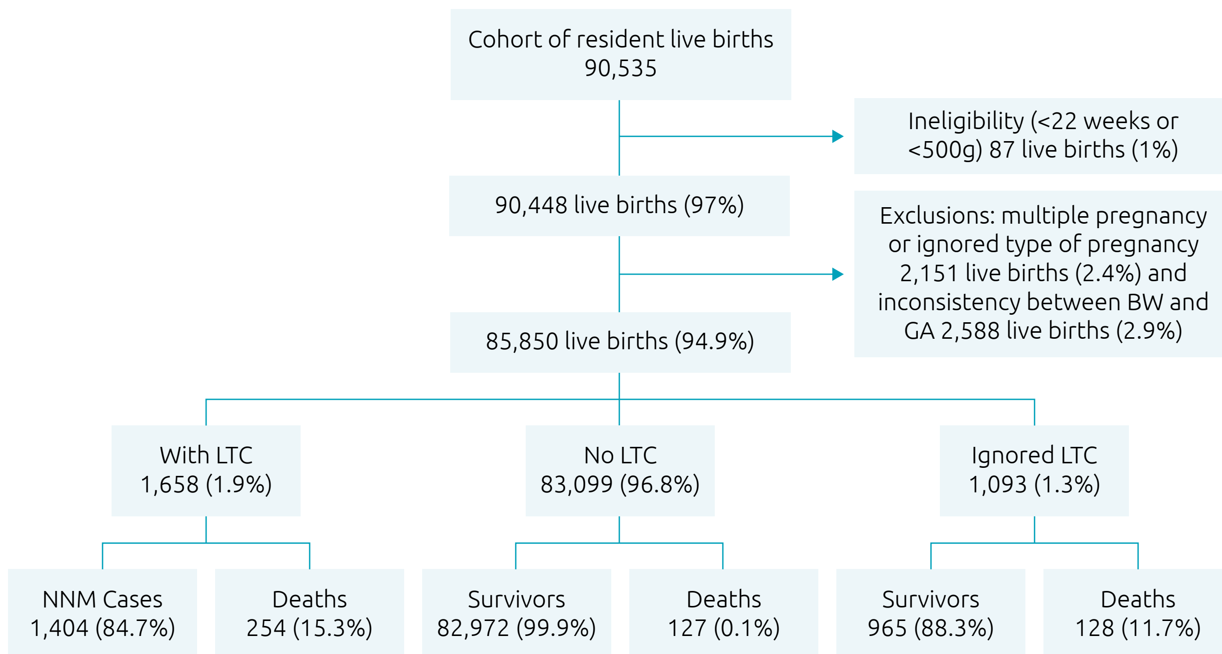
The present study was approved by the Research Ethics Committees of the Institute of Collective Health Studies of Universidade Federal do Rio de Janeiro (No. 2.105.885) and the SMSRJ (No. 2.218.098). The linkage of databases was performed in the SMSRJ, and they were transferred without identification.

RESULTS

The cohort comprised 90,535 LB, of which 90,448 were eligible (Figure 1). With the exclusion of twins and losses due to inconsistencies between BW and GA (5.1%), the number of LB decreased to 85,850, of which 1.3% were not classified according to life-threatening conditions due to lack of information (except for BW, 100% completeness).

Among newborns with the presence of at least one pragmatic neonatal near miss criterion (<32 weeks; BW<1500g, or five-minute Apgar score<7), 1,404 were classified as NNM cases, and 254 died. Among the 83,099 LB without any of the life-threatening criteria, 127 died, 33.9% due to congenital malformation, a value 2.3 times higher than the frequency of the same cause among deaths with life-threatening conditions. In addition, there were 128 deaths not classified according to life-threatening conditions, due to ignored information on five-minute Apgar score and GA, totaling 509 deaths (Figure 1). Among the deaths not classified according to life-threatening conditions, 91.4% were between 1500 and 2500g and 6.3% were due to congenital malformation.

The indicators of serious outcomes are shown in Figure 2. For every one thousand LB, 16 were NNM cases, six died, four being early neonatal deaths and two, late neonatal deaths. The ratio of NNM cases and deaths was 2.8, that is, there were three cases of NNM for each death.



BW: birth weight; GA: gestational age; LTC: life-threatening conditions; NNM: neonatal near miss.

Figure 1 Cohort of live births, municipality of Rio de Janeiro (RJ), Brazil, 2015.

