Determinantes da mortalidade neonatal e pós-neonatal no Município de São Paulo*

Determinants of neonatal and post-neonatal mortality in the City of São Paulo

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Resumo

Introdução: Nos países em desenvolvimento, nos anos 90, a mortalidade na infância (de menores de cinco anos) apresentou declínio proporcional maior do que o da mortalidade infantil. Para a redução da mortalidade na infância, deve-se entender, logo, os determinantes da mortalidade infantil. **Material e Métodos:** Relacionou-se probabilisticamente dados do SIM e do SINASC: 209628 nascidos vivos e 3842 óbitos infantis do Município de São Paulo, coorte de 1998. Utilizou-se regressão logística para analisar fatores de risco da mortalidade neonatal e pós-neonatal: peso ao nascer, idade gestacional, escores Apgar ao primeiro e quinto minuto, tipo de parto, pluralidade, sexo, educação e idade da mãe, número de perdas anteriores, número de consultas pré-natal, raça, parturição e desenvolvimento da comunidade. **Resultados e Conclusões:** Filhos de mães mais velhas apresentaram menor risco de morte neonatal, e, de mães adolescentes, maior risco de morte na infância. Associação significativa foi encontrada entre parturição acima de três e morte pós-neonatal. Não houve associação de parto cesáreo e mortalidade infantil. Houve associação entre morte neonatal e número baixo de visitas pré-natal, baixo peso ao nascer, nascimento de pré-termo e escores Apgar baixos; e entre morte pós-neonatal e número baixo de visitas pré-natal, baixo peso ao nascer, e escores Apgar baixos. A associação de residência da mãe numa comunidade mais desenvolvida e sobrevivência infantil sugere que fatores não controlados estão por trás deste resultado.

Palavras-chave: Mortalidade neonatal. Mortalidade pós-neonatal. Município de São Paulo. Fatores de risco.

Abstract

Introduction: Child Mortality (mortality of children less than five years) has declined considerably in the developing world in the 1990s, but the Infant Mortality has declined less. Therefore, to further reduce child mortality it is important to understand the determinants of neonatal and post-neonatal mortality. **Material and Methods:** We probabilistically matched 209628 live births and 3842 infant death records from the City of São Paulo, birth cohort of 1998. Data came from SINASC and SIM. We then used logistic regression to analyze the following risk factors of neonatal and post-neonatal mortality: birth weight, gestational age, Apgar scores at 1 and 5 minutes, delivery mode, plurality, sex, maternal education, maternal age, number of prior losses, prenatal care, race, parity and community development. **Results and Conclusion:** Infants of older mothers were less likely to die in the neonatal period; infants of adolescent mothers were more likely to die in both periods. Parities four or higher increased the likelihood of post-neonatal death. Cesarean delivery was not found to be associated with infant mortality. Low number of prenatal care visits, low birth weight, preterm birth and low Apgar scores were associated with neonatal death; Low number of prenatal care visits, low birth weight, and low Apgar scores were associated with post-neonatal death. Finally, having a mother live in a highest developed community decreased the likelihood of infant death, suggesting that unmeasured factors are behind such association.

Key words: Neonatal mortality. Post-neonatal mortality. City of São Paulo. Risk factors

Introduction

Determinants of infant and child mortality have been extensively studied in demographic and epidemiological research and an important conclusion is that in the 1990s there was a continued decrease in mortality among infants and children in most of the developing world[1]. This sustained decline is mostly a result of child survival interventions, such as immunization and oral rehydration[2]. The average decline in child mortality in the 1990s was estimated to be most pronounced in ages 2 to 4 (10.5% decrease), and for children aged one year (4% decrease). Neonatal and post-neonatal mortality rates declined less, 3.0% and 2.5% decrease, respectively[1], and as a consequence there is an increasing proportion of infant deaths occurring in the neonatal period, which now accounts, worldwide, for two thirds of deaths in children less than one year old, and nearly four-tenths of all deaths in children less than five years of age[3]. Therefore, to further reduce child mortality, factors associated with infant mortality, which experienced the slowest pace of decline, must be addressed.

