# Neonatal near miss in the *Birth in Brazil* survey

## Morbidade neonatal *near miss* na pesquisa *Nascer no Brasil*

## Morbilidad neonatal *near miss* en la encuesta *Nacer en Brasil*

*Antônio Augusto Moura da Silva* [1]
*Álvaro Jorge Madeiro Leite* [2]
*Zeni Carvalho Lamy* [1]
*Maria Elisabeth Lopes Moreira* [3]
*Ricardo Queiroz Gurgel* [4]
*Antonio José Ledo Alves da Cunha* [5]
*Maria do Carmo Leal* [6]

[1] *Centro de Ciências da Saúde, Universidade Federal do Maranhão, São Luis, Brasil.*
[2] *Faculdade de Medicina, Universidade Federal do Ceará, Fortaleza, Brasil.*
[3] *Instituto Nacional de Saúde da Mulher, da Criança e do Adolescente Fernandes Figueira, Fundação Oswaldo Cruz, Rio de Janeiro, Brasil.*
[4] *Centro de Ciências Biológicas e da Saúde, Universidade Federal de Sergipe, Aracaju, Brasil.*
[5] *Reitoria, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.*
[6] *Escola Nacional de Saúde Pública Sergio Arouca, Fundação Oswaldo Cruz, Rio de Janeiro, Brasil.*

**Correspondence**
*A. A. M. Silva*
*Departamento de Saúde Pública, Centro de Ciências da Saúde, Universidade Federal do Maranhão.*
*Rua Barão do Itapary 155, São Luis, MA 65020-070, Brasil.*
*aamouradasilva@gmail.com*

### Abstract

*This study used data from the* Birth in Brazil *survey, a nationwide hospital-based study of 24,197 postpartum women and their newborns, collected between February 2011 and July 2012. A three-stage cluster sampling design (hospitals, days, women) was used consisting of stratification by geographic region, type of municipality (capital or non-capital), and type of hospital financing. Logistic regression was used to identify variables that were potential predictors of neonatal mortality and neonatal near miss indicators. After testing nineteen variables, five were chosen to compose a set of neonatal near miss indicators (birth weight of less than 1,500g, Apgar score of less than 7 in the 5th minute of life, use of mechanical ventilation, gestational age of less than 32 weeks and congenital malformations). The neonatal near miss rate in the Birth in Brazil survey was 39.2 per thousand live births, three and a half times higher than the neonatal mortality rate (11.1 per thousand). These neonatal near miss indicators were able to identify situations with a high risk of neonatal death.*

*Maternal and Child Health; Infant Mortality; Low Birth Weight Infant; Parturition*

### Resumo

*Dados da pesquisa* Nascer no Brasil*, um estudo nacional de base hospitalar, incluindo 24.197 puérperas e seus recém-nascidos, de fevereiro de 2011 a julho de 2012, foram utilizados para construir um indicador de morbidade neonatal near miss. Foi utilizada amostragem por conglomerados em três estágios (hospitais, dias, mulheres), estratificada por macrorregião, tipo de município (capital ou interior) e tipo de financiamento hospitalar. Modelos de regressão logística foram utilizados para identificar as variáveis que poderiam predizer a mortalidade neonatal e compor o indicador neonatal near miss. Após serem testadas 19 variáveis, cinco foram escolhidas (peso ao nascer < 1.500g, Apgar no 5º minuto de vida < 7, uso de ventilação mecânica, idade gestacional < 32 semanas e relato de malformações congênitas). A taxa de morbidade neonatal near miss na pesquisa* Nascer no Brasil *foi de 39,2 por mil nascidos vivos, três vezes e meia a taxa de mortalidade neonatal (11,1 por mil). O indicador de morbidade neonatal near miss foi capaz de identificar situações com alto risco de morte neonatal.*

*Saúde Materno-Infantil; Mortalidade Infantil; Recém-Nascido de Baixo Peso; Parto*

## Introduction

A neonatal near miss is considered a morbid event that nearly results in newborn death within 28 days postpartum. However, there is currently no standard definition for neonatal near miss [1]. This term is analogous to the maternal near miss concept in which three types of criteria (clinical, laboratory and management) are used to determine organ dysfunction or failure [2,3].

The advantage of using this concept is that the number of survivors of severe disease (near miss or near death) is three to six times greater than the number of deaths. In Brazil, the neonatal mortality rate in 2010 was 11.1 deaths per 1,000 live births (Ministério da Saúde. Indicadores e Dados Básicos – Brasil – 2011. IDB-2011. http://tabnet.datasus.gov.br/cgi/idb2011/matriz.htm, accessed on 13/Jun/2013). It is estimated that the neonatal near miss rate was approximately 45 per 1,000 live births, four times higher than the neonatal mortality rate.

