Birth in Brazil survey: neonatal mortality, pregnancy and childbirth quality of care

Pesquisa *Nascer no Brasil*: perfil da mortalidade neonatal e avaliação da assistência à gestante e ao recém-nascido

Investigación *Nacer en Brasil*: perfil de mortalidad neonatal, evaluación de la maternidad y cuidado del recién nacido

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Abstract

This study examined neonatal deaths in the live-births cohort in the Birth in Brazil *survey, which interviewed and examined medical records of 23,940 mothers from February 2011 to October 2012. Potential risk factors were analyzed using hierarchical modeling. Neonatal mortality rate was 11.1/1,000, the highest rates occurring in the North and Northeast regions and in lower social classes. Low birth weight, risks during pregnancy and conditions of the newborn were the main factors associated with neonatal death. Inadequate prenatal and childbirth care point to unsatisfactory quality of health care. Difficulty in gaining hospital admission for delivery, and children with birth weight < 1,500g born at hospitals without a neonatal intensive care unit, indicate gaps in health system organization. Deaths from intra-partum asphyxia in term babies and late prematurity express preventable neonatal mortality. Better quality health care, especially hospital care during labor and birth, poses the main public policy challenge to progress in reducing mortality and inequalities in Brazil.*

Infant Mortality; Hospital Care; Health Services Evaluation; Parturition

Resumo

Estudo de coorte sobre a mortalidade neonatal na pesquisa Nascer no Brasil*, com entrevista e avaliação de prontuários de 23.940 puérperas entre fevereiro de 2011 e outubro de 2012. Utilizou-se modelagem hierarquizada para análise dos potenciais fatores de risco para o óbito neonatal. A taxa de mortalidade foi 11,1 por mil; maior nas regiões Norte e Nordeste e nas classes sociais mais baixas. O baixo peso ao nascer, o risco gestacional e condições do recém-nascido foram os principais fatores associados ao óbito neonatal. A inadequação do pré-natal e da atenção ao parto indicaram qualidade não satisfatória da assistência. A peregrinação de gestantes para o parto e o nascimento de crianças com peso < 1.500g em hospital sem UTI neonatal demonstraram lacunas na organização da rede de saúde. Óbitos de recém-nascidos a termo por asfixia intraparto e por prematuridade tardia expressam a evitabilidade dos óbitos. A qualificação da atenção, em especial da assistência hospitalar ao parto se configura como foco prioritário para as políticas públicas e avanços na redução da mortalidade infantil e desigualdades no Brasil.*

Mortalidade Infantil; Assistência Hospitalar; Avaliação de Serviços de Saúde; Parto

Introduction

Neonatal mortality has been the main component of infant mortality since the 1990s in Brazil and continues high, at a rate of 11.2 deaths per 1,000 live births in 2010 [1]. In 2011, the infant mortality rate in Brazil was 15.3 per 1,000 live births, achieving the 4th *Millennium Development Goal*, the commitment by United Nations member governments to improve child health and reduce child mortality by two thirds between 1990 and 2015 [1,2]. Those mortality rates are considered to fall short of Brazil's potential, however, reflecting unfavorable conditions of life and health care, in addition to historical regional and socioeconomic inequalities [3,4].

At present the main component of infant mortality is early neonatal (0-6 days of life), and infant deaths occur largely (25%) in the first 24 hours, indicating a close relation to care during labor and delivery [5]. In the literature, the main causes of death are prematurity, congenital malformation, intrapartum asphyxia, perinatal infections and maternal factors, with a considerable proportion of deaths preventable by health services [5,6].

Although births in Brazil occur predominantly in hospital (98.4%) and delivery is attended by doctors (88.7%) [7], the results are unsatisfactory compared with lower neonatal and child mortality coefficients achieved elsewhere [8]. This situation has been termed the 'Brazilian perinatal paradox': deliveries and births are intensely medicalized, but higher rates of maternal and perinatal morbidity and mortality persist, and are possibly related to poor quality of care and use of obsolete and iatrogenic procedures, which may affect perinatal outcomes [9,10]. One of the most prominent examples in that respect is the high rate of caesarean sections in Brazil – 53.7% of births in 2011 [1].

Studies of the quality of the process of care during labor, delivery and childbirth are recent initiatives and still few in number [9,11,12]. More in-depth understanding of care processes during delivery and childbirth, and their effects on neonatal mortality, may contribute to informing actions to reduce the latter more intensively [13].

The purpose of this study was to examine the profile of neonatal deaths identified in the national *Birth in Brazil* survey, and the associated factors, considering socioeconomic and demographic contextual factors, characteristics of the pregnant women and newborns, and the process of prenatal care and care during labor and delivery.

Methods

Birth in Brazil is a nationwide, hospital-based survey of women about to give birth and their newborn babies, conducted from February 2011 to October 2012. The sample was selected in three stages. The first, comprised hospitals performing 500 or more deliveries per year, stratified by Brazil's five macro-regions and by hospital location (state capital or elsewhere) and type (private, public and mixed). The second comprised days (at least seven days at each hospital), and the third, the women about to give birth. At each of the 266 hospitals sampled, 90 women about to give birth were interviewed, totaling 23,940 subjects. More detailed information on the sample design can be found in Vasconcellos et al. [14]. In the first stage of the study, the women about to give birth were interviewed face-to-face during their hospital stay, data were drawn from the women's and newborns' patient records, and the women's prenatal record cards were photographed. Telephone interviews were then conducted at before six months and at twelve months after birth to collect data on maternal and neonatal outcomes. Detailed information on the data collection is reported in do Carmo Leal et al. [15].

For this study, the outcome variable examined was neonatal death, defined as deaths of live-born babies, regardless of birth weight and gestational age, occurring before the 28th day of life. In order to identify the neonatal deaths that occurred during the study period, and to obtain relevant information, probabilistic record linkage was established between the Birth in Brazil data base and the neonatal deaths that occurred in Brazil in 2011 and 2012 as recorded in the Mortality Information System (SIM) and the Information System on Live Births (SINASC). Probabilistic record linkage was performed using the software OpenRecLink [16] and the variables mother's name, and newborn's date of birth, sex, and date of death, in three stages: standardization, blocking and record pairing; the pairs were classified into true, false and doubtful [17], and reviewed manually by the process described by Camargo Jr. & Coeli [16,18]. For variables for which there was no information in the SIM or SINASC, values were imputed according to the likelihood of each category, as estimated by regression model for each variable based on the group of infants hospitalized, because they displayed characteristics similar to those of the infants who died.