In this article we study determinants described in the literature as most likely to exert an effect on infant survival, provided that they were available in our data. Thus, we analyzed proximate determinants of neonatal and post-neonatal mortality (sex, plurality, mode of delivery, prior losses, Apgar scores at one and at five minutes, gestational age, prenatal care and birth weight), less proximate determinants (parity and maternal age) and distal determinants (race, maternal education and community development) for the 1998-birth cohort, City of São Paulo. Apgar scores, birth weight and gestational age are highly correlated with infant survival and in combination are a measure of the newborn's well-being, success of resuscitative efforts, newborn's size, and maturity[4]. Twins or higher order births account for a disproportionate large percent of dead infants in all populations[5]; male infants are known to be more likely to die in the first year of life[6]. The association between mode of delivery and infant survival is controversial though, as a review[7] shows. A mother with a higher number of prior losses is also considered to bear infants with higher risks of death, probably due to higher risks of malformation[8] and mothers with higher number of prenatal care visits are more likely to bear children with lower risks of death in infancy and it has been suggested that the effect is more pronounced in developing than in developed countries[9]. Race is another variable that has to be considered in the analysis, since black infants usually experience much worse health status compared to whites[10]. Maternal education may lower infant mortality since educated mothers are less likely to accept fatalist explanations and are more likely to manipulate modern medical systems than less educated mothers[11]. Also, maternal education may be seen, at least partially, as a surrogate for household income, which negatively affects infant death. Higher parities (four or higher previous live births) and nulliparities are considered to exert an extra risk for birth outcomes and they are likely to reflect deviance from the normal uterine function. Also, high parity can be seen as a marker for low social status and income which affects infant death[12] and is possibly capturing effects of closely spaced births known to be deleterious to infant survival[13]. Regarding maternal age, various socioeconomic disadvantages and suboptimal health outcomes are associated with adolescent pregnancy, such as insufficient education, limited career and job opportunities and poor conditions for effective parenting[14]. Women age 35 and older are also at higher risk for chromosomal abnormalities and other factors associated with higher risks of infant mortality[15]. Finally, the community where the mother resides may affect infant survival given it may influence attitudes and behavior. Some characteristics may influence more directly birth outcomes, such as the availability of health services and environmental pollution[16]. In this article, which is part of the one of the author's doctoral dissertation submitted to The Johns Hopkins University in 2002, our aim is to evaluate the importance of each of those factors on neonatal and post-neonatal mortality and compare and contrast the results.

Material and Methods

We used information from the SINASC (Information System on Live Births) and from SIM (Information System on Mortality) from the 1998-birth cohort whose mother's place of residence in 1998 was the City of São Paulo. We obtained the data on live births and also on infant deaths, assuming that the mother's place of residence at the time of birth was the same place of residence at the time of infants death; full explanation of results and methods are described in detail elsewhere[7]. In brief, we considered that a one-to-one relationship should hold between records in the two files. We used birth date, place of maternal residence, birth weight, sex, delivery mode, plurality and maternal age present as identifiers in both files to match the records. Unfortunately, we eventually had to accept more than one birth record per death record, since we had no basis whatsoever to rule out the extra records. In order to deal with this problem we gave a weight to each of the 12,426 matched pairs. The weight given to each pair represented how sure we are that the matched pair was correctly assigned to the same infant. It was assumed that certainty was inversely related to the number of matches for each infant who died. Death records with fewer matches received higher weights compared to the others. The weight was the inverse of the number of times the death record appeared in the matched file. Table 1 shows the distribution of weights for the death records and for matched pairs. Most death records were matched to one birth record only (66%) and received a weight of 1.0.What this means is that we established a one-to-one relationship between a death record in one file and a birth record in another file, which was expected and desirable, for 66% of all deaths. Even though we could not match each death record with its respec-

Table 1 – Distribution of weights for matched pairs.
***Tabela 1** – Distribuição de pesos para dados pareados*

Weights	Number of deaths	%	Cum %	Number of Pairs	%	Cum %
1.00	2517	65.5	65.5	2517	20.6	20.6
0.50	602	15.7	81.2	1204	9.7	30.3
0.33	233	6.1	87.3	798	6.4	36.7
0.25	157	4.1	91.4	628	5.0	41.7
0.20 to 0.10	144	3.7	95.1	1454	11.7	53.3
0.09 or less	189	4.9	100.0	5825	46.9	100.0
TOTAL	3842	100.0		12426	100.0	

Mean Weight for deaths: 0.78
Modal Weight for deaths: 1.00
Median for deaths: 1.00
Centile (5^{th}, 95^{th}): (0.17; 1.00)

Source/Fonte: DATASUS www.datasus.gov.br - 2000

tive birth record, the vast majority was matched to at least two birth records and received a weight of 1.0 or 0.5 (81%). When we merged the birth record file to the matched file, in order to obtain a combination of all infants exposed to infant death, we gave the birth records that were not involved in any matched pair (presumably infants that did not die) a weight of 1.0 (197,408 birth records). For the analysis of matched data we used the STATA 6 software.

The coverage of events from SIM and SINASC in the State of São Paulo is considered excellent, close to 100%. A comprehensive review of literature is elsewhere[7]. Validity and internal consistency of the data were checked very throughout earlier work [7] and data were considered of good quality on this matter. Consistency and validity were examined with empirical regularities observed in other populations or with the criterion of plausibility[7].