In Brazil, the infant mortality rate was 14 per 1,000 live births in 2011 [4] and the country has therefore already achieved the Millennium Development Goal of reducing infant mortality by two thirds, or 17.5 deaths per 1,000 live births, by 2015 [5]. However, the pace of reductions in the neonatal mortality rate has proved to be slower [4]. The use of the neonatal near miss concept can be an important tool for determining risk factors associated with death and evaluating health services [6].

Avenant [1] proposed a set of neonatal near miss indicators composed of respiratory failure/dysfunction (present in 63% of cases), infections (present in 23% of cases) and central nervous system failure/dysfunction (diagnosed in 5% of cases). The challenge of determining effective neonatal near miss indicators lies in the fact that these conditions are rarely diagnosed and/or effectively registered in medical records, especially in low and middle-income countries [7].

Based on data from the 2005 WHO Global Survey on Maternal and Perinatal Health in Brazil, Pileggi et al. [8] used the following set of neonatal near miss indicators: very low birth weight (< 1,500g), gestational age of less than 30 weeks and/or an Apgar score of less than 7 in the 5th minute of life. The study found an early neonatal mortality rate of 8.2 deaths per 1,000 live births, while the neonatal near miss rate was 21.4 per 1000 live births, with a sensitivity of 82.6%, specificity of 97.9% and positive likelihood ratio of 37.

The objectives of the present study are to define a set of neonatal near miss indicators based on data from the *Birth in Brazil* survey and evaluate their discriminatory power to predict neonatal mortality, and analyze the association between neonatal near miss rates and specific demographic, socioeconomic and health service variables.

## Methods

Details of the methods used have been published elsewhere [9]. The study used data from the *Birth in Brazil* survey, a nationwide hospital-based cohort study of postpartum women and their newborns carried out between February 2011 and October 2012. A follow-up telephone interview regarding maternal and neonatal outcomes was conducted 45 days after birth.

The study used three-stage cluster sampling which consisted of stratifying hospitals by geographic region (North, Northeast, Southeast, South and Central), type of municipality (state capital or non-capital), and by type of hospital (public, private or mixed). Hospitals that recorded ≥ 500 annual births were eligible for inclusion in the first stage: 1,403 hospitals out of a total of 3,961 were included in the sampling frame which accounted for 78.6% of all births in 2007 [9]. The final sample included 266 hospitals.

Stillbirths weighing ≥ 500g and/or with a gestational age of less than 22 weeks, and all liveborns were eligible for inclusion in the third stage. In each of the sampled hospitals 90 puerperae were selected for interview. In hospitals with less than 12 births per day mothers were consecutively included, while in hospitals with a larger number of births women were randomly selected from the admissions list on each day of the week, including weekends and holidays. Sampling design is detailed in Vasconcellos et al. [10].

The total number of newborns in the sample was 24,197 (including liveborns and stillbirths) distributed across 191 municipalities throughout Brazil. For this analysis, Stillbirths (n = 118) and newborns without information on death (n = 18) were excluded, resulting in a final sample of 24,061.

Two electronic questionnaires were applied: one via a baseline face-to-face postnatal interview and one through a follow-up telephone interview were conducted before six months and at twelve months after birth to address maternal and newborn outcomes. Another questionnaire was completed using information from the patients' medical records. This questionnaire was completed after the patient was discharged from hospital or, in the case of patients that remained in hospital, after 42 days and 28 days after birth for mothers and newborns, respectively. Detailed information about data

collection is reported by do Carmo Leal et al. [9]. Neonatal deaths were informed at the hospital or through the follow-up telephone interview. A crosscheck was made between data from the Mortality Information System (SIM) and Birth in Brazil data resulting in the inclusion of an additional 65 neonatal deaths. The following identifiers were paired using the probabilistic record linkage method: mother's name, date of birth, date of death and newborn's gender. This procedure was carried out in three steps: record standardization, blocking, and record matching. Peers were classified based on the concept of threshold scores: pairs with a score above the upper threshold were classified as true; those with a score below the lower threshold were considered false pairs; and those with scores between the two thresholds were considered doubtful and reviewed manually. Analysis was carried out using the RecLink program [11]. Part of the explanatory variable data related to the linked pairs was extracted from the Information System on Live Birth (SINASC).

