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Factors associated with neonatal-near miss: birth cohorts in three Brazilian cities - Ribeirão Preto, Pelotas and São Luís, Brazil

Fatores associados ao *near miss neonatal*: coortes de nascimentos de três cidades brasileiras - Ribeirão Preto, Pelotas e São Luís, Brasil

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Abstract *The aim of this study was to investigate the association of sociodemographic factors, lifestyle, maternal reproductive profile and prenatal and childbirth care with neonatal near miss (NNM) morbidity in four birth cohorts. This study involved four population-based birth cohorts: Ribeirão Preto (RP) and São Luís (SL) (2010), Pelotas 2004 (PEL04) and 2015 (PEL15). NNM was defined when one or more of the following conditions were present: birthweight <1,500 g, 5-minute Apgar score <7, gestational age <32 weeks, and report of congenital malformations. The covariates were obtained with questionnaires applied to the puerperal women. Some particularities between cohorts were identified. In the RP and SL cohorts, factors of the more distal levels (sociodemographic, lifestyle, and reproductive profile) were associated with NNM. On the other hand, proximal factors related to healthcare were more significant for the occurrence of NNM in PEL. Only the absence of prenatal care was associated with NNM in all cohorts: RP (OR=4.27, 95%CI 2.16-8.45), SL (OR=2.32, 95%CI 1.09-4.94), PEL04 (OR=4.79, 95%CI 1.59-14.46), and PEL15 (OR=5.10, 95%CI 2.60-9.97).*

Key words *Prenatal care, Neonatal mortality, Maternal and child health*

Resumo *O objetivo deste estudo foi investigar a associação entre fatores sociodemográficos, estilo de vida, perfil reprodutivo maternos e atenção pré-natal e ao parto com a morbidade near miss neonatal (NMN), em quatro coortes de nascimento. Este estudo envolveu quatro coortes de nascimento: Ribeirão Preto (RP) e São Luís (SL) (2010), Pelotas 2004 (PEL04) e 2015 (PEL15). Foi considerado NMN quando presente uma ou mais das seguintes condições: peso ao nascer <1.500g, índice de Apgar <7 no quinto minuto de vida, idade gestacional <32 semanas e relato de malformações congênitas. As covariáveis foram obtidas por meio de questionários aplicados às puérperas. Para análise, foi utilizada regressão logística múltipla com abordagem hierarquizada. Algumas particularidades entre as coortes foram verificadas. Nas coortes de RP e SL foram observadas associações dos fatores dos níveis mais distais (sociodemográficas, estilo de vida e perfil reprodutivo) com o NMN. Por outro lado, em PEL os fatores proximais relacionados à atenção à saúde foram mais significativos para ocorrência de NMN. Apenas a não realização do pré-natal associou-se ao NMN em todas as coortes: RP (OR=4,27, IC95% 2,16-8,45), SL (OR=2,32, IC95% 1,09-4,94), PEL04 (OR=4,79, IC95% 1,59-14,46) e PEL15 (OR=5,10, IC95% 2,60-9,97).*

Palavras-chave *Cuidado pré-natal, Mortalidade neonatal, Saúde materno-infantil*

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Introduction

Neonatal near miss (NNM) morbidity is a set of serious events that almost result in the death of the newborn within the first 28 days of life[1]. The advantage of using this concept rather than mortality is its greater capacity of identifying death-associated risk factors since the proportion of NNM is 2.6 to 8.0 times higher than the frequency of neonatal deaths[2]. Thus, the use of this indicator can provide data to improve the quality of care for pregnant women and at-risk newborns, as well as to assess health services[3]. Although no standard criteria exist for the identification of NNM, studies have generally considered pragmatic indicators associated with neonatal death (birth weight, gestational age, and 5-minute Apgar score) for classification because of the availability of and easy access to this information[4].

The prevalence of NNM varies little across Brazilian regions[5]. Pereira *et al.*[6] found a non-significant difference of 1.2 percentage points between regions, with NNM being more frequent in the southeastern region (4.3%) and less frequent in the southern and northern regions (3.1%). Nevertheless, in view of socioeconomic disparity and differences in healthcare organization during the pregnancy-puerperal period, studies conducted in some Brazilian cities suggest that the factors associated with the occurrence of NNM may vary according to the region studied[7-9]. Within this context, Silva *et al.*[7] highlighted the importance of identifying determinant factors for the occurrence of NNM in different social contexts in an effort to redirect public health actions towards preventive interventions. However, to our knowledge, there are no studies that investigated and compared factors associated with NNM between cities located in different regions of Brazil.

Therefore, the aim of this study was to investigate the association of sociodemographic factors, lifestyle, maternal reproductive profile, and prenatal and childbirth care with NNM in four ongoing birth cohort studies conducted in three Brazilian cities, located in the northeastern, southeastern and southern regions, with different socioeconomic and demographic characteristics.

Methods

The data of the present study are part of four population-based Brazilian birth cohorts: the Ribeirão Preto (RP) and São Luís (SL) cohorts started in 2010, and the Pelotas cohorts started in 2004 (PEL04) and 2015 (PEL15). The methodological details and sample planning of the baseline studies have been published recently[10].

The city of RP is located in the State of São Paulo, southeastern Brazil. In 2010, the city had a population of 604,682 inhabitants, with a Human Development Index (HDI) of 0.80. In SL, the capital of Maranhão, northeastern Brazil, the 2010 census reported a population of 1,014,837 inhabitants and a HDI of 0.768. Pelotas is located in the State of Rio Grande do Sul and had 328,275 inhabitants and a HDI of 0.739 in 2010. According to the Gini index, which represents the degree of income inequality, SL has a higher social inequality index (0.627) than PEL (0.560) and RP (0.546).