Variable Constructs

The outcome variables are whether or not an infant died in the neonatal period, and whether or not an infant died in the post-neonatal period. We created an indicator variable of neonatal mortality (dying before 28 days of life) after merging the matched file and the birth record file. From this birth cohort of 209,628 infants, 2,581 infants died in the neonatal period (12.3 per 1,000 live births). An indicator variable for post-neonatal mortality (from 28 days of life to eleven months) was also created, the reference category being those who survived to 28 days. From 207,047 infants exposed to a post-neonatal death, 1,261 died within eleven months of life (6.1 per 1,000).

Explanatory variables were classified in proximate determinants (Apgar scores at one and at five minutes, birth weight, gestational age, prenatal care, sex, plurality, prior losses and mode of delivery), less proximate determinants (parity and maternal age) and distal determinants (race, maternal education and community development). We classified both Apgar scores in: below 7; 7 and 8; 9 and 10; and unknown. In earlier results[7] we observed that Apgar scores seemed biased towards high values and we hypothesized that infants considered healthy, are given Apgar scores 9 or 10 without much adherence to specific score components. Hence, an infant with an Apgar score of 7 or 8 may be perceived to be less healthy than an infant of Apgar 9 or 10. Infants with Apgar scores of 7 or 8 may thus be at increased risk of dying in the neonatal or post-neonatal period. Birth weight was categorized into nine groups of 500 grams each (less than 1,000 g, 1,000 to 1,499 g, 1,500 to 1,999 g, 2,000 to 2,499 g; 2,500 to 2,999 g, 3,000 to 3,499 g, 3,500 to 3,999 g, 4,000 to 4,499 g, 4,500 g or higher, and missing birth weight). Categories of gestational age were taken as '27 weeks or less', '28 to 36 weeks', '37 to 41 weeks', and '42 weeks or more' and missing. Infants were also categorized according to whether they were singleton births, non-singleton births or this category was missing. Infants were also classified based on whether the delivery was normal; a cesarean; other (primarily forceps); and for unknown mode of delivery. The number of prenatal-care visits was classified based on the existing categories: no visits, 1 to 6 visits, 7 or more visits and unknown number of visits.

Finally, the number of stillbirths and abortions were considered together in a category called "prior losses" and we created four categories: no prior loss, one prior loss, more than one prior loss; and missing information on prior loss.

Maternal age was categorized into consecutive five-year age groups from 15 upwards, as it is done in most demographic research, and a first category of 11 to 14, to estimate the effect of very young maternal age on infant mortality. The last category was 40 and over; and finally an additional category for missing age. We categorized parity as zero parity; parity one; parity two or three; parity four or higher; and missing parity[17].

In categorizing race, given that whites have historically been the most affluent group in Brazil, and because among the non-white, 97% are mixed race or black, we defined two categories: "white" and "non-white" and "missing" (67% of all infants). We classified maternal education in: illiterate; incomplete elementary education; complete elementary education; secondary school; college and an additional category for missing. Information at the community (or district) level exists for each of the 96 districts in the City of São Paulo. To capture community effects, we created an indicator variable of development for each district and used the method of principal components' analysis to weight different district level indicators[18, 19, 20]. Principal components' analysis uses linear combinations of variables to explain sets of observations on many variables and simplify information contained in a group of variables[18, 19, 20]. The method applied here summarized the district-level information on 18 variables, including average educational attainment of the household head, average household income, average access to health services and other facilities, in each district, among others. The technique created a set of mutually uncorrelated components of the data. Intuitively, the first principal component is the linear index that captures the most common variation among the components obtained[18]. We used STATA's 6 factor command and specified the principal components' option within the command.

All community indicator variables were based on the 1991 population census, 1996 population counts, and other district level information, such as the number of school enrollments and unmet need for services such as health care centers in each district. Most indicators are summarized in an index developed for each district called the "Index of Social Exclusion/Inclusion"[21, 22]. The interpretation of each index is that the higher the value of the index, the higher the average degree of 'social inclusion' of its population into the society, i.e., the better off the population of the district is, in comparison to all other districts. Therefore, the interpretation is quite intuitive – the higher, the better. For some variables, though, we only had rates or percentages or even absolute numbers[21, 22].

The first principal component explained 43.2 percent of the variation in these 18 variables, which is a substantial percentage. The first component serves as a reasonable overall index [20]. In our case, the first component correlated highly and positively with the IEX_IN for household head level of schooling (any), average household income, average rate of employment, average number of bedrooms per house, and very highly and negatively with number of persons living in the same household. Also, it correlated highly and positively with percentage of women that are household heads. We have obtained an index that summarizes dimensions of education, employment, income and also household 'crowding', and in some extent, women's autonomy. The higher the index, the better off is the district, in relation to one another. After the index was constructed, we sorted the infants by 'district development'. The 40% who scored lowest were categorized as living in a 'district with poor development', the middle 40% as living in a 'district with medium development' and the highest scoring 20% were categorized as living in a ' highly developed district'[20].