Logistic regression was used to identify possible predictors of neonatal mortality and neonatal near miss indicators. The following variables, obtained from patients' medical records, were used as possible predictors of neonatal death: an Apgar score of less than 7 in the 5th minute of life; gestational age based on the last menstrual period, obstetric ultrasonography and obstetric and neonatal estimation (≤ 32, 33-36, and ≥ 37 weeks) [12]; birth weight (< 1,500g, 1,500g-2,499g, and ≥ 2,500g); multiple births; use of mechanical ventilation any time after birth; use of supplemental oxygen after birth; admission to the neonatal intensive care unit; use of continuous positive airway pressure; intubation in the delivery room; cardiac massage; use of resuscitation drugs; the use of phototherapy in the first 72 hours of life; surfactant and antibiotic administration in the first 48 hours of life; congenital malformation reported by the attending physician; convulsions; neonatal respiratory diseases (transient tachypnea, hyaline membrane disease, pulmonary hypertension and meconium aspiration syndrome); hypoglycemia or necrotizing enterocolitis.

Odds ratios (OR) were calculated to measure the association between these risk factors and neonatal death: variables with a p-value of less than 0.20 were included in the multivariable analysis. Collinear variables were evaluated using the variance inflation factor whereby the variable with the lowest p-value was selected. Variables with a p-value of less than 0.10 after the multivariable analysis were maintained in the final model. Newborns that presented at least one of the predictors selected for multivariable analysis and survived the neonatal period were considered neonatal near miss cases.

Sensitivity, specificity, positive and negative predictive values, and the positive likelihood ratio were used to measure the discriminatory power of the neonatal near miss indicators. The correct classification rate or accuracy of the neonatal near miss indicators was also calculated.

An analysis of the contribution of each factor to neonatal near miss was also performed by estimating the number and percentage of cases that fulfilled the neonatal near miss criteria, the additional contribution of each factor and the estimated increase or decrease in sensitivity or specificity with the inclusion of each factor.

The categorical log-likelihood ratio test was used to analyze the association between region of residence, residence in a state capital or non-capital, type of hospital financing, socioeconomic status based on the Brazilian Association of Research Companies' (ABEP) classification (levels A, B, C, D or E based on level of education of the head of the family and family assets – http://www.abep.org/novo/CMS/Utils/FileGenerate.ashx?id=13, accessed on 24/Oct/2013); maternal education level based on number of completed years of schooling; and mode of birth (vaginal, cesarean section or forceps).

The percentage of participants lost to follow-up was calculated by region of residence, residence in state capital or non-capital, type of hospital financing, socioeconomic status, maternal education level and mode of birth.

Sampling weights were used to account for the complex sampling design..

The research protocol was approved by the Ethics Research Committee of the National School of Public Health, Oswaldo Cruz Foundation (ENSP/Fiocruz; report no. 92/10). All women that participated in the study gave written informed consent.

## Results

There was a total of 215 neonatal deaths. The weighted neonatal mortality rate was 11.1 deaths per 1,000 births: 10.1 per 1,000 singleton births and 52.2 per 1,000 multiple births. The weighted number of cases that fulfilled neonatal near miss criteria was 943 and the weighted neonatal near miss rate was 39.2 per 1000 live births.

The variables birth weight, an Apgar score of less than 7 in the 5th minute of life, use of mechanical ventilation, preterm birth and congenital malformations were associated with neonatal death after the multivariable analysis.

Risk of death was found to be higher in the following cases: birth weight 1,500 to 2,499 g (OR = 5.38; 95%CI: 1.83-15.84), and < 1,500 (OR = 10.51; 95%CI: 3.00-36.83); Apgar score of less than 7 in the 5th minute of life (OR = 15.98; 95%CI: 6.02-42.38); use of mechanical ventilation (OR = 14.47; 95%CI: 6.90-30.35); preterm babies with a gestational age of less than 32 weeks (OR = 5.13; 95%CI: 1.59-16.52); and congenital malformation (OR = 15.50; 95%CI: 5.88-40.87) (Table 1).

Table 2 compares the occurrence of neonatal near miss with neonatal death. With respect to the neonatal near miss indicators, the results yielded 92.5% sensitivity, 97.1% specificity and 97% accuracy, and the positive likelihood ratio was 31.7 (Table 3). The greatest contributing factor for neonatal near miss was the use of mechanical ventilation, since 55.4% of all neonatal near miss cases underwent this procedure. The second most important contributing factor for neonatal near miss was gestational age of less than 32 weeks, while the least important factor was congenital malformation, which was present in only 18% of neonatal near miss cases. The factors birth weight, Apgar score and gestational age made an additional contribution in 70.1% of the cases that fulfilled the neonatal near miss criteria, while the factors mechanical ventilation and congenital malformation made an additional contribution in 18.6% and 11.2% of cases, respectively (Table 4).