For the hierarchical modeling of determinants of neonatal death, the exposure variables were divided in to four blocks [19,20], as follows:

- Block 1 – socioeconomic and demographic: maternal domicile (region of Brazil, location of

municipality, social class – ABIPEME, http://www.abipeme.org.br), maternal characteristics (race/skin color, schooling, marital status and age in years), and sex of the newborn;

- Block 2 – prior history and current pregnancy: parity; neonatal death, stillbirth, low birth weight and prior prematurity; type of gestation, adequacy of prenatal care by the Kotelchuck index [21], and maternal complications, considering pre-existing risk conditions persisting in the current pregnancy and complications in gestation or labor;
- Block 3 – care process during childbirth: referral hospital for high-risk pregnancy, hospital with neonatal intensive care unit (neonatal ICU), hospital funding type (private, public, mixed), more than one maternity facility approached before gaining admission, partograph used during labor, companion present during hospital stay for childbirth, delivery type, newborn with birth weight < 1,500g in hospital without neonatal ICU, good practices during labor and good practices during delivery. The latter two summary variables were developed as markers for care in order to evaluate the use of evidence-based procedures in care during labor, and delivery by expert consensus. The labor care practices selected – which are recommended in the literature [22,23,24,25,26], according to systematic reviews – were the women's: having the option of a liquid or light diet during labor, in contrast with the prevailing routine prescription of fasting; being given freedom of movement, counter to the prevailing practice of bed rest; access to pain relief non-drug methods; having a companion present during labor; having a partograph used in monitoring labor; and oxytocin used only with a partograph, contrary to the prevailing practice of using oxytocin without a partograph to monitor labor. In the same way, the variable 'good childbirth practices' was constructed considering non-use of the Kristeller maneuver (uterine fundal pressure during delivery, a procedure unsupported by scientific evidence, which can produce pain and harm to parturient and newborn); and being able to choose upright delivery positions, contrasting with the predominant practice of delivery in the lithotomy position;
- Block 4 – general conditions of the newborn and care for the newborn: birth weight, gestational age, congenital malformation, admission to neonatal ICU, use of mechanical ventilation, use of surfactant, presentation for birth, and Apgar < 7 at the 5th minute of life.

Deaths were also described by the main groupings established by França & Lansky [5] for neonatal deaths, drawing on the causes recorded on the death certificate obtained by linking the survey data base and the SIM and the causes stated in the hospital patient records (only for 25 deaths not identified in the SIM). This list of causes groups the codes of the 10th revision of the International Classification of Diseases (ICD-10) so as to give greater visibility to the main causes of death: prematurity, congenital malformation, perinatal infections, intrapartum asphyxia, maternal factors, respiratory problems, and other groupings.

Statistical analysis

The descriptive statistics consisted first in presenting absolute and relative frequencies and numerical summary numbers for the chosen variables by regions of Brazil. For all the variables used in the hierarchical model, neonatal mortality rates were calculated as a measure of risk. The initial statistical analysis consisted in using the chi-square test to evaluate the hypothesis of homogeneous proportions, comparing the survivor and neonatal death groups.

Bivariate analyses were performed between the exposure variables and the occurrence of neonatal death, to obtain crude odds ratio (OR) as a measure of magnitude of association, as appropriate to the logistic regression model. Variables displaying $p \leq 0.20$ were retained for multivariate analysis by multiple logistic regression, considering the hierarchization in blocks. In keeping with the conceptual model, the socioeconomic and demographic variables were analyzed as the most distal level in terms of proximity to the outcome. Variables relating to prior maternal history and current pregnancy, and to the childbirth care process, were considered intermediate. Lastly, the block of variables relating to overall conditions and neonatal care entered the model as the proximal level. Variables from each block with $p \leq 0.10$ were retained in the hierarchized model to control for residual confounder effects on the variables. In analyzing and discussing the results, exposure variables with a 5% level of significance were considered to be associated with neonatal death [12,15,19,27]. Cases of collinear variables were evaluated using the variance inflation factor, and the variable with lower p-value was selected.

In the statistical analysis, the complex sample design was taken into account by way of the *svy* commands in the Stata software, version 12 (Stata Corp., College Station, USA) and the *complex samples* module of the IBM SPSS statistics package, version 18 (IBM Corp., Armonk, USA). All estimates were weighted, because the selection probabilities were unequal [15].

Ethical considerations

The project was approved by the Ethics Research Committee of the National School of Public Health, Oswaldo Cruz Foundation (ENSP/Fiocruz), opinion n. 92/10. The hospital managers and women selected who agreed with and signed the declaration of free and informed consent were interviewed.

Results

In this study, 24,061 live births and 268 neonatal deaths were identified, resulting in a weighted neonatal mortality rate of 11.1 deaths per 1,000 live births. Table 1 shows some characteristics of the deaths, by location of the maternity facility where the birth occurred, by region of Brazil. The deaths were concentrated in Brazil's Northeast (38.3%) and Southeast (30.5%) regions and among premature and low birth-weight newborns (81.7% and 82%). Southeast, Central and South regions of Brazil had the highest preterm. Extreme prematurity (< 32 weeks) and very low birth weight (< 1,500g) represented 60.2% and 59.6% of deaths, respectively, with highest rates in the Central and Southeast regions. The highest rate of full-term newborn deaths was in the Northeast (21.3%).

Of the groups by cause of neonatal death, the prematurity group predominated, responding for about 1/3 of cases, followed by congenital malformation (22.8%), infections (18.5%), maternal factors (10.4%) and asphyxia/hypoxia (7%). The Northeast and North regions showed the highest rates of death recorded as from infection (26.9% and 20.7%), compared with 10.5% and 7.7% in the South and Central regions, respectively. The rates of deaths recorded as from congenital malformation were higher in the South and Southeast (42.1 and 35.9%), while the North and South returned the highest rates of death from asphyxia.