Multivariate Analysis

The odds ratio is a key measure in many epidemiologic analyses and represents a ratio between the probability that an event occurs and the probability the event does not occur. It measures the relative magnitude of two sets of odds occurring under differing conditions, and it varies from zero to infinity[23]. To obtain an adjusted odds ratio, we used a multivariate logistic regression in order to model the two dichotomous outcomes under study. Because characteristics of mothers and infants from the same community were related, we corrected the standard errors for lack of independence between observations using the Huber/White correction, which assumes that observations are independent across clusters but not within clusters (the community of mother's residence at the time of birth) [24]. We used STATA 6 for the regression analysis and selected the cluster option within the logit command. This approach does not change the coefficients but takes into account the clustering in the covariance matrix.

By chance alone, the ratio between two odds can vary. Therefore, the p-value indicates the probability that the two sets of odds occurring under differing conditions are equal to one, adjusted by all other covariates. The significance of the Wald test of whether the odds ratio is equal to one is given in parenthesis in Table 3, next to the odds ratios[23]. Whenever the p-values fell in between 0.10 and 0.19, the significance was considered marginal and is written in the text. Also, in Table 3, we present the 95% confidence intervals for the odds ratios.

Results

Before we show results from multivariate analysis, we present the distribution for infants who died in the first year of life, from the 1998 birth cohort, in Table 2. As a brief description, most infants had high Apgar scores, were males, singleton births, weighed between 3,000 and 3,500 grams at birth, were term, and were delivered vaginally (even though a very high percentage of infants, 46.2%, were delivered by cesarean section). Most infants who had race or color recorded were white, but 66.3% of the infants did not have this information recorded. Most women did not have any prior losses, had more than seven prenatal care visits (but the percentage is not overwhelming since 32.4% of women had less than 7 visits), delivered their first child, were in the age group 20 to 24 and had only incomplete elementary school. The educational level of these mothers may be considered low: even though 79.1% of all mothers were at least 20 years old, an age by which every person, theoretically, could have finished secondary school, 37% of all mothers were illiterate or did not have an elementary school degree.

The results of the multivariate analysis are in Table 3.

As expected, female infants had a lower odds of dying in the neonatal and post-neonatal period, as compared to male infants (OR=0.85, p=0.001; OR= 0.88, p=0.006, respectively).

Non-singleton births had a significantly lower odds of death in the neonatal period, but not in the post-neonatal period (OR=0.72, p =0.003). This finding is consistent with the idea that after the neonatal period other factors play a role in determining infant health and mortality outcomes. The relative advantage of a twin as compared to a same size singleton birth tends to disappear with age. It is important to remember that after controlling for birth weight and gestational age, twins or higher order births are expected to have a better survival. [25] Infants with no information on plurality had an odds of death in the neonatal and in the post-neonatal pe-

Table 2 – Univariate description of infants, exposed to infant mortality.
***Tabela 2** – Descrição univariada de nascidos vivos, expostos à mortalidade infantil.*

Variable		Distribution (percentages) of infants exposed to infant death
Infant's Sex	Male	50.9
	Female	49.1
	Missing	0.0
Plurality	Singleton	96.6
	Twins or higher order	1.9
	Missing	1.5
Delivery Mode	Normal	49.2
	Cesarean	45.4
	Other	3.9
	Missing	1.5
Prior Losses	None	57.5
	One	9.4
	Two or more	2.9
	Missing	30.2
Apgar score at 1 minute	0 to 6	7.6
	7 and 8	49.9
	9 and 10	38.0
	Missing	4.5
Apgar score at 5 minutes	0 to 6	1.2
	7 and 8	8.7
	9 and 10	85.8
	Missing	4.3
Weeks' Gestation	27 weeks or less	0.5
	28 to 36 weeks	5.2
	37 to 41 weeks	87.4
	42 weeks or more	1.1
	Missing	5.8
Prenatal Visits	None	2.1
	1 to 6 visits	29.9
	7 visits or more	34.9
	Missing	33.1
Birth Weight	999 g or less	0.4
	1000 to 1499 grams	0.8
	1500 to 1999 grams	1.6
	2000 to 2499 grams	6.0
	2500 to 2999 grams	24.6
	3000 to 3499 grams	41.2
	3500 to 3999 grams	20.1
	4000 to 4499 grams	3.7
	4500 grams or higher	0.5
	Missing	1.1
Parity	None	35.2
	One	24.6
	Two or three	16.7
	Four or more	4.1
	Missing	19.4
Maternal Age	11 to 14	0.5
	15 to 19	16.6
	20 to 24	28.5
	25 to 29	25.7
	30 to 34	18.2
	35 to 39	8.0
	40 or higher	2.0
	Missing	0.5