No statistically significant association was found between neonatal near miss and region of residence, socioeconomic status and maternal education level. Prevalence of neonatal near miss was higher among babies born in state capitals (OR = 1.89; 95%CI: 1.35-2.64) than in infants born in non-capitals. The neonatal near miss rate was lower among babies born in private (OR = 0.60; 95%CI: 0.42-0.86) and mixed hospitals (OR = 0.58; 95%CI: 0.41-0.83) than in infants born in public hospitals. The risk of neonatal near miss was higher among babies delivered by cesarean section than in those delivered through vaginal birth (OR = 1.28; 95%CI: 1.04-1.57) (Table 5).

It was not possible to trace 32.4% of the mothers. Losses to follow-up were significantly higher among women living in the North and Northeast and in non-capital cities, in women who had their baby at a public hospital, in women from socioeconomic level D and E and with a low level of education, and among mothers whose baby was delivered through vaginal birth (Table 6).

## Discussion

Five of the 19 variables tested showed a significant association with neonatal mortality and were chosen to compose a set of neonatal near miss indicators: birth weight of less than 1,500g, an Apgar score of less than 7 in the 5th minute of life, use of mechanical ventilation, gestational age of less than 32 weeks, and presence of congenital malformations. The neonatal near miss rate in the Birth in Brazil survey was 39.2 per 1,000 live births; nearly four times the neonatal mortality rate (11.1 per 1,000 live births). Results yielded high sensitivity and specificity, indicating that this set of indicators may serve as a useful tool for neonatal monitoring.

The neonatal mortality rate was equal to the national rate of Brazil reported in 2010 (11.1/1,000 live births), suggesting that the *Birth in Brazil* survey was able to identify practically all deaths in the target sample (Ministério da Saúde. Indicadores e dados básicos. http://tabnet.datasus.gov.br/cgi/idb2011/matriz.htm, accessed on 13/Jul/2013). This was made possible by crosschecking the data with information from the National Death Registry which identified an additional 65 neonatal deaths missed by the telephone interviews.

A study by Pileggi et al. [8] used very low birth weight (< 1,500g), gestational age of less than 30 weeks and an Apgar score of less than 7 in the 5th minute of life as neonatal near miss indicators. The results yielded 82.6% sensitivity, 97.9% specificity and a positive likelihood ratio of 37. Our set of indicators, which also included mechanical ventilation and congenital malformations and used a gestational age of less than 32 weeks as opposed to less than 30 weeks, yielded higher sensitivity (92.5%), similar specificity (97.1%) and a slightly lower positive likelihood ratio (31.7). In our study the use of mechanical ventilation was the main contributing factor to neonatal near miss. Furthermore, the inclusion of the factors use of mechanical ventilation and congenital malformation led to an increase in sensitivity and a slight decrease in specificity. The inclusion of congenital malformation was important because an additional 106 (11.2%) new neonatal near miss cases were identified based solely on this variable. Birth weight between 1,500 and 2,499g was associated with a higher risk of neonatal death. However, despite sensitivity of 95.5%, this factor was not included because specificity was only 90.3%. In addition, the inclusion of this factor resulted in a moderate positive predictive value and positive likelihood ratio (9.9 and 9.8, respectively) therefore making it an inadequate indicator (data available on request).

Table 1

Adjusted analysis of risk factors for neonatal death. *Birth in Brazil* survey, 2011-2012.

| Variables | n (unweighted) * | Per thousand (weighted) | OR (95%CI) ** | p-value *** |
|---|---|---|---|---|
| Birth weight (g) | | | | |
| ≥ 2,500 | 21,740 | 2.2 | 1.00 | |
| 1,500-2,499 | 1,763 | 31.3 | 5.38 (1.83-15.84) | 0.002 |
| < 1,500 | 321 | 407.9 | 10.51 (3.00-36.83) | < 0.001 |
| Apgar score in the 5th minute of life | | | | |
| ≥ 7 | 22,909 | 7.1 | 1.00 | |
| < 7 | 211 | 369.8 | 15.98 (6.02-42.38) | < 0.001 |
| Mechanical ventilation | | | | |
| No | 23,631 | 3.1 | 1.00 | |
| Yes | 430 | 370.7 | 14.47 (6.90-30.35) | < 0.001 |
| Gestational age (weeks) | | | | |
| ≥ 37 | 21,174 | 2.2 | 1.00 | |
| 32-36 | 2092 | 20.6 | 1.30 (0.47-3.62) | 0.641 |
| < 32 | 336 | 386.3 | 5.13 (1.59-16.52) | 0.006 |
| Congenital malformation | | | | |
| No | 23,914 | 9.5 | 1.00 | |
| Yes | 147 | 230.3 | 15.50 (5.88-40.87) | < 0.001 |

95%CI: 95% confidence interval; OR: odds ratio.