Tables 2, 3 and 4 show the distributions of births and deaths, neonatal mortality rates and bivariate analyses of the blocks of variables proposed for the hierarchical model. The women who participated in the study were predominantly 20 to 34 years old (70.8%), had brown skin (54.6%), and belonged to social class C (49.1%), had begun or completed middle school, and lived with a partner. Most of the births and deaths occurred in municipalities other than the state capital, and 56.7% of the children were delivered by caesarian section. As regards the neonatal deaths, 21.2% of the mothers were adolescents, 33.5% did not live with their partner, and one third had fewer than eight years' schooling (Table 2).

The lowest neonatal mortality rates (per 1,000 live births) were found in the South (6.2), Southeast (8.0) and Central (8.4) and the highest, in the North (22.3) and Northeast (14.5). Notable among the other socioeconomic and demographic variables studied (Table 2) was that

Table 1

Distribution of neonatal deaths by selected variables and regions of Brazil, 2011-2012 *.

Selected variables	North n (%)	Northeast n (%)	Southeast n (%)	South n (%)	Central n (%)	Brazil n (%)
Neonatal death	52 (19.3)	103 (38.3)	82 (30.5)	19 (6.9)	13 (5.0)	268 (100.0)
Birth weight (g)						
Low weight (< 2,500g)	44 (84.6)	83 (80.6)	66 (81.5)	15 (83.3)	11 (84.6)	219 (82.0)
Very low weight (< 1,500g)	27 (52.9)	59 (57.8)	53 (65.4)	11 (57.9)	10 (76.9)	160 (60.2)
Gestational age (weeks)						
Premature (< 37)	42 (80.8)	74 (78.7)	64 (85.3)	14 (82.4)	11(84.6)	205 (81.7)
Extremely premature (< 32)	30 (57.7)	60 (63.8)	51 (68.0)	10 (58.1)	11(84.6)	162 (64.5)
Causes of death						
Prematurity	11 (22.2)	34 (33.9)	23 (30.5)	3 (15.8)	7 (53.8)	77 (30.3)
Congenital malformation	12 (24.5)	7 (7.6)	27 (35.9)	8 (42.1)	3 (23.1)	58 (22.8)
Infection	14 (26.9)	20 (20.7)	10 (13.1)	2 (10.5)	1 (7.7)	47 (18.5)
Maternal factors	3 (5.5)	15 (15.0)	8 (11.3)	1 (5.3)	1 (7.7)	28 (10.4)
Asphyxia/Hypoxia	7 (13.5)	5 (5.3)	2 (2.6)	3 (15.8)	1 (7.7)	18 (7.0)
Other causes	4 (7.4)	17 (17.5)	5 (6.6)	2 (10.5)	0 (0.0)	28 (9.8)

* weighted n.

Table 2

Distribution of live births, neonatal mortality rate, crude odds ratio (OR) and chi-square: socioeconomic and demographic variables – Block 1. Brazil, 2011-2012.

Socioeconomic and demographic variables	Live births *	Neonatal mortality rate per 1,000 live births **	Crude OR	CI95%	Chi-square (p-value)
Region of Brazil					0.011
South	4,173	6.1	1.00		
Southeast	8,063	8.0	1.32	0.66-2.63	
Central	2,803	8.4	1.37	0.65-2.91	
Northeast	6,128	14.5	2.39	1.13-5.01	
North	2,894	22.3	3.71	1.65-8.35	
Municipality type					0.099
Non-state capital	16,436	9.0	1.00		
State capital	7,625	14.5	1.61	0.91-2.85	
Social class					0.039
A+B	6,717	7.3	1.00		
C	11,708	11.2	1.55	0.94-2.54	
D+E	5,404	15.0	2.08	1.14-3.82	
Mother's race/skin color					0.242
White	8,682	9.2	1.00		
Black	1,865	8.0	0.86	0.37-2.00	
Brown	13,148	12.7	1.38	0.97-1.98	
Other	359	8.1	0.87	0.22-3.40	
Mother's schooling					< 0.001
Complete University and above	2,792	3.4	1.00		
Complete Secondary School	9,402	8.2	2.46	1.03-5.83	
Complete Primary School	5,774	14.9	4.51	1.79-11.35	
Incomplete Primary School	5,983	14.2	4.27	1.73-10.51	
Mother's marital status					< 0.001
With spouse	19,903	8.7	1.00		
Without spouse	4,142	21.7	2.55	1.81-3.58	
Mother's age (years)					0.166
20-34	16,997	9.8	1.00		
< 20	4,349	13.1	1.34	0.83-2.15	
35 or more	2,708	15.4	1.57	0.91-2.72	
Sex of newborn					0.016
Female	11,599	8.8	1.00		
Male	12,447	12.7	1.45	1.07-1.97	

* n not weighted;

** Weighted rates.

Note: the total n may vary by the presence of disregarded variables.

the maternal mortality rate was higher for male newborns, for mothers of social classes D+E, living in state capitals, adolescents and those 35 or more years old, and was four times higher for mothers with little schooling (Table 2). No association was found between neonatal death and race/skin color.

The highest neonatal mortality rates occurred among children weighing less than 1,500g born in hospitals without neonatal ICU, those with very low birth weight (< 1,500g), extreme prematures (< 32 weeks), those with Apgar < 7 at the 5th minute of life, those who used mechanical ventilation or surfactant, those with con-

genital malformation, those in breech presentation, twins, those whose mothers reported approaching more than one hospital before being admitted, who had unfavorable prior maternal and obstetric histories, for whom no partograph was charted during labor, babies born in public hospitals, in referral hospitals for high-risk pregnancies, in hospitals with neonatal ICU, mothers who had no companion during their hospital stay for childbirth, and babies born by vaginal delivery (Tables 3 and 4).

Rates were also high among mothers who received inadequate prenatal and labor care. Care practices considered adequate were used during labor in only 1% and 1.2% of births, i.e., in the vast majority of cases they were not used or were used only partially. There was no statistical difference between deaths and live births in that good practices were used during delivery in similar proportions in both groups, only 2.1% and 2.3%, respectively. Meanwhile, non-recommended practices were frequent: the Kristeller maneuver, for instance, was used in 36.5% of all vaginal deliveries and in 21.5% of neonatal deaths (data not presented).