The distribution of LB per sociodemographic, reproductive, pregnancy, childbirth, maternal, and newborn variables and according to severe outcome is shown in Tables 1 and 2. Ignored information ranged from 0 to 3.7%. Regardless of the negative outcome, young mothers (<35 years), with level of education between four and 11 years of formal education, brown skin color, without a partner, multiparous, with the onset of prenatal care during the first trimester, and who had cesarean delivery predominated. Conversely, survivors without life-threatening conditions, NNM cases, and deaths were heterogeneous according to the analyzed variables, except for parity and type of delivery (Tables 1 and 2). Considering the increasing gradient of severity of outcomes, there was an increase in the proportion of adolescent mothers, brown and black women, without a partner, previous deceased children, non-prenatal care, and non-cephalic presentation.

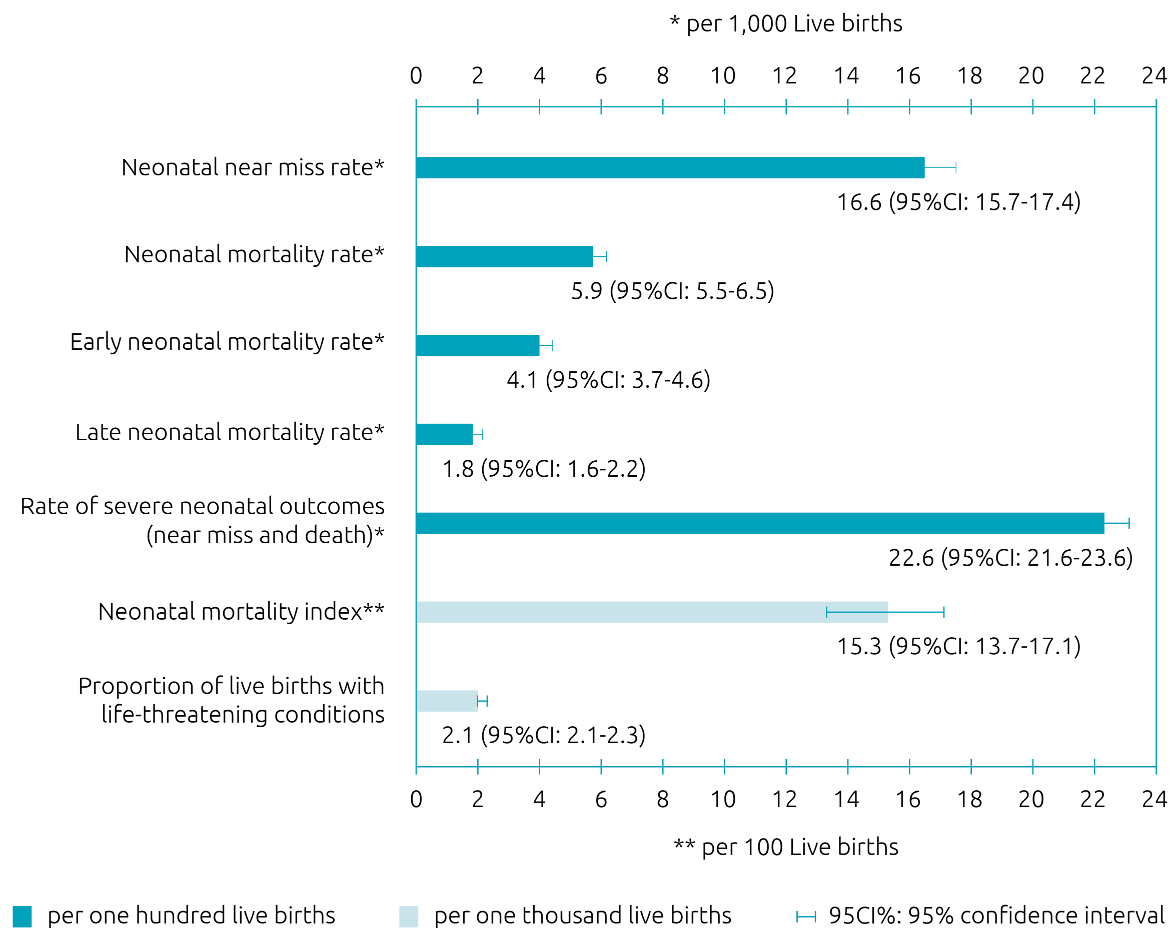
The regression models for the NNM outcome are demonstrated in Table 3. In the crude analysis, with the exception of "sex," all variables were associated with NNM (p<0.20), and in the adjusted analysis, only the category of adolescents was not maintained (considering p<0.05). At the distal level, the chance of being a case of NNM was higher in children of black mothers with low level of education; and at the intermediate level, children of older women and those without a partner. The adjusted strength of association greater than 3 between prenatal care adequacy ("no prenatal care" category) and the NNM outcome stands out.