In RP, the study was conducted from 1 January to 31 December 2010 in all public and private hospitals with a maternity service. All mothers from the municipality were invited to participate in the study; 7,752 live births were evaluated, corresponding to 95.7% of all births during the period. In SL, one of three births that occurred in 2010 in all hospitals with more than 100 births per year was selected, totaling 5,166 live births which corresponded to 89.8% of all births during the period. The PEL04 cohort included 99.3% (4,231) of the live births in 2004 of mothers resident in the city of Pelotas. In 2015, 4,275 live births of mothers resident in the urban area of the city, corresponding to 98.7% of birth in the year, were evaluated.

The classification suggested by Silva *et al.*[5] was used for the definition of NNM, which considers the presence of one or more of the following conditions as a criterion: birth weight <1,500 g, 5-minute Apgar score <7, gestational age <32 weeks, report of congenital malformations, and use of mechanical ventilation. The use of mechanical ventilation was not considered in the present study because of the lack of information in the cohorts. Nevertheless, the use of four criteria exhibited high sensitivity and specificity for neonatal mortality (Table 1).

In all cohorts, the birth weight and 5-minute Apgar score data were obtained from the registry book and medical records of the maternities. Information on malformations was obtained by interview with the mothers held within 24 hours after delivery. Two criteria were used for the calculation of gestational age in RP and SL: date of the last menstruation reported by the mother or an algorithm based on the date of the last men-

Table 1. Sensitivity and specificity of neonatal near miss with neonatal mortality. RPS birth cohorts.

	Sensitivity	Specificity
Ribeirão Preto 2010	0.91	0.97
São Luís 2010	0.74	0.96
Pelotas 2004	0.72	0.96
Pelotas 2015	0.87	0.97

Source: Authors.

struation and on an obstetric ultrasound, when available. In PEL04 and PEL15, the gestational age was obtained as the best obstetric estimate based mainly on the first or second trimester ultrasound. When no ultrasound data were available, the date of the last menstruation was adopted[11-13].

The covariates were collected by applying validated and standardized questionnaires to the mothers within the first 24 hours after delivery. Data on socioeconomic and demographic conditions, lifestyle, reproductive profile, and healthcare were obtained in all cohorts.

The following independent variables were analyzed: newborn sex; self-reported skin color of the mother (white, black, brown); maternal educational level in years of schooling (≥12, 9-11 and ≤8 years); socioeconomic class assessed according to the Economic Classification Criteria of the Brazilian Association of Research Companies (ABEP in the Portuguese acronym[14]) (classes AB, C and DE, with AB being the most privileged and DE the least privileged); marital status (married/consensual union and without a partner); maternal age (<20 years, 20-34 years, and ≥35 years); smoking during pregnancy (yes, if smoking at least one cigarette per day, and no); gestational hypertension (yes, reported by the mother, and no); parity (1, 2-4, and 5+); prenatal care (yes and no); type of delivery (vaginal and cesarean), and childbirth care (health insurance/private and public).

The data were analyzed with the Stata 14 program (College Station, Texas, USA). The proportion of the covariates was compared between the non-NNM and NNM groups by the chi-squared test. A hierarchical approach was used to identify risk factors associated with NNM.

The first level (sociodemographic) comprised skin color, maternal education level and socioeconomic class. The second level (lifestyle and reproductive profile) included marital status, maternal age, smoking during pregnancy, gestational hypertension, and parity. Finally, the third level, most proximal to the outcome, consisted of prenatal care, type of delivery, and childbirth care. First, multiple logistic regression analysis was performed using the variables of the distal level. Variables with a p value <0.20 were then successively added to the set of variables of the second level and this process was repeated until the last level. Cases of neonatal mortality up to day 28 of life (42 in RP, 48 in SL, 51 in PEL04, and 37 in PEL15), twin pregnancies (185 in RP, 99 in SL, 82 in PEL04, and 106 in PEL15), and cases of non-NNM without information on any of the four criteria used for the classification of NNM (88 in RP, 72 in SL, 25 in PEL04, and 12 in PEL15) were excluded. The level of significance was set at <0.05 in all analyses.

All procedures were approved by the Ethics Committee of the local university institutions involved in the study. Only women who properly understood and signed the free informed consent form participated in the present study.

Results

A total of 20,577 mother-infant binomials were evaluated, including 7,437 in RP, 4,947 in SL, 4,073 in PEL04, and 4,120 in PEL15. The prevalence of NNM was 3.0% in RP, 3.9% in SL, 3.3% in PEL04, and 3.0% in PEL15. The lack of overlapping 95%CI indicates the absence of differences in the prevalence of NNM between cohorts (Table 2). Among children with NNM, gestational age <32 weeks was more frequent in RP (44.3%), SL (47.4%) and PEL15 (43.2%), and a 5-minute Apgar score <7 in PEL04 (49.6%) (Table 2).

Table 3 shows the characteristics of the non-NNM and NNM groups according to cohort. Neonatal near miss was more frequent among black mothers from RP and SL; among mothers with lower education level from RP and PEL04; among mothers of socioeconomic classes D/E from RP and PEL04; among mothers without a partner from RP and SL; among younger mothers from SL and PEL04, and among smokers and mothers reporting gestational hypertension from RP and PEL04. In the four cohorts, NNM was more prevalent among mothers who did not receive prenatal care and those receiving childbirth care in the public sector.

The results of unadjusted and adjusted association analysis between NNM and the independent variables are shown in Tables 4 and 5,

Table 2. Distribution of neonatal near miss (NNM) characteristics. Ribeirão Preto (RP), São Luís (SL) and Pelotas (PEL04 and PEL15) Consortium.