Table 2 – (continued)
Tabela 2 *– (continuação)*

Variable		Distribution (percentages) of infants exposed to infant death
Race/color	White	23.1
	Non-White	10.4
	Missing	66.5
Maternal Education	No schooling	1.4
	Elementary, incomplete	35.5
	Elementary, complete	17.3
	Secondary	17.4
	College	7.7
	Unknown schooling	20.7
Community Development	Low	38.5
	Medium	41.1
	High	20.4

Note: Weighted frequency for exposed to infant death: 201206
Nota: Freqüência ponderada dos expostos à mortalidade infantil: 201206
Source/Fonte: DATASUS www.datasus.gov.br - 2000

Note: . Nota:

Table 3 – Adjusted odds ratios for neonatal and post-neonatal mortality, p-values (in parenthesis) and 95% confidence intervals for the odds ratios.
Tabela 3 *– Razões das chances para mortalidade neonatal e pós-neonatal, valores de p (entre parênteses) e intervalos de confiança de 95% para as razões das chances.*

Variable	Odds ratio of dying in the…		95% Confidence Intervals	
	neonatal period	post-neonatal period	neonatal period	post-neonatal period
Infant's Sex (ref: male)				
Female	0.85 (0.001)	0.88 (0.006)	(0.78;0,94)	(0.81;0.96)
Plurality (ref: singleton)				
Twins or higher order	0.72 (0.003)	0.86 (0.359)	(0.58;0.89)	(0.62;1.19)
Unknown plurality	0.59 (0.014)	0.89 (0.621)	(0.39;0.90)	(0.57;1.40)
Delivery Mode (ref: normal)				
Cesarean Section	0.99(0.820)	0.97(0.590)	(0.90;1.09)	(0.89;1.07)
Forceps or other	0.56(0.000)	0.85(0.162)	(0.43;0.74)	(0.67;1.07)
Missing delivery mode	0.52(0.001)	1.22(0.430)	(0.34;0.78)	(0.75;1.98)
Prior losses (ref: no loss)				
One prior loss	1.14(0.079)	1.14(0.052)	(0.99;1.31)	(1.00;1.30)
Two or more losses	1.06(0.585)	1.33(0.035)	(0.86;1.31)	(1.02;1.73)
Unknown number of losses	1.06(0.458)	1.08(0.396)	(0.91;1,22)	(0.91;1.27)
Apgar score 1 minute (ref:7-8)				
0 to 6	1.82(0.000)	1.43(0.000)	(1,58;2.09)	(1.18;1.72)
9 to 10	0.77(0.000)	0.92(0.178)	(0.68;0.87)	(0.81;1.04)
Missing	0.81(0.395)	0.83(0.672)	(0.51;1.31)	(0.35;1.97)
Apgar score 5 minute (ref:7-8)				
0 to 6	4.26(0.000)	1.63(0.009)	(3.65;4.95)	(1.13;2.35)
9 to 10	0.56(0.000)	0.85(0.057)	(0.48;0.65)	(0.72;1.00)
Missing	1.79(0.028)	1.37(0.482)	(1.07;2.99)	(0.57;3.29)