* Numbers may not add up to the total (24,061) due to missing values;

** OR calculated using multiple logistic regression with adjustment for all variables in the table;

*** p-value calculated using the categorical log-likelihood ratio test.

Table 2

Comparison of neonatal near miss and neonatal death. *Birth in Brazil* survey, 2011-2012.

| Neonatal near miss | Neonatal death | | Total |
|---|---|---|---|
| | Yes | No | |
| Yes | 248 | 695 | 943 |
| No | 20 | 23,098 | 23,118 |
| **Total** | 268 | 23,793 | 24,061 |

Table 3

Screening evaluation of neonatal near miss. *Birth in Brazil* survey, 2011-2012.

| Parameter | Estimate | Lower-upper 95%CI |
|---|---|---|
| Sensitivity | 92.5% | 88.8-95.1 |
| Specificity | 97.1% | 96.9-97.3 |
| Positive predictive value | 26.3% | 23.6-29.2 |
| Negative predictive value | 99.9% | 99.8-99.9 |
| Diagnostic accuracy | 97.0% | 96.8-97.2 |
| Likelihood ratio of a positive test | 31.7 | 31.6-31.8 |
| Likelihood ratio of a negative test | 0.08 | 0.07-0.09 |

95%CI: 95% confidence interval.

Table 4

Contribution of each factor to neonatal near miss. *Birth in Brazil* survey, 2011-2012.

| Factors | Cases fulfilling criteria (n) * | Cases fulfilling criteria (%) * | Additional contribution of each factor (n) | Additional contribution of each factor (%) | Sensitivity | Specificity |
|---|---|---|---|---|---|---|
| Birth weight < 1,500g | 397 | 42.0 | 397 | 42.0 | 59.8 | 99.0 |
| Apgar score < 7 in the 5th minute of life | 240 | 25.5 | 166 | 17.6 | 73.0 | 98.5 |
| Gestational age < 32 weeks | 416 | 44.1 | 99 | 10.5 | 77.5 | 98.1 |
| Mechanical ventilation | 522 | 55.4 | 175 | 18.6 | 90.1 | 97.5 |
| Congenital malformation | 170 | 18.0 | 106 | 11.2 | 92.5 | 97.1 |

* Total is over 943 and sum of percentages is over 100% because more than one factor may have contributed to each case.

Table 5

Non-adjusted analysis of specific factors associated with neonatal near miss. *Birth in Brazil* survey, 2011-2012.

| Variables | n (unweighted) * | Per thousand (weighted) | OR (95%CI) ** | p-value *** |
|---|---|---|---|---|
| Region of residence | | | | 0.422 |
| North | 2,894 | 43.1 | 1.00 | |
| Northeast | 6,128 | 41.5 | 0.96 (0.52-1.76) | |
| Southeast | 8,063 | 41.5 | 0.96 (0.59-1.57) | |
| South | 4,173 | 27.9 | 0.64 (0.38-1.07) | |
| Central | 2,803 | 29.8 | 0.68 (0.37-1.26) | |
| Residence | | | | < 0.001 |
| Non-capital | 16,434 | 30.0 | 1.00 | |
| State capital | 7,625 | 55.1 | 1.89 (1.35-2.64) | |
| Type of hospital financing | | | | 0.002 |
| Public | 8,589 | 51.2 | 1.00 | |
| Mixed | 10,374 | 30.5 | 0.58 (0.41-0.83) | |
| Private | 5,098 | 31.4 | 0.60 (0.42-0.86) | |
| Socioeconomic status | | | | 0.055 |
| A | 653 | 26.7 | 1.00 | |
| B | 6,064 | 32.1 | 1.21 (0.63-2.31) | |
| C | 11,708 | 39.4 | 1.49 (0.76-2.93) | |
| D | 4,263 | 47.3 | 1.81 (0.90-3.63) | |
| E | 1,141 | 36.1 | 1.36 (0.59-3.13) | |
| Maternal schooling (years) | | | | 0.639 |
| ≥ 12 | 5,452 | 31.7 | 1.00 | |
| 9 to 11 | 9,893 | 34.9 | 1.10 (0.82-1.49) | |
| 5 to 8 | 6,439 | 37.7 | 1.20 (0.93-1.54) | |
| 0 to 4 | 2,103 | 35.9 | 1.14 (0.78-1.65) | |
| Mode of birth | | | | 0.043 |
| Vaginal | 10,116 | 34.2 | 1.00 | |
| Cesarean section | 13,644 | 43.3 | 1.28 (1.04-1.57) | |
| Forceps | 301 | 44.9 | 1.33 (0.64-2.73) | |

95%CI: 95% confidence interval; OR: odds ratio.