	RP			SL			PEL04			PEL15		
	N	%	95%CI	N	%	95%CI	N	%	95%CI	N	%	95%CI
NNM	221	3.0	2.6-3.4	192	3.9	3.3-4.4	135	3.3	2.8-3.9	125	3.0	2.5-3.6
NNM characteristics												
Gestational age <32 weeks	98	44.3	38.0-51.0	91	47.4	40.4-54.5	44	32.6	26.0-41.9	54	43.2	34.7-52.1
Weight <1500 g	82	37.1	30.9-43.7	43	22.4	17.1-29.0	25	18.5	12.9-26.2	26	20.8	14.7-29.4
Congenital malformation	68	31.0	25.0-37.3	53	27.6	17.3-29.3	26	19.2	13.4-26.9	32	25.6	18.6-34.1
Five-minute Apgar score <7	44	20.0	15.7-26.7	43	22.4	21.9-34.8	67	49.6	41.8-58.9	37	29.6	22.3-38.6

95%CI: 95% confidence interval.

Source: Authors.

respectively. In unadjusted analysis, at the sociodemographic level, black skin color in RP and SL and brown skin color in RP and PEL15 were associated with NNM. In addition, a low maternal education level and socioeconomic class D/E were associated with NNM in the RP, PEL04 and PEL15 cohorts. At the lifestyle level, having no partner was associated with NNM only in RP and SL. Furthermore, an association was observed between maternal age <20 years and NNM in SL and between smoking during pregnancy and gestational hypertension in RP and PEL04. At the healthcare level, receiving no prenatal care and receiving childbirth care in the public sector were associated with NNM, while no association was observed for the type of delivery.

In adjusted analysis, skin color remained associated with NNM in RP and SL. Black women were more likely to have NNM than white women in RP and SL. Similarly, brown women were more likely to have NNM than white women in RP. Maternal education level remained associated with NNM only in RP. Women with 9 to 11 and less than 8 years of schooling were more likely to have NNM than women with ≥12 years of schooling.

Related to lifestyle and reproductive profile, women without a partner continued to have higher odds of NNM in RP and SL compared to married women or those living in a stable union. Maternal age remained associated with NNM only in SL, in which women <20 years had a 59% higher odds of having this outcome than women aged 20 to 34 years. Maternal smoking continued to be associated with NNM after adjustment only in RP. Women who smoked had a 62% higher odds of having NNM than non-smokers in RP. Gestational hypertension remained associated with NNM in RP and PEL04, with hypertensive women being two to three times more likely to have this outcome. The association between NNM and receiving no prenatal care persisted in all cohorts, with the highest odds being observed in the PEL15 cohort, followed by the PEL04 and RP cohorts, and the lowest odds in the SL cohort. The type of delivery was associated with NNM in RP after adjustment. Women undergoing cesarean delivery were more likely to have NNM than those with vaginal delivery. The type of childbirth care remained associated with NNM only in RP, PEL04 and PEL15. Women who received childbirth care in the public sector were two to four times more likely to have NNM than those with a health insurance or private care.

Discussion

The data of the present study indicate no differences in the prevalence of NNM between cohorts. Nevertheless, some particularities of the cities were found. In the RP cohort, associations were observed between factors of the more distal levels, such as skin color, education level and marital status, and NNM. Similarly, in SL, skin color, marital status and maternal age were associated with the outcome. On the other hand, in PEL, proximal factors were more significant for the occurrence of NNM. In general, healthcare-related variables, particularly prenatal care, were determinant in all cohorts.

Table 3. Characterization of the sample according to neonatal near miss (NNM) classification. RPS birth cohorts.