Table 3 – (continued)
Tabela 3 – *(continuação)*

Variable	Odds ratio of dying in the…		95% Confidence Intervals	
	neonatal period	post-neonatal period	neonatal period	post-neonatal period
Weeks'gestation (ref:37-41 w)				
Less 28 weeks	2.34(0.000)	1.05(0.830)	(1.85;2.95)	(0.66;1.68)
28 to 36 weeks	1.37(0.001)	1.11(0.305)	(1.14;1.65)	(0.91;1.34)
42 weeks or more	1.21(0.489)	0.85(0.402)	(0.70;2.10)	(0.57;1.25)
Unknown weeks' gestation	1.16(0.099)	0.91(0.480)	(0.97;1.39)	(0.70;1.18)
Prenatal care visits (ref: 7or more)				
No visits	1.07(0.627)	1.74(0.000)	(0.82;1.40)	(1.34;2.26)
1 to 6 visits	1.15(0.018)	1.06(0.379)	(1.02;1.29)	(0.93;1.20)
Unknown number of visits	1.16(0.045)	1.08(0.262)	(1.00;1.35)	(0.94;1.25)
Birth Weight (ref: 3000 to 3500g)				
999 g or less	62.1(0.000)	15.6(0.000)	(49.3;78.4)	(10.3;23.5)
1000 to 1499 g	21.0(0.000)	8.20(0.000)	(16.9;26.0)	(6.02;11.2)
1500 to 1999 g	7.21(0.000)	2.54(0.000)	(5.96;8.73)	(1.86;3.48)
2000 to 2499 g	2.83(0.000)	1.46(0.000)	(2.40;3.34)	(1.22;1.74)
2500 to 2999 g	1.42(0.000)	1.08(0.667)	(1.25;1.61)	(0.91;1.17)
3500 to 3999 g	1.05(0.458)	0.93(0.320)	(0.92;1.21)	(0.81;1.07)
4000 to 4499 g	0.86(0.301)	0.71(0.031)	(0.65;1.14)	(0.52;0.97)
4500 g or more	1.31(0.360)	1.00(0.997)	(0.74;0.23)	(0.57;1.77)
Missing birth weight	5.43(0.000)	1.08(0.816)	(4.06;7.28)	(0.55;0.21)
Race (ref: white)				
Non-white	0.99(0.922)	1.19(0.025)	(0.83;1.18)	(1.02;1.39)
Missing race	1.03(0.576)	1.12(0.077)	(0.92;1.16)	(0.99;1.26)
Parity (exc. index child) (ref:zero)				
One child	1.07(0.282)	1.05(0.468)	(0.94;1.21)	(0.92;1.21)
Two or three	1.06(0.463)	1.10(0.164)	(0.90;1.26)	(0.96;1.26)
Four or more	1.16(0.188)	1.34(0.041)	(0.93;1.46)	(1.01;1.78)
Unknown parity	0.97(0.741)	1.04(0.695)	(0.79;1.18)	(0.85;1.27)
Maternal Age (ref: 20 to 24)				
11 to 14	1.53(0.035)	1.61(0.069)	(1.03;2.26)	(0.96;2.71)
15 to 19	1.16(0.011)	1.02(0.742)	(1.04;1.30)	(0.89;1.17)
25 to 29	1.01(0.898)	0.97(0.588)	(0.89;1.14)	(0.87;1.08)
30 to 34	0.87(0.066)	0.92(0.241)	(0.75;1.01)	(0.80;1.06)
35 to 39	0.87(0.101)	0.85(0.188)	(0.73;1.03)	(0.67;1.08)
40 or higher	0.62(0.003)	1.01(0.935)	(0.44;0.85)	(0.75;1.37)
Maternal age unknown	3.08(0.000)	0.30(0.030)	(1.78;5.32)	(0.10;0.89)
Maternal education (ref:el incom)				
No schooling	1.22(0.221)	1.26(0.297)	(0.89;1.66)	(0.82;1.93)
Elementary, complete	1.05(0.509)	1.10(0.105)	(0.92;1.20)	(0.98;1.24)
Secondary	0.92(0.243)	1.00(0.952)	(0.79;1.06)	(0.87;1.14)
College	0.93(0.579)	0.85(0.159)	(0.73;1.19)	(0.67;1.07)
Unknown schooling	1.19(0.019)	0.97(0.685)	(1.03;1.37)	(0.84;1.12)
Community development (ref: high)				
Medium	1.33(0.000)	1.17(0.080)	(1.15;1.55)	(0.98;1.40)
Low	1.60(0.000)	1.35(0.004)	(1.37;1.86)	(1.10;1.65)

Source/Fonte: DATASUS www.datasus.gov.br - 2000 riod that were 41% lower and 11% lower. Therefore, more difficult deliveries associated with the delivery of non-singleton births are possibly related to the non-recording of such information.

Cesarean section did not exert any effect on neonatal or post-neonatal death as compared to vaginal deliveries. Another method of delivery substantially reduced the odds of neonatal mortality and marginally reduced the odds of post-neonatal death (OR=0.56, p=0.000 and OR=0.85, p=0.162, respectively).

Infants whose mothers had one prior loss had an increased odds of death. The odds were 14% higher in both the neonatal and post-neonatal period (OR=1.14, p=0.079). The odds of death were also 6 and 33 percent higher in the neonatal and in the post-neonatal period, respectively, (OR=1.06, p=0.585 and OR=1.33, p=0.035, respectively) if the mother had more than one loss, but this finding was significant only for post-neonatal mortality.

As compared to infants with Apgar scores 7 and 8 at one minute, infants with lower Apgar scores at one minute had an odds of dying that were respectively, 82 and 43% higher in the neonatal and in the post-neonatal period (OR=1.82, p=0.000 and OR=1.43, p=0.000, respectively). Infants with scores at one minute 9 and 10 had odds of dying that were 23% and 8% lower in the neonatal and post-neonatal period respectively, (OR=0.77, p=0.000 and OR=0.92, p=0.178, respectively) but the finding was only marginally significant for post-neonatal mortality. Infants with low Apgar scores at five minutes, compared to infants with scores 7 to 8 had an odds of death in the neonatal and post-neonatal period, respectively 4.3 and 1.6 times higher (OR=4.26, p=0.000 and OR=1.63, p=0.000, respectively). Infants with the highest five-minute scores had an odds of death in the neonatal and in the post-neonatal period that were, respectively, 44% and 15% lower as compared to the reference group (OR=0.56, p=0.000 and OR=0.85, p=0.057, respectively). Infants with Apgar score missing at five minutes had an odds of death that were 79% higher than the reference group, indicating that this group more heavily comprises infants who were assigned low scores (OR=1.79, p=0.028)