Regarding the hierarchical determination of neonatal death, except for the "parity" variable, all the others were strongly associated in the crude analysis (Table 4). The variable "have partner," when adjusted, showed no significant association. The adjusted odds ratios (OR), when compared with unadjusted values, were lower, except for those aged ≥35 years, which increased (negative confounding). Intermediate II and proximal variables showed greater strength of association with death, even after confounding control, with emphasis on no prenatal care ($OR_{adjusted}$=6.5), non-cephalic presentation ($OR_{adjusted}$=5.6), five-minute Apgar score<7 ($OR_{adjusted}$=29.5), weight<2500g ($OR_{adjusted}$=8.1), and prematurity ($OR_{adjusted}$=4.6).

DISCUSSION

In the Rio de Janeiro LB cohort of 2015, sociodemographic factors related to prenatal care, delivery, and the newborn were strongly associated with severe negative neonatal outcomes.

Burdens of severe morbidity and neonatal mortality pointed to a more adequate scenario in the municipality in 2015 (NNMR=16 and NMR=5.9 per one thousand LB), when compared with 2012.[19] NNM and mortality rates decreased by 3.5 and 0.8 per one thousand LB, respectively. Both the present study (LB cohort of 2015) and the study conducted on the LB cohort of 2012[19] are single-pregnancy LB cohorts and used



95%CI: 95% confidence interval.

Figure 2 Indicators of severe negative neonatal outcomes. Cohort of single-pregnancy live births in the city of Rio de Janeiro (RJ), Brazil, 2015. Source: SIM/SINASC/SMSRJ.

the same definition of NNM. In 2012, in the city of Joinville (state of Santa Catarina, Brazil),[4] NNMR (33 per one thousand LB) was higher, and NMR (4.5 per one thousand LB) was lower than in Rio de Janeiro, suggesting lower-risk births and/or better health care. The Santa Catarina study used population data from SINASC, did not exclude multiparous mothers, and adopted the definition of NNM according to Silva et al.[10]

Most national studies are hospital-based, with higher rates, especially in public and reference hospitals for high-risk pregnancies. In the city of Recife (state of Pernambuco, Brazil), in 2012, the total NNMR was 86.5 per one thousand LB: 112.8 in public hospitals and 28 per one thousand LB in private hospitals.[20] In the university hospital of Maceió (state of Alagoas, Brazil), in 2015/2016, the NNMR was 220 and the NMR was 57 per one thousand LB.[21] In the study on six public maternity hospitals in the cities of São Paulo (state of São Paulo, Brazil), Rio de Janeiro and Niterói (RJ, Brazil), in 2011, the global NNMR was 17.1 and the NMR, 4.1 per one thousand LB (respectively ranging from 3.7 to 30.5 per one thousand LB, and from 1.9 to 14.4 per one thousand LB among the six participating institutions).[7] In the national survey on maternity hospitals, NNMR and NMR were 39.2 and 11.1 per one thousand LB, respectively.[10]

The differences between the studies can be explained by the varied hospital profiles of risk and quality of obstetric and neonatal care, by the type of study – hospital- or population-based –, and exclusion criteria such as multiple pregnancy.[4,10,11,13] Additionally, changes in the cutoff points of the pragmatic criteria and the addition of other criteria (clinical and laboratory) to the NNM definition resulted in variations in the indicators.[4,10,11]

Regarding the associated factors, the present study corroborated the maternal sociodemographic variables, level of education, and skin color. These are important markers of vulnerability in studies on maternal and child health.[22,23] These variables comprised the distal level of the hierarchical models and were

Table 1 Distribution of maternal sociodemographic and reproductive characteristics, according to severe neonatal outcomes. Cohort of single-pregnancy live births in the city of Rio de Janeiro (RJ), Brazil, 2015*.