The proximal variables, those relating to the newborn and the current pregnancy, displayed stronger associations with neonatal death in the

Table 3

Distribution of live births, neonatal deaths, neonatal mortality rate, crude odds ratio (OR) and chi-square: prior history and current pregnancy – Block 2. Brazil, 2011-2012.

Variables of previous history and current pregnancy	Live births *	Neonatal mortality rate per 1,000 live births **	Crude OR	95%CI	Chi-square (p-value)
Parity					0.951
Multiparous	11,246	11.1	1.00		
Primiparous	12,814	11.0	0.99	0.68-1.44	
Prior neonatal death					0.116
No	23,612	10.9	1.00		
Yes	449	20.2	1.87	0.85-4.12	
Prior stillbirth					< 0.001
No	23,519	10.1	1.00		
Yes	542	52.0	5.40	3.05-9.57	
Prior low weight					< 0.001
No	22,399	9.8	1.00		
Yes	1,662	27.4	2.83	1.86-4.30	
Prior premature					< 0.001
No	22,566	9.8	1.00		
Yes	1,495	30.0	3.14	2.02-4.87	
Gestation type					< 0.001
Single	23,566	10.0	1.00		
Twin	492	52.2	5.43	2.93-10.05	
Adequate antenatal care (Kotelchuck)					0.009
More than adequate	6,153	4.5	1.00		
Adequate	9,665	11.0	2.43	1.42-4.17	
Partly adequate	4,010	13.1	2.92	1.44-5.91	
Inadequate	3,584	17.4	3.89	1.81-8.35	
Maternal complications					< 0.001
No	15,034	3.7	1.00		
Yes	9,027	23.1	6.37	4.07-9.98	

* n not weighted;

** Weighted rates.

Note: the total n may vary by the presence of missing values.

95%CI: 95% confidence interval.

Table 4

Distribution of live births, neonatal mortality rate, crude odds ratio (OR) and chi-square: care during childbirth and overall conditions of newborn – Blocks 3 and 4. Brazil, 2011-2012.

Variables of childbirth and newborn	Live births *	Neonatal mortality rate per 1,000 live births **	Crude OR	95%CI	Chi-square (p-value)
Birth					
Referral hospital for high-risk pregnancy					< 0.001
No	12,181	5.8	1.00		
Yes	11,698	15.3	2.66	1.59-4.48	
Hospital with neonatal ICU					< 0.001
No	10,256	5.8	1.00		
Yes	13,625	14.2	2.47	1.54-3.95	
Hospital type					< 0.001
Private	5,098	6.4	1.00		
Mixed	10,374	6.7	1.04	0.52-2.13	
Public (SUS)	8,589	17.5	2.78	1.37-5.64	
Admission denied at first hospital approached					< 0.001
No	20,570	6.9	1.00		
Yes	3,475	32.7	4.89	3.27-7.32	
Partograph used					< 0.001
Yes	5,325	5.0	1.00		
No	9,663	17.6	3.59	2.28-5.66	
Cesarian section ***	9,073	8.4	1.70	1.04-2.77	
Companion present					0.016
Always	8,461	6.7	1.00		
Sometimes	6,554	13.8	2.07	1.21-3.55	
Never	9,033	12.5	1.87	1.18-2.96	
Good practices used during labor					0.038
Yes	354	2.0	1.00		
Not used or used incompletely	14,607	10.0	4.98	0.64-38.68	
No labor	9,100	13.5	6.72	0.93-48.32	
Good practices used during delivery					0.234
Yes	218	3.6	1.00		
Not used or used incompletely	10,199	12.4	3.47	0.51-23.38	
Caesarian section	13,644	10.1	2.84	0.45-18.02	
Delivery type					0.311
Vaginal	10,116	12.3	1.00		
Forceps/Vacuum-assisted	301	5.0	0.40	0.71-2.26	
Cesarian section	13,644	10.1	0.82	0.59-1.15	
Newborn < 1,500g in hospital without neonatal ICU					< 0.001
No	24,009	10.0	1.00		
Yes	52	551.80	121.45	54.69-269.71	

(continues)

Table 4 (continued)

Variables of childbirth and newborn	Live births *	Neonatal mortality rate per 1,000 live births **	Crude OR	95%CI	Chi-square (p-value)
Newborn					
Birth weight (g)					< 0.001
≥ 2,500	21,740	2.2	1.00		
1,500-2,499	1,763	31.3	14.57	7.88-26.95	
< 1,500	321	407.3	309.42	186.88-512.32	
Gestational age (weeks)					< 0.001
≥ 37	21,174	2.2	1.00		
33-36	1,986	19.5	9.01	4.74-17.14	
≤ 32	442	306.7	200.91	120.70-334.41	
Presentation of newborn					< 0.001
Cephalic	22,941	8.9	1.00		
Breech	968	62.9	7.43	4.37-12.64	
Shoulder	152	5.3	0.59	0.09-4.04	
Congenital malformation					< 0.001
No	23,914	9.5	1.00		
Yes	147	230.3	31.17	18.23-53.29	
Apgar < 7 at 5th minute of life					< 0.001
No	22,904	6.6	1.00		
Yes	216	399.3	100.61	62.95-160.79	
Mechanical ventilation					< 0.001
No	23,631	3.1	1.00		
Yes	430	370.2	188.25	122.68-288.87	
Surfactant used					< 0.001
No	22,732	7.8	1.00		
Yes	329	210.4	33.92	21.91-52.49	

95%CI: 95% confidence interval; SUS: Brazilian Unified National Health System; ICU: intensive care unit.

* n not weighted;

** Weighted rates;

*** Excludes women who went into labor.

Note: the total n may vary by the presence of disregarded variables.

bivariate analysis (Table 4). Extreme prematures and babies with low birth weight were 200 to 300 times more likely to die in the first 28 days of life than full-term newborns with birth weight ≥ 2,500g. Likelihood of the same outcome was also very high for newborns with use of mechanical ventilation, those with < 1500g born in hospitals without neonatal ICU, those with intrapartum asphyxia, those with use of surfactant, and those with congenital malformation. Newborns with breech presentation at birth and twins displayed a strong association with neonatal death (OR 5 to 7).