Preterm infants (28 to 36 weeks), and very preterm infants (less than 28 weeks), had higher odds of death in the neonatal period. Very preterm infants had odds of death 2.3 times higher than their term counterparts (OR=2.34, p=0.000), and those born between 28 to 36 weeks' gestation were 1.4 times more likely to die than their term counterparts (OR=1.37, p=0.001). For the post-neonatal period, the findings for prematurity were not significant. Post-maturity, on the other hand, was associated neither with neonatal death nor post-neonatal death. Finally, infants with missing information had a higher odds of death in the neonatal period (OR=1.16, p=0.099), but not in the post-neonatal period (OR=0.91, p=0.480). Therefore, we have some evidence that preterm infants mostly comprised this group.

If a mother had no prenatal care visits, her infant was at increased odds of neonatal and post-neonatal death, as compared to infants of mothers who had 7 or more prenatal visits. Infants of mothers with 1 to 6 visits had also higher odds of death in the neonatal and in the post-neonatal period as compared with women with the highest number of visits, but the finding was significant for the neonatal period only (OR=1.15, p =0.018, OR=1.06, p =0.379, respectively). Having a missing value for number of prenatal care visits was associated with higher odds of neonatal death and post-neonatal death, but the latter finding was not significant (OR=1.16, p 0.045; OR=1.08, p= 0.262, respectively). It seems then that these infants were more highly represented in such a group of infants.

Infants below 3,000 grams had a higher odds of dying in the neonatal period and in the post-neonatal period than their 3,000 to 3,499 gram-infants counterparts. The weight for which we observed the lowest mortality was in the range 4,000 to 4,499 grams and decreased the odds of death by 14% and by 29% in the neonatal and post-neonatal period, respectively, (OR=0.86, p=0.301 and

OR=0.71, p=0.031, respectively) but the effect was significant only for post-neonatal mortality. Heavier infants appeared to be at increased odds of death, but the coefficient did not reveal significance. Infants with missing information on birth weight had odds of dying in the neonatal period 5.4 times higher as compared to infants in the reference group (OR=5.43, p=0.000). This indicates a higher percentage of low birth weight infants in this category.

There was no significant effect of parity on the odds of dying in the neonatal period, except for a marginal increase in the odds of death for fifth children (OR=1.16, p=0.188). In the post-neonatal period, the significance of this effect was more pronounced: infants who were the fifth child had 34% increased odds of dying in the post-neonatal period as compared to first born-children counterparts (OR=1.34, p=0.041). The effect of being a third to fourth child was marginally significant (OR=1.10, p=0.164) and increased the odds of post-neonatal death. Also, the direction and magnitude of the odds ratio increased from lower to higher parities, which suggests that the higher the number of siblings the higher the risk of post-neonatal death. Lack of information on parity was not associated with neonatal or post-neonatal mortality.

Infants of young adolescent mothers had a 53% increased odds of dying in the neonatal period as compared to infants of mothers 20 to 24 and this figure was 62% in case of death in the post-neonatal period (OR=1.53, p=0.035 and OR=1.62, p=0.069, respectively). For neonatal death, infants of older adolescent mothers also had significantly higher odds of death (OR=1.161, p=0.011). For post-neonatal death, only a marginal significance of age 35 to 39 was noticed in decreasing the odds of neonatal death relative to age 20 to 24 (OR=0.85, p=0.188). This finding suggests that in the presence of most proximate factors, infants of older mothers do better. Since a very low weighed percentage of infants who died had missing information on maternal age, very high and very low odds ratios for missing maternal age category may be seen as a result of instability of coefficients due to small numbers.

Regarding maternal education, having no information on schooling increased the odds of neonatal death only (OR=1.19, p=0.019). The magnitude of the odds ratio indicates that illiterate mothers or those with lower levels of schooling were more likely to be represented in this category.

Being a non-white newborn was significantly associated with post-neonatal mortality but not with neonatal mortality. Non-white infants had an odds of dying in the neonatal period 19% higher compared to their white counterparts (OR=1.19, p=0.025). This effect was found in the post-neonatal period and not in the neonatal period and we may infer that socioeconomic determinants over and above those included in the model that lead to the disadvantage of non-white infants were behind such increased odds of death. Infants with missing information on race/color had significantly higher odds of dying in the post-neonatal period only (OR=1.12, p=0.077), suggesting that non-white infants were more highly represented among infants with missing race/color category.