Characteristics	Survivors				Deaths		p-value[a]
	No LTC (82,972)		Near Miss (1,404)		(509)		
	n	%	n	%	n	%	
Age group (years)							<0.001
<20	12,682	15.28	254	18.09	103	20.24	
20–34	56,280	67.83	881	62.75	309	60.71	
≥35	14,010	16.89	269	19.16	97	19.06	
Level of education (years)							<0.001
<4	1,298	1.56	33	2.35	6	1.18	
4–11	59,327	71.50	1,041	74.15	396	77.80	
≥12	20,960	25.26	296	21.08	92	18.07	
Ignored	1,387	1.67	34	2.42	15	2.95	
Ethnicity/skin color[b]							<0.001
White	30,713	37.02	461	32.83	134	26.33	
Black	7,243	8.73	151	10.75	59	11.59	
Brown	43,300	52.19	770	54.84	300	58.94	
Others	303	0.37	6	0.43	1	0.20	
Ignored	1,413	1.70	16	1.14	15	2.95	
Have a partner							<0.001
No	54,369	65.53	990	70.51	366	71.91	
Yes	28,008	33.76	402	28.63	131	25.74	
Ignored	595	0.72	12	0.85	12	2.36	
Deceased children							<0.001
None	67,109	80.88	1,097	78.13	377	74.07	
≥1	15,574	18.77	299	21.30	131	25.74	
Ignored	289	0.35	8	0.57	1	0.20	
Living children							0.002
None	39,310	47.38	594	42.31	225	44.20	
1–4	40,727	49.09	759	54.06	266	52.26	
≥4	2,934	3.54	51	3.63	18	3.54	
Ignored	1	≈0.0	–	–	–	–	
Parity							0.220
Primiparous	35,673	42.99	635	45.23	217	42.63	
Multiparous	47,192	56.88	765	54.49	292	57.37	
Ignored	107	0.13	4	0.28	–	–	

*All information was obtained from the Brazilian Live Birth Information System (SINASC), including from deaths after the linkage of databases (SINASC and the Brazilian Mortality Information System); LTC: Life-threatening conditions; [a]Pearson's chi-square test, except for level of education, for which the Fisher's exact test was used (the "ignored" category of the variables was not considered; only age group presented 100% completeness of the information); [b]the homogeneity test for maternal ethnicity/skin color also excluded the "others" category.

Table 2 Distribution of pregnancy, delivery, and newborn characteristics according to severe neonatal outcomes. Cohort of single-pregnancy live births in the city of Rio de Janeiro (RJ), Brazil, 2015.

Characteristics	Survivors				Deaths		p-value[a]
	No LTC (82,972)		Near Miss (1,404)		(509)		
	n	%	n	%	n	%	
Prenatal care							<0.001
No	565	0.68	33	2.35	25	4.91	
Onset≤3rd month	63,497	76.53	980	69.80	328	64.44	
Onset>3rd month	18,395	22.17	371	26.42	144	28.29	
Ignored	515	0.62	20	1.42	12	2.36	
Presentation[b]							<0.001
Cephalic	78,350	94.43	–	–	406	79.76	
Breech	2,535	3.06	–	–	78	15.32	
Transverse	202	0.24	–	–	6	1.18	
Ignored	1,885	2.27	–	–	19	3.73	
Type of delivery							0.095
Vaginal	36,918	44.49	584	41.60	226	44.40	
Cesarean	46,046	55.50	820	58.40	283	55.60	
Ignored	8	≈0.0	–	–	–	–	
Sex							0.017
Female	40,582	48.91	667	47.51	217	42.63	
Male	42,385	51.08	737	52.49	288	56.58	
Ignored	5	≈0.0	–	–	4	0.79	

*All information was obtained from the Brazilian Live Birth Information System (SINASC), including from deaths after the linkage of databases (SINASC and the Brazilian Mortality Information System); LTC: Life-threatening conditions; [a]Pearson's chi-square test, except for presentation of newborn (survivors with no LTC and deaths), for which the Fisher's exact test was used (the "ignored" category of the variables was not considered; only age group presented 100% completeness of the information); [b]near miss cases were excluded from the analysis due to the independent effect of gestational age on the fetal presentation of preterm newborns[12]. Source: SIM/SINASC/SMSRJ.

Table 3 Logistic regression models with hierarchical strategy for determining neonatal near miss cases. Cohort of single-pregnancy live births in the city of Rio de Janeiro (RJ), Brazil, 2015*.