Other factors strongly associated with neonatal death were: risks in the current and prior pregnancies (prior stillbirth, premature and low birth weight babies), mothers with little schooling, multiple hospitals approached before gaining admission, residence in the North region of Brazil, good practices not used during labor and delivery, partograph not used during labor, inadequate prenatal care, public hospital (Brazilian Unified National Health System, SUS), referral hospital for high-risk pregnancy and hospital with neonatal ICU, and not having a companion at some or any time during hospital stay for childbirth.

In relation to the markers for care and for health system organization, most of the deaths occurred in hospitals of the SUS, 50% of babies weighing < 1,500g were born in hospitals without neonatal ICU, 23.3% of mothers received inad-

equate prenatal care entailing four times higher risk of neonatal death, while about 40% were not admitted to the first hospital approached and had no companion during their hospital stay for childbirth. Little use was made of partographs to monitor labor, either among newborns who survived (35.7%) or among those who died (36.5%) (Tables 3 and 4).

Table 5 shows the final model, which does not include the variables mother's race/skin color and parity ($p > 0.20$), delivery type (already considered in the variable partograph), hospital with ICU, and < 1,500g birth weight in hospital without neonatal ICU (collinearity). The variables removed from the final model ($p > 0.10$) were social class and municipality type (Block 1), prior stillbirth and low birth weight (Block 2), use of surfactant and gestational age (Block 4).

The variables that continued associated with neonatal death were, in decreasing order of magnitude of association: very low birth weight; mechanical ventilation; congenital malformation; intrapartum asphyxia; maternal complications during pregnancy; breech presentation; twins; mothers with little schooling; North and Northeast regions; prior stillbirth; multiple hospitals approached for admission; partograph not used during labor; inadequate prenatal care; mother without companion; prior premature; high-risk pregnancy referral hospital; and male sex.

Discussion

The neonatal mortality found in this study approximates to that observed for Brazil in 2010, of 11.2 per 1,000 live births. Prematurity and low birth weight (especially extremely low birth weight) were the main factors associated with neonatal death. The predominant characteristics of neonatal deaths (very low birth weight and prematurity, followed by congenital malformation) approximate Brazil to more developed countries, where the vast majority of infant deaths occur among newborns with lesser likelihood of survival [4,28,29]. Variables indicating greater severity in newborns were maintained associated to neonatal death.

Late prematurity was associated with 17.1% of neonatal deaths, nine times the likelihood of neonatal death for term newborns. This is related to the growing concern in Brazil over the tendency to increasing prematurity, which affected 11.5% of live births in 2011 [30], a level far higher than in developed countries, where rates are around 7% [1,28,31]. In that scenario, it is fundamental to invest in measures to prevent avoidable prematurity, in addition to improving care for these more vulnerable newborns. Two goals should be kept in focus: prevention in prenatal care, including control of infections and risks in pregnancy, and prevention of iatrogenic prematurity [3,29] relating to undue interruption of pregnancy, as in caesarian sections without technical indication, which are a serious problem in Brazil and contribute to the high total prevalence of caesarian sections [3,31,32].

Another cause of avoidable and neonatal death that demands specific action is intrapartum asphyxia: 18% of the newborns who died were term babies and 40.9% scored Apgar < 7 at the 5th minute of life. In Brazil reducing this cause of death is closely related to hospital care during labor and delivery, because the vast majority of deliveries and deaths occur in hospitals and are attended by trained professionals [6]. The causes of intrapartum asphyxia need to be recognized if it is to be prevented. In addition to prenatal care measures to prevent problems of intrauterine hypoxia, according to Lawn et al. [33], delay in adequate interventions by health services could avert some 36% of intrapartum related deaths in countries where access has been provided to care during childbirth, as in Brazil.

This study pointed to problems in the quality of prenatal care and care during childbirth. Good practices during labor were not used just as frequently among live births (96.6%) as among deaths (99%) and, as a result, there was no significant difference between the groups. It was practically an exception for good practices to be used during childbirth. The Kristeller maneuver, which is not recommended by scientific evidence, was often performed, both among surviving live births and among newborns who died [23,34]. Meanwhile, little use was made of recommended practices, such as the partograph to monitor labor, upright delivery positions, and so on [29].

The association between perinatal outcomes and the care process has not been as widely recognized Brazil as it should. Implementation of good practices during labor and childbirth is a powerful measure to prevent avoidable neonatal deaths and, as a result, to reduce infant mortality. Persistent use of procedures not recommended by scientific evidence – such as excessive use of oxytocin, immobilization in bed and delivery in the lithotomy position, in which the major vessels are compressed, for instance – compromises intrauterine oxygenation, prolongs labor and delivery, and may cause adverse effects on perinatal outcomes [35]. Coupled to these poor practices, the situations of stress that mothers about to give birth are subject to, such as fasting, solitude, insecurity and disrespectful treatment, also influence perinatal outcomes [25].

Table 5

Final model of factors associated with neonatal mortality. Brazil, 2011-2012.

Selected variables	Adjusted OR	95%CI	Adjusted chi-square (p-value)
Block 1			
Region of Brazil			0.013
South	1.00		
Central	1.37	0.66-1.85	
Southeast	1.23	0.63-2.39	
Northeast	2.36	1.14-4.88	
North	3.48	1.57-7.73	
Mother's schooling			0.019
Complete University or more	1.00		
Complete Secondary School	2.35	0.97-5.68	
Complete Primary School	4.24	1.61-11.16	
Incomplete Primary School	3.60	1.43-9.07	
Mother's marital status			< 0.001
With spouse	1.00		
Without spouse	2.49	1.69-3.66	
Mother's age (years)			0.095
20-34	1.00		
11-19	0.85	0.48-1.48	
≥ 35	1.62	0.95-2.78	
Sex of newborn			0.015
Female	1.00		
Male	1.49	1.08-2.05	
Block 2 *			
Prior stillbirth			< 0.001
No	1.00		
Yes	3.62	2.05-6.41	
Prior pre-term birth			0.027
No	1.00		
Yes	1.84	1.07-3.17	
Gestation type			< 0.001
Single	1.00		
Twin	4.79	2.37-9.68	
Adequate antenatal care (Kotelchuk)			0.012
More than adequate	1.00		
Adequate	2.27	1.30-3.94	
Partly adequate	2.30	1.10-4.83	
Inadequate	2.84	1.44-5.62	
Maternal complications during pregnancy			< 0.001
No	1.00		
Yes	6.07	3.85-9.55	