* Numbers may not add up to the total (24,061) due to missing values;

** OR calculated using simple logistic regression;

*** p-value calculated using the categorical log-likelihood ratio test.

Table 6

Comparison between followed up cases and those cases not traced. *Birth in Brazil* survey 2011-2012.

| Variables | n (unweighted) * | % lost to follow-up (weighted) | p-value ** |
|---|---|---|---|
| Region of residence | | | < 0.001 |
| North | 2,894 | 49.8 | |
| Northeast | 6,128 | 42.5 | |
| Southeast | 8,063 | 26.5 | |
| South | 4,173 | 16.7 | |
| Central | 2,803 | 29.7 | |
| Residence | | | 0.001 |
| Non-capital | 16,434 | 34.1 | |
| State capital | 7,625 | 29.4 | |
| Type of hospital financing | | | < 0.001 |
| Public | 8,589 | 38.1 | |
| Mixed | 10,374 | 29.5 | |
| Private | 5,098 | 24.8 | |
| Socioeconomic status | | | |
| A | 653 | 21.1 | |
| B | 6,064 | 21.5 | |
| C | 11,708 | 28.6 | |
| D | 4,263 | 46.3 | |
| E | 1,141 | 72.4 | |
| Maternal schooling (years) | | | < 0.001 |
| ≥ 12 | 5,452 | 23.7 | |
| 9-11 | 9,893 | 26.4 | |
| 5-8 | 6,439 | 37.6 | |
| 0-4 | 2,103 | 58.7 | |
| Mode of birth | | | < 0.001 |
| Vaginal | 10,116 | 36.5 | |
| Cesarean section | 13,644 | 29.0 | |
| Forceps | 301 | 23.8 | |

* Numbers may not add up to the total (24,061) due to missing values;

** p-value calculated using the chi-square test.

A very low positive predictive value (26.3%) coupled with a very high negative predictive value (99.9%) shows that the model has low discriminatory power when the result is positive and death occurs. This situation is expected given the limitations of OR for gauging the performance of a prognostic marker [13]. In contrast, when death does not occur the discriminatory power of the model is close to 100%. These results are expected since predictive values are influenced by the prevalence of death as a rare event.

Very low birth weight, gestational age of less than 32 weeks and a low Apgar score [15] are life-threatening conditions associated with a high risk of neonatal death [14]. The use of mechanical ventilation is typically associated with serious respiratory disease. Congenital malformation was also associated with a high risk of neonatal death and improved discriminatory power; however, it should be noted that the concept of congenital malformation is not strictly defined and it appears that serious malformations tend to be reported more often than milder ones.

The neonatal near miss rate was twice as high in babies born in state capitals than in infants born in non-capital cities. Wide availability of neonatal intensive care units (neonatal ICU) is associated with high rates of early detection of respiratory diseases and high medical intervention rates [16]. Furthermore, newborns with severe diseases tend to be referred to public neonatal intensive care units located in state

capital cities. These factors might explain the higher rate of neonatal near miss in babies in state capitals.

The use of the neonatal near miss concept has been proposed as a tool to evaluate health care quality, whereby a low neonatal near miss rate indicates high quality of care [6]. However, neonatal mortality rates are low in hospitals which use low-complexity technology, such as natural birth centers [17]. Disease detection and medical intervention rates are related to availability of neonatal ICUs and in Brazil these units are concentrated in more developed areas [16]. It would appear therefore that neonatal near miss rates may also reflect health service availability and access to health care at hospitals using more complex technology, thus detracting from its use as a proxy for health care quality. Without the development of a general index of complexity to account for this situation during analysis, neonatal near miss may be a more appropriate indicator for comparing health care quality between regions or countries, as opposed to hospital facilities.

Interestingly, lower socioeconomic status or a lower level of maternal education was not associated with higher neonatal near miss rates. This is in sharp contrast to findings of other studies which observed that infant and neonatal mortality rates were lower among babies from families with higher socioeconomic status [18,19,20]. A recent study also based on data from the *Birth in Brazil* survey found that neonatal mortality was higher among babies from families with a low socioeconomic status [21].

The neonatal near miss rate was also higher in public hospitals than in private or mixed hospitals. However, it is not possible to infer that the quality of health care is poorer in public hospitals from these results since the majority of severe cases occur in poorer families, which in turn are more likely to use public hospitals [22]. Disease severity can therefore be a powerful confounder of the association between neonatal near miss and hospital type. Furthermore, some public hospitals are equipped with neonatal intensive care units. It therefore appears that without taking into account confounding factors, especially disease severity, neonatal near miss is not a good indicator of quality of health care [23].