Hierarchical level/associated factors	Crude analysis				Adjusted analysis[a]			
	p-value	OR	95%CI		p-value	OR	95%CI	
Independent								
Male	0.303	1.06	0.95	1.17	–	–	–	–
Distal								
Black skin color	0.001	1.38	1.15	1.67	0.002	1.34	1.11	1.62
Brown skin color	0.005	1.18	1.05	1.33	0.033	1.14	1.01	1.28
<8 years of formal education	0.001	1.19	1.04	1.35	0.043	1.15	1	1.31
Intermediate								
<20 years	0.001	1.28	1.11	1.47	0.314	1.09	0.93	1.27
≥35 years	0.004	1.22	1.07	1.41	<0.001	1.33	1.15	1.54
Primiparous	0.084	0.91	0.82	1.01	0.01	0.86	0.76	0.96
Single	<0.001	1.27	1.13	1.42	0.005	1.2	1.06	1.37
Proximal								
No prenatal care	<0.001	3.71	2.6	5.31	<0.001	3.72	2.57	5.38
Inadequate prenatal care	<0.001	1.31	1.16	1.47	<0.001	1.3	1.14	1.48

OR: Odds Ratio; 95%CI: 95% confidence interval; *reference category of the variables: sex of live birth (female), ethnicity/skin color (white), level of education (≥8 years of formal education), maternal age (20–34 years old), parity (multiparous), have a partner (yes), adequacy of prenatal care (onset at first trimester); [a]adjusted ORs were adjusted at the distal level only for the variables of the same hierarchical level; at the intermediate level, for those of the same hierarchical and previous level; and at the proximal level, for all variables.

Table 4 Logistic regression models with hierarchical strategy for determining neonatal deaths. Cohort of single-pregnancy live births in the city of Rio de Janeiro (RJ), Brazil, 2015*.

Hierarchical level/associated factors	Crude analysis				Adjusted analysis[a]			
	p-value	OR	95%CI		p-value	OR	95%CI	
Independent								
Male	0.008	1.27	1.06	1.52	0.008	1.27	1.06	1.52
Distal								
Black skin color	<0.001	1.84	1.35	2.5	<0.001	1.82	1.34	2.49
Brown skin color	<0.001	1.57	1.28	1.93	<0.001	1.48	1.2	1.82
<8 years of formal education	0.003	1.37	1.11	1.69	0.048	1.24	1	1.54
Intermediate I								
<20 years	0.001	1.84	1.17	1.84	0.031	1.3	1.03	1.65
≥35 years	0.05	1.26	1	1.58	0.009	1.37	1.08	1.74
Primiparous	0.926	1.01	0.85	1.2	–	–	–	–
Single[b]	0.001	1.42	1.16	1.74	–	–	–	–
Intermediate II								
No prenatal care	<0.001	7.55	4.99	11.42	<0.001	6.45	4.15	10.02
Inadequate prenatal care	<0.001	1.49	1.22	1.81	0.011	1.32	1.07	1.64
Non-cephalic presentation	<0.001	5.73	4.51	7.26	<0.001	5.6	4.35	7.23
Proximal								
<2500g	<0.001	39.76	32.65	48.41	<0.001	8.06	5.86	11.09
<37 weeks	<0.001	28.62	23.37	35.05	<0.001	4.63	3.35	6.41
Five-minute Apgar score<7	<0.001	87.95	72.36	106.88	<0.001	29.54	23.04	37.86

OR: Odds Ratio; 95%CI: 95% confidence interval; *reference category of the variables: sex of live birth (female), ethnicity/skin color (white), level of education (≥8 years of formal education), maternal age (20–34 years old), parity (multiparous), have a partner, adequacy of prenatal care (onset at first trimester), newborn presentation at delivery (cephalic), birth weight (≥2500g), prematurity (≥37 weeks), five-minute Apgar score (≥7); [a]adjusted ORs were adjusted at the distal level only for the variables of the same hierarchical level; at the intermediate level, for those of the same hierarchical and previous level; and at the proximal level, for all variables; [b]in the model adjusted for the variables of the same hierarchical level and of the previous level, having a partner did not present statistical significance level <0.05 and, therefore, it was not selected in the analyses of subsequent hierarchical levels.

associated with the outcomes. Some studies found an association between maternal education and NNM[10] and neonatal deaths,[7,23] and others did not, such as the one by Pereira et al.,[5] in relation to the NNM, and the one by Garcia et al.,[24] regarding death. Maternal skin color was associated with NNM, but not with death, in the study on maternity hospitals in Rio de Janeiro and São Paulo.[7] In the meta-analysis of neonatal death, skin color was not even included among the evaluated factors.[3] These disagreements may be related to the analysis models. In the hierarchical strategy, these variables are at the distal level and are adjusted only at this level, highlighting their effect more than in the analysis in which all variables are adjusted between each other, regardless of hierarchical relationship. Another explanation is the form of collection, as secondary data is more subject to information biases. Specifically, skin color has been the subject of discussion due to recent changes in the collection means, by self-declaration, adopted by SINASC in 2011.