(continues)

Table 5 (continued)

Selected variables	Adjusted OR	95%CI	Adjusted chi-square (p-value)
Block 3 **			
Referral hospital for high-risk pregnancy			0.011
No	1.00		
Yes	1.91	1.16-3.15	
Admission denied at first hospital approached			< 0.001
No	1.00		
Yes	3.17	2.26-4.43	
Partograph used			< 0.001
Yes	1.00		
No	2.97	1.82-4.83	
Cesarean section	1.65	0.94-2.89	
Companion present			0.092
Always	1.00		
Sometimes	1.67	1.05-2.67	
Never	1.48	0.88-2.48	
Block 4 ***			
Birth weight (g)			< 0.001
≥ 2,500	1.00		
1,500-2,499	5.19	2.44-11.04	
< 1,500	32.27	12.65-82.35	
Presentation of newborn			< 0.001
Cephalic	1.00		
Breech	4.09	1.97-8.48	
Shoulder	0.19	0.02-2.28	
Congenital malformation			< 0.001
No	1.00		
Yes	16.55	6.47-42.38	
Apgar < 7 at 5th minute of life			< 0.001
No	1.00		
Yes	15.79	6.54-38.14	
Mechanical ventilation			< 0.001
No	1.00		
Yes	25.68	11.66-56.53	

* Block 2: model fitted for significant variables from Block 1;

** Block 3: model fitted for significant variables from Blocks 1 and 2;

** Block 4: model fitted for significant variables from Blocks 1, 2 and 3.

95%CI: confidence interval.

In order to change the present situation, it is fundamental to change the model of care, especially in labor and birth, by improving the quality of care provided once access is assured; it is no longer enough to go on offering more of the same [36]. The Ministry of Health initiative, *Rede Cegonha* [37], proposes to alter the model of labor and delivery care by using multidisciplinary teams that include obstetric nurses/obstetricians, using protocols and monitoring service indicators with target-coupled funding. That model is being encouraged in other countries, including New Zealand, Canada, United Kingdom, Holland, Japan and Australia [38], and is being used experimentally at the local level in Brazil with significant perinatal outcomes, such as reduced mortality from intrapartum asphyxia [39].

Brazil's successful efforts to improve the quality of care for newborns requiring neonatal resuscitation needs to be expanded to primary prevention of intrapartum asphyxia. It is recommended that perinatal care, from the moment

the expectant mother is admitted and throughout labor, should indeed be the work of a team including those professions that traditionally take responsibility for the child only after birth (pediatricians, nurses and other personnel). The multidisciplinary team should be co-responsible from the moment the expectant mother is admitted, in order to ensure that appropriate technologies are used (immediate reception, free choice of companion, doula, methods to afford comfort from pain, free choice of birthing position, and so on), and use of protocols to foster physiological progression of labor without unwarranted interventions.

Other care markers reflected problems in the organization of the perinatal care system, such as women about to give birth having to approach more than one hospital before gaining admission, and at-risk newborns being delivered in inappropriate places. Women in labor need urgent care and should be attended to immediately at a health service. Extreme prematures should be born in a higher-complexity hospital; that may be decisive to their survival and obviates the need for subsequent transfer to such a facility after delivery, which entails added risks. In this study, approximately 50% of babies weighing < 1,500g born in hospitals without neonatal ICU died.

The traditional association of neonatal death with factors such as mother's race/skin color and social class did not continue to hold, but this inequality was demonstrated in the association with mothers' lack of schooling. Some authors have pointed to the decrease in neonatal mortality inequality as a result of the economic betterment of the lower-income population and improved access to health services, growth in the numbers of private health plan users in the major metropolises and so on [40,41,42]. On the other hand, the results may have been influenced by the fact that the poorer population (resident in smaller municipalities with facilities handling < 500 births/year and home births) did not take part in the study. Future studies could consider more sensitive indicators and analyses to capture probable intra-urban and intra-regional socioeconomic differences in neonatal mortality. Another aspect that must be considered a limitation of this study was the utilization of hospitals record data of births and deaths, which hinges on the quality of information (for instance, recording the health care process performed, causes of neonatal death and socioeconomic and demographic particulars, such as race/skin color), which can obscure possible inequities.

The North and Northeast regions continued to show association with neonatal death and showed the highest rates of death from perinatal infection, reflecting the need for greater local investment in organizing and improving the quality of care. If effective, timely, quality care actions are made to reach the most excluded population groups, that will also cause more rapid decline in mortality and in the still existing inequalities [44,45].

Evaluation of the quality of care offered during labor and childbirth in hospitals deserves more in-depth examination, because these are the predominant place of birth in Brazil, and the outcomes of the care processes and markers analyzed in this study were not satisfactory. Prior studies have pointed to important differences in perinatal outcomes associated with hospital performance (material and human resources and care practices), independently of the client characteristics [12,46]. Other studies could explore these aspects in greater depth, detailing care indicators designed to evaluate labor and childbirth care, particularly those relating to the main causes of avoidable death, such as intrapartum asphyxia, iatrogenic prematurity, and infections that are preventable during prenatal care and hospital care for the newborn. Other important aspects to be considered are health professionals' training and placement in childbirth care, evaluation of models of care provided by multidisciplinary teams, sociocultural considerations, such as women's playing a leading role and continuous support for women during childbirth, so as to inform public policies designed to achieve greater reductions in infant mortality.