	Ribeirão Preto				São Luís				Pelotas 2004				Pelotas 2015			
		NMN				NMN				NMN				NMN		
	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value
Newborn sex				0.495				0.659				0.163				0.233
Female	3,769 (50.7)	3,652 (96.9)	117 (3.1)		2,422 (49.0)	2,331 (96.2)	91 (3.8)		1,960 (48.1)	1,903 (97.1)	57 (2.9)		2,029 (49.3)	1,974 (97.3)	55 (2.7)	
Male	3,668 (49.3)	3,564 (97.2)	104 (2.8)		2,525 (51.0)	2,424 (96.0)	101 (4.0)		2,113 (51.9)	2,035 (96.3)	78 (3.7)		2,091 (50.7)	2,021 (96.6)	70 (3.4)	
Skin color				<0.001				0.027				0.276				0.107
White	4,305 (58.9)	4,210 (97.8)	95 (2.2)		913 (18.7)	888 (97.3)	25 (2.7)		2,491 (62.5)	2,418 (97.1)	73 (2.9)		2,913 (71.2)	2,831 (97.2)	82 (2.8)	
Black	708 (9.7)	674 (95.2)	34 (4.8)		626 (12.8)	592 (94.6)	34 (5.4)		661 (16.6)	634 (95.9)	27 (4.1)		646 (15.8)	627 (97.1)	19 (2.9)	
Brown	2,296 (31.4)	2,209 (96.2)	87 (3.8)		3,337 (68.4)	3,205 (96.0)	132 (4.0)		835 (20.9)	805 (96.4)	30 (3.6)		530 (13.0)	506 (95.5)	24 (4.5)	
Maternal years of schooling				<0.001				0.088				0.001				0.050
≥12	1,687 (22.8)	1,663 (98.6)	24 (1.4)		750 (15.2)	724 (96.5)	26 (3.5)		412 (10.2)	405 (98.3)	7 (1.7)		1,276 (31.0)	1,249 (97.9)	27 (2.1)	
9 to 11	3,794 (51.2)	3,681 (97.0)	113 (3.0)		2,814 (56.9)	2,713 (96.4)	101 (3.6)		1,347 (33.4)	1,316 (97.7)	31 (2.3)		1,406 (34.1)	1,361 (96.8)	45 (3.2)	
≤8	1,924 (26.0)	1,844 (95.8)	80 (4.2)		1,383 (28.0)	1,318 (95.3)	65 (4.7)		2,275 (56.4)	2,178 (95.7)	97 (4.3)		1,437 (34.9)	1,384 (96.3)	53 (3.7)	
Socioeconomic class				0.017				0.500				0.029				0.060
A and B	3,221 (46.2)	3,145 (97.6)	76 (2.4)		903 (19.4)	875 (96.9)	28 (3.1)		567 (17.8)	559 (98.6)	8 (1.4)		1,218 (30.6)	1,190 (97.7)	28 (2.3)	
C	3,048 (43.7)	2,960 (97.1)	88 (2.9)		2507 (53.8)	2410 (96.1)	97 (3.9)		1,109 (34.8)	1,079 (97.3)	30 (2.7)		1,984 (49.8)	1,925 (97.0)	59 (3.0)	
D and E	699 (10.1)	669 (95.7)	30 (4.3)		1,246 (26.8)	1196 (96.0)	50 (4.0)		1,512 (47.4)	1,458 (96.4)	54 (3.6)		779 (19.6)	747 (95.9)	32 (4.1)	
Marital status				<0.001				0.001				0.932				0.050
With a partner	6,430 (86.5)	6,268 (97.5)	162 (2.5)		4,001 (80.9)	3,863 (96.5)	138 (3.5)		3,420 (84.0)	3,307 (96.7)	113 (3.3)		3,538 (85.9)	3,438 (97.2)	100 (2.8)	
Without a partner	1,004 (13.5)	946 (94.2)	58 (5.8)		946 (19.1)	892 (94.3)	54 (5.7)		653 (16.0)	631 (96.6)	22 (3.4)		581 (14.1)	556 (95.7)	25 (4.3)	
Maternal age (years)				0.525				0.005				0.025				0.415
20-34	5,551 (74.6)	5,392 (97.1)	159 (2.9)		3,647 (73.7)	3,520 (96.5)	127 (3.5)		2,758 (67.7)	2,670 (96.8)	88 (3.2)		2,911 (70.7)	2,824 (97.0)	87 (3.0)	
<20	962 (12.9)	928 (96.5)	34 (3.5)		922 (18.6)	869 (94.2)	53 (5.8)		770 (18.9)	734 (95.3)	36 (4.7)		608 (14.8)	585 (96.2)	23 (3.8)	
≥35	924 (12.4)	896 (97.0)	28 (3.0)		378 (7.6)	366 (96.8)	12 (3.2)		543 (13.3)	532 (98.0)	11 (2.0)		600 (14.6)	585 (97.5)	15 (2.5)	

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Table 3. Characterization of the sample according to neonatal near miss (NNM) classification. RPS birth cohorts.

	Ribeirão Preto				São Luís				Pelotas 2004				Pelotas 2015			
		NMN				NMN				NMN				NMN		
	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value	Total N (%)	No N (%)	Yes N (%)	P-value
Smoking during pregnancy				0.001				0.375				0.016				0.670
No	6,569 (88.4)	6,395 (97.3)	174 (2.7)		4,750 (96.0)	4,568 (96.2)	182 (3.8)		2,963 (72.7)	2,877 (97.1)	86 (2.9)		3,441 (83.6)	3,344 (97.2)	97 (2.8)	
Yes	863 (11.6)	820 (95.0)	43 (5.0)		197 (4.0)	187 (94.9)	10 (5.1)		1,110 (27.3)	1,061 (95.6)	49 (4.4)		676 (16.4)	648 (95.9)	28 (4.1)	
Gestational hypertension				<0.001				0.060				<0.001				0.060
No	6,492 (87.6)	6,331 (97.5)	161 (2.5)		4,134 (83.6)	3,983 (96.3)	151 (3.7)		3,099 (76.2)	3,023 (97.6)	76 (2.4)		3,085 (74.9)	3,000 (97.2)	85 (2.8)	
Yes	922 (12.4)	867 (94.0)	55 (6.0)		812 (16.4)	771 (94.9)	41 (5.1)		966 (23.8)	908 (94.0)	58 (6.0)		1,032 (25.1)	992 (96.1)	40 (3.9)	
Parity				0.320				0.301				0.164				0.974
2-4	3,500 (47.1)	3,400 (97.1)	100 (2.9)		2,416 (48.8)	2,329 (96.4)	87 (3.6)		2,056 (50.5)	1,995 (97.0)	61 (3.0)		1,904 (46.2)	1,846 (97.0)	58 (3.0)	
1	3,696 (49.7)	3,586 (97.0)	110 (3.0)		2,366 (47.8)	2,265 (95.7)	101 (4.3)		1,619 (39.8)	1,555 (96.1)	64 (3.9)		2,064 (50.1)	2,002 (97.0)	62 (3.0)	
≥5	241 (3.2)	230 (95.4)	11 (4.6)		165 (3.3)	161 (97.6)	4 (2.4)		397 (9.7)	387 (97.5)	10 (2.5)		150 (3.6)	145 (96.7)	5 (3.3)	
Prenatal care				<0.001				0.007				0.005				<0.001
Yes	7,343 (98.8)	7,137 (97.2)	206 (2.8)		4,863 (98.3)	4,679 (96.2)	184 (3.8)		4,010 (98.5)	3,881 (96.8)	129 (3.2)		4,025 (97.7)	3,912 (97.2)	113 (2.8)	
No	90 (1.2)	77 (85.6)	13 (14.4)		84 (1.7)	76 (90.5)	8 (9.5)		62 (1.5)	56 (90.3)	6 (9.7)		95 (2.3)	83 (87.4)	12 (12.6)	
Type of delivery				0.536				0.138				0.098				0.351
Vaginal	3,078 (41.4)	2,991 (97.2)	87 (2.8)		2,601 (52.6)	2,490 (95.7)	111 (4.3)		2,245 (55.1)	2,180 (97.1)	65 (2.9)		1,453 (35.3)	1,404 (96.6)	49 (3.4)	
Cesarean	4,359 (58.6)	4,225 (96.9)	134 (3.1)		2,346 (47.4)	2,265 (96.6)	81 (3.4)		1,828 (44.9)	1,758 (96.2)	70 (3.8)		2,666 (64.7)	2,590 (97.1)	76 (2.9)	
Childbirth care				< 0.001				0.048				<0.001				<0.001
Health insurance/ private	3,288 (44.3)	3,231 (98.3)	57 (1.7)		795 (16.1)	774 (97.4)	21 (2.6)		776 (19.1)	769 (99.1)	7 (0.9)		1,264 (31.7)	1,252 (99.1)	12 (0.9)	
Public	4,143 (55.7)	3,983 (96.1)	160 (3.9)		4,151 (83.9)	3,980 (95.9)	171 (4.1)		3,292 (80.9)	3,164 (96.1)	128 (3.9)		2,728 (68.3)	2,621 (96.1)	107 (3.9)	