Neonatal near miss rates were higher among babies delivered by cesarean section than in those delivered through vaginal birth. Therapeutic cesarean sections are often performed in cases of maternal complications, such as preeclampsia and placental abruption, thus preventing antepartum stillbirths [23,24]. However, unnecessary cesarean sections have been associated with preterm birth [26], increased neonatal respiratory morbidity, admissions to neonatal intensive care unit and need of mechanical ventilation, and [24,26,28] may be responsible for some neonatal near miss cases.

One of the strengths of this study is that it was based on a population-based survey that used a nationwide sample. However, hospitals with less than 500 annual births and home births were not included. Due to incomplete reporting and different availability of technological resources, some variables that could have been useful elements of the set of neonatal near miss indicators, such as laboratory markers for organ dysfunction, were not included. Another limitation of this study is the possibility of incorrect classifications of live births as stillbirths. Although all interviewers were trained to address this potential bias, we can not entirely rule out this possibility.

## Conclusion

The set of neonatal near miss indicators consisting of five variables (birth weight of less than 1,500g, an Apgar score of less than 7 in the 5th minute of life, use of mechanical ventilation, gestational age of less than 32 weeks, and congenital malformations) was able to identify situations with a high risk of neonatal death.

## Resumen

*Se utilizaron datos de la encuesta Nacer en Brasil, un estudio nacional de base hospitalaria, realizado con 24.197 madres y sus recién nacidos, recabado de febrero 2011 a julio 2012, para construir un indicador de morbilidad neonatal* near miss. *Se utilizó el muestreo por conglomerados en tres etapas (hospitales, días, mujeres), estratificado por microrregiones, tipo de municipio (capital o interior), y tipo de financiamiento de los hospitales. Se emplearon modelos de regresión logística para identificar las variables que podrían predecir la mortalidad neonatal y componer el indicador de morbilidad neonatal* near miss. *Una vez ensayadas 19 variables, cinco fueron elegidas (peso al nacer < 1.500g; Apgar a los 5 minutos de vida; < 7 ventilación mecánica; edad gestacional < 32 semanas, y reporte de malformaciones congénitas). La tasa de morbilidad neonatal* near miss *fue de un 30,2 por mil nacidos vivos, tres veces y media la tasa de mortalidad neonatal (11,1 por mil). El indicador de morbilidad neonatal* near miss *fue capaz de identificar situaciones con alto riesgo de muerte neonatal.*


*Salud Materno-Infantil; Mortalidad Infantil; Recién Nacido de Bajo Peso; Parto*

## Contributors

All authors formulated the study hypothesis. A. A. M. Silva conducted statistical analyses and wrote the first version of this article. All authors contributed to interpretation of results and read, revised and approved the final version of the manuscript.

## Acknowledgements

To regional and state coordinators, supervisors, interviewers and crew of the study and the mothers who participated and made this study possible.

## Funding

National Council for Scientific and Technological Development (CNPq); Science and Tecnology Department, Secretariat of Science, Tecnology, and Strategic Inputs, Brazilian Ministry of Health; National School of Public Health, Oswaldo Cruz Foundation (INOVA Project); and Foundation for supporting Research in the State of Rio de Janeiro (FAPERJ).

## References


1. Avenant T. Neonatal near miss: a measure of the quality of obstetric care. Best Pract Res Clin Obstet Gynaecol 2009; 23:369-74.
2. Say L, Souza JP, Pattinson RC. Maternal near miss – towards a standard tool for monitoring quality of maternal health care. Best Pract Res Clin Obstet Gynaecol 2009; 23:287-96.
3. World Health Organization. Evaluating the quality of care for severe pregnancy complications: The WHO near-miss approach for maternal health. Geneva: World Health Organization; 2011.
4. United Nations Children's Fund. Levels & trends in child mortality. Report, 2012. New York: United Nations Children's Fund; 2012.
5. Presidência da República. Objetivos de desenvolvimento do milênio. Relatório Nacional de Acompanhamento. Brasília: Instituto de Pesquisa Ecopnômica Aplicada; 2010.
6. Say L. Neonatal near miss: a potentially useful approach to assess quality of newborn care. J Pediatr (Rio J.) 2010; 86:1-2.
7. Caldeira AP, Franca E, Goulart EM. Mortalidade infantil pós-neonatal e qualidade da assistência médica: um estudo caso-controle. J Pediatr (Rio J.) 2001; 77:461-8.
8. Pileggi C, Souza JP, Cecatti JG, Faundes A. Neonatal near miss approach in the 2005 WHO Global Survey Brazil. J Pediatr (Rio J.) 2010; 86:21-6.
9. do Carmo Leal MC, da Silva AA, Dias MA, da Gama SG, Rattner D, Moreira ME, et al. Birth in Brazil: national survey into labour and birth. Reprod Health 2012; 9:15.
10. Vasconcellos MTL, Silva PLN, Pereira APE, Schilithz AOC, Souza Junior PRB, Szwarcwald CL. Desenho da amostra *Nascer no Brasil*: Pesquisa Nacional sobre Parto e Nascimento. Cad Saúde Pública 2014; 30 Suppl:S49-58.
11. Camargo Jr. KR, Coeli CM. *Reclink*: aplicativo para o relacionamento de bases de dados, implementando o método *probabilistic record linkage*. Cad Saúde Pública 2000; 16:439-47.