Advanced maternal age can lead to obstetric complications.[25] Women aged 35 years or older were more likely to have a negative outcome in the present study, corroborating other studies.[3,5,25] Only in Maceió[21] there was a protective effect of advanced age in relation to NNM, attributed to planned pregnancy and greater prenatal care in these women. The differential of the maternity unit studied in Maceió, a reference for high risk and linked to the university institution, must be taken into account. Also at the intermediate hierarchical level, absence of a partner and primiparity were associated with NNM, in agreement with other studies.[7,26]

Failures in the health care provided to pregnant women, addressed in this study in relation to the adequacy of access to prenatal care, still occurred quite frequently and unevenly in the capital of Rio de Janeiro. Among non-life-threatening survivors, the lack of prenatal care was less than 1% and the onset of prenatal care after the first trimester was 22%. Among the NNM cases, the values were 2.4 and 26.8%, and among the deaths, 5.7 and 29%. Therefore, a gradient in the severity of the outcome was observed as the proportion of inadequate access increases. The association between prenatal care and severe negative neonatal outcomes is consistent with other studies.[3,5,20,24,26,27] In the national studies[10,13] and in Joinville,[4] adequacy of prenatal care showed no association with NNM. The adequacy of prenatal care in these two studies considered only women who underwent prenatal care, depending on the number of consultations according to GA, and based on the Prenatal Care and Birth Humanization Program (*Programa de Humanização no Pré-Natal e Nascimento* – PHPN).

Regarding the presentation of the newborn at delivery, the OR was also high, in agreement with hospital-based studies conducted in Ethiopia[26] and Brazil.[27] In the hierarchical determination of death, factors of newborns (proximal), BW, GA, and five-minute Apgar score were highlighted, results well-documented in the literature.[3,24,27]

The lack of a universal definition for NNM may interfere with the comparison of study results. The authors consider that the pragmatic criteria are the easiest to apply. In addition, we defend the cutoff points of 1500g and 32 weeks, defined in the literature as very low birth weight and extremely preterm, and used to define the severity of perinatal care.[28]

Another important issue is a possible underestimation of cases and NNM due to unknown or inconsistent information. However, among the 2,587 LB excluded, the majority had BW≥1500g (94%) and five-minute Apgar score≥7 (97%), with incompatible GA being the reason for the inconsistency (data not shown in the table). Therefore, LB small for GA and some LB large for GA may have been lost, but few cases of NNM. It is known that, of the pragmatic criteria, GA has the lowest reliability.[29]

Some of the strengths of the present study were the treatment of the data, with the elimination of inconsistencies between BW and GA, and the proper completion of the number of the LB certificate on the death certificate, allowing a deterministic linkage above 90% of the databases. The adaptation of the variable "adequacy of access to prenatal care" provided by the Ministry of Health[18] is easily applicable and timely for NNM studies. Modeling with hierarchical strategy values the representation of distal variables, which may have contributed to the study results.

The identification of factors associated with NNM and neonatal death contributes to the development and implementation of effective strategies for its reduction. Preventing life-threatening births may reduce preventable deaths up to five years in the municipality of Rio de Janeiro by 97.6%.[19] Although survivors of the neonatal period, NNM cases present higher mortality up to five incomplete years, especially in the post-neonatal period,[19] permanence of hospitalization for delivery, hospitalization after discharge from delivery, and weaning in the first year of life, evidencing conditions of vulnerability and the need for social assistance and support for their families.[30]

Besides confirming the effect of low birth weight, prematurity, and asphyxia on neonatal death, this study identified that socioeconomic vulnerability markers — low education level and brown or black skin colors — were associated with neonatal death and NNM. Absent or inadequate prenatal care were strongly associated with both outcomes, being stronger for neonatal death. Investments in prenatal care and reduction of disparities in health care are necessary in Rio de Janeiro.

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Conflict of interests

The authors declare there is no conflict of interests.

Authors' contribution:

Study design: Rocha NM, Kale PL. *Data collection:* Rocha NM, Kale PL. *Data analysis:* Rocha NM, Kale PL. *Manuscript writing:* Rocha NM, Kale PL, Fonseca SC, Brito AS. *Manuscript review:* Rocha NM, Kale PL, Fonseca SC, Brito AS. *Study supervision:* Kale PL.

Declaration

The database that originated the article is available with the corresponding author.

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