Source: Authors.

Black skin color in RP and SL and brown skin color in RP and PEL15 were associated with NNM. Few Brazilian studies have investigated the effect of skin color on NNM[6-8]. For decades, studies have drawn attention to the apparent disadvantage of children born to black and brown women in terms of health indicators[15,16]. In a study conducted in Pelotas in 1993, Barros *et al.*[15] observed a higher frequency of preterm birth, low birthweight, and neonatal and infant mortality associated with black skin color. These findings can largely be explained by socioeco-

Table 4. Unadjusted logistic regression analysis of the association between covariates and neonatal near miss in the RPS birth cohorts.

	Ribeirão Preto 2010	São Luís 2010	Pelotas 2004	Pelotas 2015
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Level 1 - Sociodemographic				
Skin color				
White	1	1	1	1
Black	2.23 (1.49-3.33)	2.04 (1.20-3.45)	1.41 (0.84-2.21)	1.04 (0.63-1.73)
Brown	1.74 (1.29-2.34)	1.46 (0.94-2.25)	1.23 (0.80-1.90)	1.63 (1.02-2.60)
Maternal years of schooling				
≥12	1	1	1	1
9 to 11	2.12 (1.36-3.31)	1.03 (0.68-1.60)	1.36 (0.59-3.11)	1.52 (0.94-2.47)
≤8	3.01 (1.89-4.77)	1.37 (0.86-2.18)	2.57 (1.18-5.58)	1.77 (1.10-2.83)
Socioeconomic class				
A/B	1	1	1	1
C	1.23 (0.90-1.67)	1.25 (0.82-1.92)	1.94 (0.88-4.26)	1.30 (0.82-2.05)
D/E	1.85 (1.20-2.85)	1.30 (0.81-2.09)	2.58 (1.22-5.47)	1.82 (1.08-3.05)
Level 2 - Lifestyle and reproductive profile				
Marital status				
Married/Consensual union	1	1	1	1
Without a partner	2.37 (1.74-3.23)	1.69 (1.22-2.34)	1.02 (0.64-1.62)	1.54 (0.99-2.41)
Maternal age (years)				
20-34	1	1	1	1
<20	1.24 (0.85-1.81)	1.69 (1.21-2.34)	1.48 (1.00-2.21)	1.27 (0.79-2.03)
≥35	1.05 (0.70-1.59)	0.90 (0.49-1.65)	0.62 (0.33-1.18)	0.83 (0.47-1.45)
Smoking during pregnancy				
No	1	1	1	1
Yes	1.92 (1.36-2.71)	1.34 (0.69-2.57)	1.54 (1.08-2.20)	1.48 (0.97-2.28)
Gestational hypertension				
No	1	1	1	1
Yes	2.49 (1.82-3.41)	1.40 (0.98-1.99)	2.54 (1.79-3.60)	1.42 (0.97-2.08)
Parity				
2-4	1	1	1	1
1	1.04 (0.79-1.37)	1.19 (0.89-1.59)	1.34 (0.94-1.92)	0.98 (0.68-1.41)
≥5	1.62 (0.86-3.07)	0.66 (0.24-1.83)	0.84 (0.42-1.66)	1.09 (0.43-2.77)
Level 3 - Healthcare				
Prenatal care				
Yes	1	1	1	1
No	5.84 (3.19-10.7)	2.67 (1.27-5.62)	3.22 (1.36-7.61)	5.00 (2.65 - 9.43)
Type of delivery				
Vaginal	1	1	1	1
Cesarean	1.09 (0.83-1.43)	0.80 (0.59-1.07)	1.33 (0.94-1.88)	0.84 (0.58-1.21)
Childbirth care				
Health insurance/private	1	1	1	1
Public	2.28 (1.68-3.09)	1.58 (1.00-2.50)	4.44 (2.07-9.55)	4.26 (2.34-7.76)

Source: Authors.

nomic inequality and the poor quality of prenatal care. Similarly, no association was observed in the present study between brown skin color and NNM when the analysis was adjusted for the other sociodemographic variables in PEL15. In contrast, in RP and SL, the data suggest that

Table 5. Hierarchical analysis of the variables associated with neonatal near miss in the RPS birth cohorts.