Intrapartum asphyxia and late prematurity account for approximately 23% of newborn deaths, expressing the avoidability of such deaths and the possibility that implementing recommended practices during labor and delivery will produce greater impact in less time, given that the health services are available. To maximize the reduction in neonatal mortality in Brazil it will be necessary to reinforce public policies with measures more directly related to improving the quality of health care. First, a regionalized perinatal care network must be implemented. Second, investment must be made in implementing scientific evidence-based practices and improving the quality of care processes in prenatal services, and particularly those providing care during labor and childbirth. On the one hand, the perinatal care network must assure pregnant women and their newborns timely access to services at an appropriate level of complexity. On the other, they must be guaranteed access to the best care practices available in state-of-the-art knowledge, and the severe, generalized gap between childbirth

care practices in Brazil and scientific evidence-based recommendations must be closed. One example would be the presence of a companion during labor, which is still only incipient in Brazil, although the right has been guaranteed by federal law since 2005.

This study profiled neonatal deaths in Brazil and the main related problems. It indicated that further progress in reducing neonatal mortality and, as a result, infant mortality – as well as maternal deaths and avoidable fetal deaths, given that the related problems in care are similar – will depend on establishing a regionalized, hierarchical, integrated network and on improving the quality of care processes, especially during labor and childbirth.

Resumen

Se trata de un estudio de cohorte sobre la mortalidad neonatal en la investigación Nacer en Brasil, con entrevistas y revisión de los registros médicos de 23.940 mujeres durante el posparto, entre febrero de 2011 y octubre de 2012. Se utilizó el modelado jerárquico con el fin de analizar los factores de riesgo potenciales para la muerte neonatal. La tasa de mortalidad fue de 11,1/1.000; mayor en las regiones Norte y Nordeste y en las clases sociales más bajas. El bajo peso al nacer, el riesgo gestacional y la condición del recién nacido fueron los principales factores asociados a la mortalidad neonatal. Una asistencia prenatal y al parto inadecuados indican una calidad insuficiente de atención. La peregrinación de las mujeres embarazadas durante el parto y el nacimiento de niños con peso < 1.500g en un hospital sin unidad de cuidado intensivo neonatal demostró deficiencias en la organización de la red de salud. El motivo final de las muertes de los recién nacidos por asfixia intraparto y la prematuridad tardía expresan la posibilidad de que las muertes podrían haber sido evitadas. La cualificación en la atención, especialmente en la prestación de atención hospitalaria se configura como un foco prioritario para la política pública y el progreso en la reducción de la mortalidad infantil y las desigualdades.

Mortalidad Infantil; Atención Hospitalaria; Evaluación de Servicios de Salud; Parto

Contributors

S. Lansky took part in the conception, design, and data analysis and interpretation; drafting of the article, final approval of the version for publication, and was responsible for guaranteeing the accuracy and completeness of the article on all aspects of the study. A. A. L. Friche, A. A. M. Silva and M. L. Carvalho participated in the data analysis and interpretation, drafting the article and critical review of the intellectual content. D. Campos and S. D. A. Bittencourt collaborated on data acquisition, analysis and interpretation, and critical review of the intellectual content. P. G. Frias, R. S. Cavalcante and A. J. L. A. Cunha contributed to critical review of the intellectual content.

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References

1. Maranhão AGK, Vasconcelos AMN, Trindade CM, Victora CG, Rabello Neto DL, Porto D, et al. Mortalidade infantil no Brasil: tendências, componentes e causas de morte no período de 2000 a 2010. In: Departamento de Análise de Situação de Saúde, Secretaria de Vigilância em Saúde, Ministério da Saúde, organizadores. Saúde Brasil 2011: uma análise da situação de saúde e a vigilância da saúde da mulher. v. 1. Brasília: Ministério da Saúde; 2012. p. 163-82.
2. Murray CJ, Laakso T, Shibuya K, Hill K, Lopez AD. Can we achieve Millennium Development Goal 4? New analysis of country trends and forecasts of under-5 mortality to 2015. Lancet 2007; 370:1040-54.
3. Victora CG, Aquino EML, Leal MC, Monteiro CA, Barros FC, Szwarcwald CL. Maternal and child health in Brazil: progress and challenges. Lancet 2011; 377:1863-76.
4. Barros FC, Matijasevich A, Requejo JH, Giugliani E, Maranhão AG, Monteiro CA, et al. Recent trends in maternal, newborn, and child health in Brazil: progress toward Millennium Development Goals 4 and 5. Am J Public Health 2010; 100:1877-89.
5. França E, Lansky S. Mortalidade infantil neonatal no Brasil: Situação, tendências e perspectivas. In: Rede Interagencial de Informações para Saúde, organizador. Demografia e saúde: contribuição para análise de situação e tendências. Brasília: Organização Pan-Americana da Saúde; 2009. p. 83-112. (Série G. Estatística e Informação em Saúde) (Série Informe de Situação e Tendências).
6. Liu L, Johnson H, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional and national causes of child mortality in 2000–2010: an updated systematic analysis. Lancet 2002; 379:2151-61.
7. Ministério da Saúde. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher: PNDS 2006. Dimensões do Processo Reprodutivo e da Saúde da Criança. Brasília: Ministério da Saúde; 2009. (Série G. Estatística e Informação em Saúde).
8. Oestergaard MZ, Inoue M, Yoshida S, Mahanani WR, Gore FM, Cousens S, et al. Neonatal mortality levels for 193 countries in 2009 with trends since 1990: a systematic analysis of progress, projections, and priorities. PLoS Med 2011; 8:e1001080.
9. 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.
10. Diniz S, d'Oliveira AFP, Lansky S. Equity and women's health services for contraception, abortion and childbirth in Brazil. Reprod Health Matters 2012; 20:94-101.
11. Lansky S, França E, Kawachi I. Social inequalities in perinatal mortality in Belo Horizonte, Brazil: the role of hospital care. Am J Public Health 2007; 97:867-73.
12. Barros AJD, Matijasevich A, Santos IS, Albernaz EP, Victora CG. Neonatal mortality: description and effect of hospital of birth after risk adjustment. Rev Saúde Pública 2007; 42:1-9.
13. Lee ACC, Cousens S, Darmstadt GL, Blencowe H, Pattinson R, Moran NF, et al. Care during labor and birth for the prevention of intra-partum-related neonatal deaths: a systematic review and Delphi estimation of mortality effect. BMC Public Health 2011; 11(Suppl 3):S10.
14. 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.
15. do Carmo Leal MC, Silva AAM, Dias MAB, Gama SGN, Rattner D, Moreira ME, et al. Birth in Brazil: national survey into labour and birth. Reprod Health 2012; 9:15.
16. Newcombe HB. Record linkage: methods for health and statistical studies, administration and business. New York: Oxford University Press; 1989.
17. Camargo Jr. KR, Coeli CM. Reclink: aplicativo para o relacionamento de banco de dados implementando o método probabilistic record linkage. Cad Saúde Pública 2000; 16:439-47.
18. Camargo Jr. KR, Coeli CM. OpenRecLink: guia do usuário. http://download2.polytechnic.edu.na/pub4/sourceforge/r/re/reclink/guiausuario.pdf (accessed on Mar/2013).
19. Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. Popul Dev Rev 1984; 10:25-45
20. Lima S, Carvalho ML Vasconcelos AGG. Proposta de modelo hierarquizado aplicado à investigação de fatores de risco de óbito infantil neonatal. Cad Saúde Pública 2008; 24:1910-6.
21. Kotelchuck M. An evaluation of the Kessner Adequacy of Prenatal-Care Index and a proposed Adequacy of Prenatal-Care Utilization Index. Am J Public Health 1994; 84:1414-20.
22. Organização Mundial da Saúde. Maternidade segura: assistência ao parto normal. Um guia prático. Brasília: Organização Mundial da Saúde; 1996.
23. Berghella V, Baxter JK, Chauhan SP. Evidence-based labor and delivery management. Am J Obstet Gynecol 2008; 199:445-54.
24. Ministério da Saúde. Guia de prática clínica sobre cuidados com o parto normal. Brasília: Ministério da Saúde; 2010.
25. Hodnett ED, Gales S, Hofmeyr GJ, Sakala C, Weston J. Continuous support for women during childbirth. Cochrane Database Syst Rev 2011; (2):CD003766.
26. Departamento de Ações Programáticas e Estratégicas, Secretaria de Atenção à Saúde, Ministério da Saúde. Além da sobrevivência: práticas integradas de atenção ao parto, benéficas para a nutrição e a saúde de mães e crianças. Brasília: Ministério da Saúde; 2011. (Série F. Comunicação e Educação em Saúde).
27. Schoeps D, Almeida MF, Alencar GP, França Jr. I, Novaes HMD, Siqueira AAF, et al. Fatores de risco para mortalidade neonatal precoce. Rev Saúde Pública 2007; 41:1013-22.