12. Pereira APE, Leal MC, Gama SGN, Domingues RMSM, Schilithz AOC, Bastos MH. Determinação da idade gestacional com base em informações do estudo *Nascer no Brasil*. Cad Saúde Pública 2014; 30 Suppl:S59-70.
13. Pepe MS, Janes H, Longton G, Leisenring W, Newcomb P. Limitations of the odds ratio in gauging the performance of a diagnostic, prognostic, or screening marker. Am J Epidemiol 2004; 159:882-90.
14. Nascimento RM, Leite AJM, Almeida NMGS, Almeida PC, Silva CF. Determinantes da mortalidade neonatal: estudo caso-controle em Fortaleza, Ceará, Brasil. Cad Saúde Pública 2012; 28:559-72.
15. Oliveira TG, Freire PV, Moreira FT, Moraes JS, Arrelaro RC, Ricardi SR, et al. Apgar score and neonatal mortality in a hospital located in the southern area of São Paulo City, Brazil. Einstein (São Paulo) 2012; 10:22-8.
16. Silva AA, Silva LM, Barbieri MA, Bettiol H, Carvalho LM, Ribeiro VS, et al. The epidemiologic paradox of low birth weight in Brazil. Rev Saúde Pública 2010; 44:767-75.
17. Silva ZP, Almeida MF, Ortiz LP, Alencar GP, Alencar AP, Schoeps D, et al. Características dos nascidos vivos, das mães e mortalidade neonatal precoce na Região Metropolitana de São Paulo, Brasil. Cad Saúde Pública 2009; 25:1981-9.
18. Zanini RR, Moraes AB, Giugliani ER, Riboldi J. Contextual determinants of neonatal mortality using two analysis methods, Rio Grande do Sul, Brazil. Rev Saúde Pública 2011; 45:79-89.
19. Goldani MZ, Barbieri MA, Bettiol H, Barbieri MR, Tomkins A. Infant mortality rates according to socioeconomic status in a Brazilian city. Rev Saúde Pública 2001; 35:256-61.
20. Sousa A, Hill K, Dal Poz MR. Sub-national assessment of inequality trends in neonatal and child mortality in Brazil. Int J Equity Health 2010; 9:21.
21. Lansky S, Friche AAL, Silva AAM, Campos D, Bittencourt SDA, Carvalho ML, et al. Pesquisa *Nascer no Brasil*: perfil da mortalidade neonatal e avaliação da assistência à gestante e ao recém-nascido. Cad Saúde Pública 2014; 30 Suppl: S192-207.
22. Silva ZP, Almeida MF, Ortiz LP, Alencar GP, Alencar AP, Schoeps D, et al. Morte neonatal precoce segundo complexidade hospitalar e rede SUS e não-SUS na Região Metropolitana de São Paulo, Brasil. Cad Saúde Pública 2010; 26:123-34.
23. Barros AJ, Matijasevich A, Santos IS, Albernaz EP, Victora CG. Neonatal mortality: description and effect of hospital of birth after risk adjustment. Rev Saúde Pública 2008; 42:1-9.
24. Signore C, Klebanoff M. Neonatal morbidity and mortality after elective cesarean delivery. Clin Perinatol 2008; 35:361-71.
25. Villar J, Carroli G, Zavaleta N, Donner A, Wojdyla D, Faundes A, et al. Maternal and neonatal individual risks and benefits associated with caesarean delivery: multicentre prospective study. BMJ 2007; 335:1025.
26. Bettiol H, Rona RJ, Chinn S, Goldani M, Barbieri MA. Factors associated with preterm births in southeast Brazil: a comparison of two birth cohorts born 15 years apart. Paediatr Perinat Epidemiol 2000; 14:30-8.
27. Villar J, Valladares E, Wojdyla D, Zavaleta N, Carroli G, Velazco A, et al. Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America. Lancet 2006; 367:1819-29.
28. Tracy SK, Tracy MB, Sullivan E. Admission of term infants to neonatal intensive care: a population-based study. Birth 2007; 34:301-7.

Submited on 12/Jul/2013
Final version resubmitted on 21/Jan/2014
Approved on 28/Jan/2014