	Ribeirão Preto 2010	São Luís 2010	Pelotas 2004	Pelotas 2015
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Level 1 - Sociodemographic				
Skin color				
White	1	1		
Black	1.98 (1.27-3.09)	1.77 (1.02-3.08)		
Brown	1.59 (1.14-2.22)	1.31 (0.84-2.07)		
Maternal years of schooling				
≥12	1			
9 to 11	1.95 (1.20-3.18)			
≤8	2.44 (1.40-4.27)			
Socioeconomic class				
A/B			1*	
C			1.74 (0.73-4.13)	
D/E			2.18 (0.88-5.39)	
Level 2 - Lifestyle and reproductive profile				
Marital status				
Married/Consensual union	1	1	1*	1*
Without a partner	2.02(1.45-2.82)	1.52 (1.09-2.13)	0.53 (0.26-1.07)	1.45 (0.91-2.30)
Maternal age (years)				
20-34		1		
<20		1.59 (1.11-2.26)		
≥35		0.94(0.51-1.74)		
Smoking during pregnancy				
No	1			1*
Yes	1.62 (1.12-2.33)			1.41 (0.90-2.20)
Gestational hypertension				
No	1	1*	1	1*
Yes	2.39 (1.73-3.30)	1.42 (0.99-2.03)	3.00 (1.96-4.58)	1.45 (0.98-2.13)
Level 3 - Healthcare				
Prenatal care				
Yes	1	1	1	1
No	4.27 (2.16-8.45)	2.32 (1.09-4.94)	4.79 (1.59-14.46)	5.10 (2.60-9.97)
Type of delivery				
Vaginal	1			
Cesarean	1.97 (1.42-2.73)			
Childbirth care				
Health insurance/private	1		1	1
Public	2.04 (1.36-3.04)		2.66 (1.09-6.54)	4.31 (2.28-8.12)

*p-value<0.20 - added to the next level's set of variables.

Source: Authors.

sociodemographic factors other than maternal education and socioeconomic class could explain the association between skin color and NNM.

Mothers without a partner from RP and SL were more likely to have NNM. Different studies have demonstrated higher odds of behavioral problems and risk habits for the fetus in pregnant women without a partner. The lack of a partner has been associated with a higher prevalence of depression, stress and anxiety during pregnan-

cy[17], increased consumption of illicit drugs[18], and inadequate prenatal care[19], factors that may result in a lower birthweight of the child, preterm birth or congenital malformations, which would be indicators of NNM. On the other hand, Shah *et al.*[20] emphasized that the effect of marital status on perinatal outcomes may vary according to local customs and is less pronounced in regions where mothers without a partner are more welcomed and accepted by society.

In RP, low maternal education level was associated with NNM, even after adjusting for skin color and the other variables of the sociodemographic level. Although the present data do not allow to identify the reasons why this association was only observed in RP, a low education level has historically been recognized as a determinant factor for outcomes such as infant mortality[21] and intrauterine growth restriction[22] in the city.

Smoking during pregnancy was associated with NNM in RP. Several lines of evidence indicate the negative impact of smoking during pregnancy on the fetus[23-25]. The adverse outcomes include a lower birthweight, intrauterine growth restriction, preterm birth, and congenital malformations[25], which could explain the association with NNM observed in the present study. The lack of an association between tobacco consumption and NNM in SL might be explained by the low prevalence of smoking observed in this city compared to the other cohorts[26]. Furthermore, the association between smoking during pregnancy and NNM did not persist in PEL04 when the analysis was adjusted for socioeconomic class and marital status. In the PEL15 cohort, a reduction of approximately 11 percentage points in tobacco consumption was observed compared to the PEL04 cohort, which could explain the lack of association between smoking and NNM.

Gestational hypertension was associated with NNM in RP and PEL04, in agreement with the study of Pereira *et al.*[6] which demonstrated double the risk of NNM among women with hypertensive syndrome. According to the authors, although the etiology of hypertensive syndrome is not fully understood, its effects have been associated with neonatal outcomes that compose the criteria of NNM, including birth at less than 32 weeks, low birthweight[27] and a low Apgar score[28]. In the present study, gestational hypertension was self-reported by the mother and neither the onset nor chronicity of the disease was considered, a fact that may explain the variation in the prevalence of hypertension (12.4% in RP and 25.1% in PEL15), as well as the differences in the effect of hypertension on NNM between cohorts.

Younger mothers (<20 years) from SL were more likely to have NNM. These findings corroborate previous studies conducted in the city that found higher frequencies of perinatal adversities among adolescent mothers, often associated with poor socioeconomic and reproduction conditions and inadequate prenatal care[29,30].

In all cohorts, the odds of NNM were higher among pregnant women who did not receive prenatal care. Although prenatal care is practically universal in Brazil, lower coverage is more common in socially vulnerable groups[31,32]. According to Viellas *et al.*[32], being indigenous or black, living without a partner, adolescent age and a low educational level are some of the characteristics associated with low maternity coverage and late initiation of care. Therefore, public policies that encourage and guarantee access to prenatal care, especially for more vulnerable pregnant women, are essential to minimize the risks of adversity during the pregnancy-puerperal period.