28. Beck S, Wojdyla D, Say L, Pilar Betran A, Merialdi M, Harris Requejo J, et al. The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity. Bull World Health Organ 2010; 88:31-8.
29. Hofmeyr GJ, Haws RA, Bergstrom S, Lee AC, Okong P, Darmstadt GL, et al. Obstetric care in low-resource settings: what, who, and how to overcome challenges to scale up? Int J Gynaecol Obstet 2009; 107 (Suppl 1):S21-44.
30. Pereira APE, Leal MC, Gama SNG, 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.
31 Howson CP, Kinney MV, Lawn JE. Born too soon: the global action report on preterm birth. Geneva: World Health Organization; 2012.
32. Santos IS, Matijasevich A, Silveira MF, Sclowitz IK, Barros AJ, Victora CG, et al. Associated factors and consequences of late preterm birth: results from the 2004 Pelotas birth cohort. Pediatr Perinat Epidemiol 2008; 22:350-9.
33. Lawn JE, Kinney M, Lee ACC, Chopra M, Donnay F, Paul VK, et al. Reducing intrapartum-related deaths and disability: can the health system deliver? J Int Fed Gynaecol Obstet 2009; 17 (Suppl 1):S123-40.
34. Leal M, Pereira APE, Domingues RMSM, Theme Filha MM, Dias MAB, Nakamura-Pereira M, et al. Intervenções obstétricas durante o trabalho de parto e parto em mulheres brasileiras de risco habitual. Cad Saúde Pública 2014; 30 Suppl:S17-47.
35. Clark SL, Simpson KR, Knox E, Garite TJ. Oxytocin: new perspectives on an old drug. Am J Obstet Gynecol 2009; 200:35.e1-6.
36. Victora CG, Wagstaff A, Schellenberg JA, Gwatkin D, Claeson M, Habicht JP. Applying an equity lens to child health and mortality: more of the same is not enough. Lancet 2003; 362:233-41.
37. Ministério da Saúde. Rede Cegonha. http://portal.saude.gov.br/PORTAL/SAUDE/GESTOR/AREA.CMF?ID_AREA=1816 (accessed on Mar/2013).
38. Davis-Floyd RE, Barclay L, Tritten J, Daviss B. Birth models that work. London: University of California Press; 2009.
39. Pattinson R, Kerber K, Buchmann E, Friberg IK, Belizan M, Lansky S, et al. Lancet's Stillbirths Series steering committee. Lancet 2011; 377:1610-23.
40. Goldani MZ, Benatti R, Silva AAM, Bettiol H, Correa JCW, Tietzmann M, et al. Redução das desigualdades na mortalidade infantil na região Sul do Brasil. Rev Saúde Pública 2002; 36:478-83.
41. Garcia LP, Santana LR. Evolução das desigualdades socioeconômicas na mortalidade infantil no Brasil, 1993-2008. Ciênc Saúde Coletiva 2011; 16:3717-28.
42. Gakidou E, Cowling K, Lozano R, Murray CJL. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis. Lancet 2010; 376: 959-74.
43. Barros AJ, Ronsmans C, Axelson H, Loaiza E, Bertoldi AD, França GV, et al. Equity in maternal, newborn, and child health interventions in Countdown to 2015: a retrospective review of survey data from 54 countries. Lancet 2012; 379:1225-33.
44. Children's Rights & Emergency Relief Organization. Progress for children: achieving the MDG's with equity. v. 9. New York: Children's Rights & Emergency Relief Organization; 2010.
45. Souza A, Hill K, Poz MRD. Sub-national assessment of inequality trends in neonatal and child mortality in Brazil. Int J Equity Health 2010; 9:21.
46. Lansky S, Subramanian SV, França E, Kawachi I. Higher perinatal mortality in National Public Health System hospitals in Belo Horizonte, Brazil. BJOG 2007; 114:1240-5.

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