Having a mother live in a highest developed community reduced the odds of neonatal and post-neonatal death. After controlling for all factors, living in a community with medium development increased the odds of neonatal and post-neonatal death, respectively, by 33 and 17% as compared to living in a highest developed community. The effect of living in a lowest developed community as compared to a highest developed one was to increase the odds of neonatal and post-neonatal death by 60 and 35%, respectively. The result suggests that other proximate determinants or other indicators of socioeconomic status of the mother remained uncontrolled for, or a net effect, over and above proximate factors of community development.

Discussion and Conclusions

In this article we probabilistically matched two datasets in order to study determinants of infant mortality in the City of São Paulo, Brazil. Even though we could not achieve a one-to-one relationship for every death record, we could do so for most death records (over 65%). We stress the importance and the need to conduct further studies using probabilistic matching and to make use of the available data from SINASC and SIM in a combined way. Another drawback of our study is the high percentage of missing information on some variables, such as prior losses, parity, race/color and maternal education. Distortions may indeed have happened in the odds ratios estimations for such variables. For example, for neonatal death, in the case of maternal education, if all or almost all mothers with the lowest level of schooling were misclassified as mothers with unknown level of schooling our conclusions would possibly be slightly different. We would conclude, more certainly, that low levels of schooling would exert a deleterious effect on neonatal mortality, but not on post-neonatal mortality. However, we considered that including a missing category rather than imputing data would be more appropriate in order to find out the particularities of infants with no recording of information.

Considering the substantive results, as compared to mothers 20 to 24, being an adolescent mother increased the odds of neonatal and post-neonatal mortality. In the post-neonatal period, being 11 to 14 decreased the odds of survival. In the neonatal period the effect of older motherhood was to increase the chances of survival. We suggest that after controlling for proximate factors that were associated with disadvantages of infants of older mothers, such as number of prior losses, method of delivery and prenatal care utilization, infants of older mothers have a better chance of neonatal survival. Indeed, though much is assumed about the disadvantage of teenage mothers, motherhood in the early twenties is also likely to be disadvantageous as compared to older motherhood[26]. Older mothers are more likely to be married, and to have less mistimed pregnancies. A pathway may be suggested: women with intended pregnancies tend to be older and more likely to either initiate breastfeeding and also to continue breastfeeding, as compared to mothers with unintended pregnancy, who tended to be younger [26]. Older mothers may also be more likely to highly value continuity of prenatal care and comprehensive care, more than young mothers[27] and are more likely to attend more prenatal care visits, which reduces morbidities throughout the pregnancy period.

A marginal effect of college education for post-neonatal mortality was found (OR=0.845; p=0.159) suggesting that college exerts a protective effect on post-neonatal survival. This maybe the case because as secondary education expanded in recent years in Brazil, and has (especially grades 7 to 9) become mass education. As a consequence, students from previously 'excluded' socio-economic strata are entering the secondary educational system[28]. But college mothers are still a very selective group of Brazilian society, and it is reasonable to assume that the chance of death of their infants would be lower as well.

There was no effect of cesarean section on infant mortality in our data. In the neonatal period, the use of forceps, as compared to vaginal delivery, increased the odds of survival. This finding makes sense, since in the hands of a skilled and experienced physician the use of forceps can hasten the delivery and alleviate possible fetal distress. Its use, then, is ultimately beneficial to infant survival.

A higher number of losses are likely to be related to some morbidity of the mother and difficulties she might have had with previous pregnancies and it is reasonable that infants of mothers with a higher number of prior losses have a higher risk of death. However, we expected that the effect would be more pronounced in the neonatal period rather than in the post-neonatal period. An explanation is that this variable may be partially capturing the effect of socio-economically disadvantaged mothers, who were more exposed to higher percentages of fetal losses (due to infections, or induced abortions, for example).

The same factors that led to fetal losses for these mothers may have been conducive to the post-neonatal death of their infants.

Birth weight, gestational age, and Apgar scores were the most important predictors of neonatal survival, as expected. For post-neonatal mortality, birth weight and Apgar scores were the most important predictors.

Community development remained significant in the presence of all variables used in this study. Our community variable can be seen as an index that comprises overall quality, income level and investment level in the community, as well as education of the household head. It also measures the average household density. More developed communities are more likely to be better served by sanitation connections which improve infant survival. Community infrastructure may also improve hygienic practices[29]. Interactions between friends and neighbors in communities may also lead to change in behavior regarding infant care and in this sense better off communities may benefit from an overall level of community education. These are all suggested pathways through which community development may affect infant survival that were not captured through our variables and may all be reflected in the community variable. Qualitative studies may be a next step in order to understand and minimize health disparities among children of different communities in this population.

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