Cesarean delivery was associated with NNM in RP after hierarchical adjustment, in agreement with the results of previous studies[5-8]. According to Silva *et al.*[7] and Pereira *et al.*[6], maternal-fetal complications that would require the termination of pregnancy to protect the health of the mother or fetus are usually a therapeutic indication of cesarean delivery. Thus, the route of delivery would not be the cause of NNM but rather an intervention measure. However, the authors emphasized that, for confirmation of this hypothesis, it would be necessary to identify and distinguish therapeutic from elective cesarean sections when performed without clinical justification. Within this context, Barros *et al.*[33] stated that, although the cesarean delivery rate has increased over the last years in all socioeconomic classes in Pelotas, 90% of women in the wealthiest quintile had a cesarean delivery in PEL15, with 93.9% of these deliveries occurring in the private sector. Such rates are difficult to explain by clinical reasons and are probably associated with elective cesarean deliveries, possibly obscuring the association of therapeutic cesarean delivery with NNM in some cohorts.

Neonatal near miss was more common among women receiving childbirth care in the public sector. However, according to Silva *et al.*[5], this result does not necessarily reflect the quality of care since cases of high-risk pregnancies are more prevalent in vulnerable populations that more frequently use public hospitals. Within this context, the authors highlight that NNM is not a good indicator for assessing the quality of childbirth care when severity is not considered a confounding factor.

Some limitations of this study should be addressed, such as the use of self-reported measures for obtaining the covariates, a fact that may have resulted in information bias. However, these variables were collected within the first 24 hours after birth using a standardized questionnaire, which was applied by a field team duly trained by the coordinators of the respective research centers in order to reduce possible errors. Also, the information about congenital malformations obtained with a questionnaire may be considered inaccurate. However, Silva *et al.*[5] reported malformation to be a variable associated with a high risk of neonatal death. Another limitation is the difference in the sampling period between the RP and SL cohorts and the two PEL cohorts. However, there were no differences in the prevalence of NNM between cohorts and the sociodemographic effects on the outcome vary even between cohorts started at the same time (RP and SL). In addition, the factors associated with NNM in the two PEL cohorts were relatively similar, although there was an interval of 11 years between the start of the cohorts.

The strengths of this research include the population-based design of the studies, the high methodological rigor, and the similarity of all data collection procedures. In addition, to our knowledge, this is the first study that analyzes factors associated with NNM in cohorts followed up in cities located in different regions of Brazil using a similar methodology. Furthermore, the hierarchical analysis used in this study allows to determine the interrelationship of factors of different levels associated with NNM, as suggested by Pereira *et al.*[6].

In conclusion, black and brown skin color, having no partner, smoking during pregnancy, gestational hypertension, and healthcare-related factors (particularly receiving no prenatal care) are associated with higher odds of NNM. Therefore, these factors must be considered when elaborating, updating or improving public policies and care strategies for pregnant women aimed at reducing NNM cases.

Collaborations

PRH Rocha, MA Barbieri and H Bettiol worked on the conception and design of the study. PRH Rocha, MA Barbieri, H Bettiol, G Bazo, RC Cavalli, AAM Silva, LYG Aristizábal, SC Confortin, VMF Simões, A Matijasevich, IS Santos and MF Silveira worked on the data analysis and interpretation, writing of the study, and critical revision. All authors approved the submitted final version of the manuscript.

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References

1. Say L. Neonatal near miss: A potentially useful approach to assess quality of newborn care. *J Pediatr* 2010; 86(1):1-2.
2. Santos JP, Pileggi-Castro C, Camelo JS, Silva AA, Duran P, Serruya SJ, Cecatti JG. Neonatal near miss: A systematic review. BMC Pregnancy and Childbirth. *BMC Pregnancy Childbirth* 2015; 15(1):1-10.
3. Avenant T. Neonatal near miss: a measure of the quality of obstetric care. *Best Pract Res Clin Obstet Gynaecol* 2009; 23(3):369-374.
4. Kale PL, Jorge MHPM, Laurenti R, Fonseca SC, Silva KS. Pragmatic criteria of the definition of neonatal near miss: a comparative study. *Rev Saude Publica* 2017; 51:111.
5. Silva AAM, Leite ÁJM, Lamy ZC, Moreira MEL, Gurgel RQ, Cunha AJLA, Leal MC. Morbidade neonatal near miss na pesquisa Nascer no Brasil. *Cad Saude Publica* 2014; 30(Supl. 1):1-10.
6. Pereira TG, Rocha DM, Fonseca VM, Moreira MEL, GamaI SGN. Fatores associados ao near miss neonatal no Brasil. *Rev Saude Publica* 2020; 54:123.
7. 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.
8. Kale PL, Mello-Jorge MHP, Silva KS, Fonseca SC. Casos de near miss e óbitos neonatais: Fatores associados aos recém-nascidos com ameaça à vida em seis maternidades do Sudeste do Brasil. *Cad Saude Publica* 2017; 33(4):1-12.
9. Brasil DRPA, Rodrigues Vilela MB, França KEX, Sarinho SW. Neonatal morbidity near miss in Tertiary hospitals in a capital of Northeast Brazil. *Rev Paulista Pediatr* 2019; 37(3):275-282.
10. Confortin SC, Ribeiro MRC, Barros AJD, Menezes AMB, Horta BL, Victora CG, Barros FC, Gonçalves H, Bettiol H, Santos IS, Barbieri MA, Saraiva MCP, Alves MTSSB, Silveira MF, Domingues MR, Lima NP, Rocha PRH, Cavalli RC, Batista RFL, Cardoso VC, Simões VMF, Silva AAM. RPS Brazilian Birth Cohorts Consortium (Ribeirão Preto, Pelotas and São Luís): history, objectives and methods. *Cad Saude Publica* 2021; 37(4):e00093320.
11. Barros AJD, Santos IS, Victora CG, Albernaz EP, Domingues MR, Timm IK, Matijasevich A, Bertoldi AD, Barros FC. Coorte de nascimentos de Pelotas, 2004: metodologia e descrição. *Rev Saude Publica* 2006; 40(3):402-413.
12. Hallal PC, Bertoldi AD, Domingues MR, Silveira MF, Demarco FF, Silva ICM, Barros FC, Victora CG, Bassani DG. Cohort profile: The 2015 Pelotas (Brazil) birth cohort study. *Int J Epidemiol* 2018; 47(4):1048-1048H.
13. Silva AAM, Simões VMF, Barbieri MA, Cardoso VC, Alves CMC, Thomaz EBAF, Queiroz RCS, Cavalli RC, Batista RFL, Bettiol H. A protocol to identify non-classical risk factors for preterm births: The Brazilian Ribeirão Preto and São Luís prenatal cohort (BRISA). *Reprod Health* 2014; 11(1):79.
14. Associação Brasileira de Empresas de Pesquisa (ABEP). *Critério Brasil. Critério Brasil 201 e Atualização da Distribuição de Classes para 2016*. São Paulo: ABEP; 2016.

15. Barros FC, Victora CG, Horta BL. Ethnicity and infant health in Southern Brazil. A birth cohort study. Int J Epidemiol 2001; 30(5):1001-1008.
16. Silva LM, Silva RA, Silva AAM, Bettiol H, Barbieri MA. Racial inequalities and perinatal health in the southeast region of Brazil. *Braz J Med Biol Res* 2007; 40(9):1187-1194.
17. Biaggi A, Conroy S, Pawlby S, Pariante CM. Identifying the women at risk of antenatal anxiety and depression: A systematic review. J Affect Disord 2016; 191:62-77.
18. Rocha PC, Alves MTSSB, Chagas DC, Silva AAM, Batista RFL, Silva RA. Prevalência e fatores associados ao uso de drogas ilícitas em gestantes da coorte BRISA TT. *Cad Saude Publica* 2016; 32(1):e00192714.
19. Alves E, Silva S, Martins S, Barros H. Family structure and use of prenatal care. *Cad Saude Publica* 2015; 31(6):1298-1304.
20. Shah PS, Zao J, Ali S. Maternal marital status and birth outcomes: A systematic review and meta-analyses. *Maternal Child Health J* 2011; 15(7):1097-1109.
21. Goldani MZ, Barbieri MA, Rona RJ, Silva AAM, Bettiol H. Increasing pre-term and low-birthweight rates over time and their impact on infant mortality in South-East Brazil. *J Biosoc Sci* 2004; 36(2):177-188.
22. Aragão VMF, Barbieri MA, Silva AAM, Bettiol H, Ribeiro VS. Risk factors for intrauterine growth restriction: A comparison between two Brazilian cities. *Pediatr Res* 2005; 57(5 I):674-679.
23. Hackshaw A, Rodeck C, Boniface S. Maternal smoking in pregnancy and birth defects: A systematic review based on 173 687 malformed cases and 11.7 million controls. *Hum Reprod Update* 2011; 17(5):589-604.
24. Dwyer JB, Broide RS, Leslie FM. Nicotine and brain development. *Birth Defects Res C Embryo Today* 2008; 84(1):30-44.
25. Rogers JM. Tobacco and pregnancy. *Reprod Toxicol* 2009; 28(2):152-160.
26. Mola CL, Cardoso VC, Batista R, Gonçalves H, Saraiva MCP, Menezes AMB, Santos IS, Domingues MR, Silva AAM, Bettiol H, Alves MTSSB, Barbieri MA, Barros A, Horta BL. Maternal pregnancy smoking in three Brazilian cities: trends and differences according to education, income, and age. *Int J Public Health* 2020; 65(2):207-215.
27. Ferrazzani S, Luciano R, Garofalo S, D'Andrea V, De Carolis S, De Carolis MP, Paolucci V, Romagnoli C, Caruso A. Neonatal outcome in hypertensive disorders of pregnancy. *Early Hum Develop* 2011; 87(6):445-449.
28. Law A, McCoy M, Lynen R, Curkendall SM, Gatwood J, Juneau PL, Landsman-Blumberg P. The prevalence of complications and healthcare costs during pregnancy. *J Med Econ* 2015; 18(7):533-541.
29. Figuerêdo ED, Lamy Filho F, Lamy ZC, Silva AAM. Maternal age and adverse perinatal outcomes in a birth cohort (BRISA) from a Northeastern Brazilian city. *Rev Bras Ginecol Obstet* 2014; 36(12):562-568.
30. Simões VMF, Silva AAM, Bettiol H, Lamy-Filho F, Tonial SR, Mochel EG. Características da gravidez na adolescência em São Luís, Maranhão. *Rev Saude Publica* 2003; 37(5):559-565.
31. Leal MC. Prenatal care in Brazil. *Cad Saude Publica* 2014; 30:S1-S15.
32. Viellas EF, Domingues RMSM, Dias MAB, Gama SGND, Theme Filha MM, Costa JV, Bastos MH, Leal MDC. Assistência pré-natal no Brasil. *Cad Saude Publica* 2014; 30:S85-S100.
33. Barros AJD, Victora CG, Horta BL, Wehrmeister FC, Bassani D, Silveira MF, Santos LP, Blumenberg C, Barros FC. Antenatal care and caesarean sections: Trends and inequalities in four population-based birth cohorts in Pelotas, Brazil, 1982-2015. *Int J Epidemiol* 2019; 48:I37-I45.

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