DOI: 10.1590/1413-81232023282.11162022EN

Proportion and factors associated with Apgar less than 7 in the 5th minute of life: from 1999 to 2019, what has changed?

Alessandra Lourenço Caputo Magalhães (https://orcid.org/0000-0002-8150-3915) [1]
Denise Leite Maia Monteiro (https://orcid.org/0000-0003-4679-1859) [1]
Alexandre José Baptista Trajano (https://orcid.org/0000-0002-0758-1800) [1]
Flavio Monteiro de Souza (https://orcid.org/0000-0002-9906-2695) [1]

Abstract *Although variation between observers in the assessment of the Apgar score, it remains a useful indicator of the general conditions of the newborn. This is a cross-sectional study based on population of live births in Brazil in 1999 and biennium 2018-2019. All declarations of live births (DNV) obtained from the Live Births System database were accessed. Frequencies were compared between groups using Pearson's chi-square test and multivariate logistic regression analysis was performed. A statistical significance level of 0.05 was considered. We included 9.050.521 DNVs in our research. We found that 2,1% of newborns had 5th minute Apgar < 7 in 1999 compared with 0,9% in 2018-2019. Multivariate analysis shows that twins and teenage pregnancy are no longer risk factors. Among risk factors, we observed an increase in prematurity, low birth weight and congenital anomalies. An improvement in maternal markers was observed, especially increase in the number of prenatal consultations and schooling. Such findings demonstrate the importance access and adequate prenatal care and improved socioeconomic conditions as effective strategy to reduce neonatal morbidity and mortality.*

Key words *Asphyxia neonatorum, Apgar score, Delivery of health care*

[1] Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro. Av. Prof. Manuel de Abreu 444, 2º andar, Vila Isabel. 20550-170 Rio de Janeiro RJ Brasil. alecaputom@gmail.com

Introduction

Brazil continues to have high perinatal mortality and morbidity rates. In 2019, 35,293 children died in the country before completing the first year of life, 69% of these deaths in the first month of life and 52% within the first week, corresponding to a neonatal mortality rate of 8.6/1,000 live births[1]. Despite a marked reduction of more than two-thirds in neonatal mortality over the last twenty-five years, its monitoring continues to be a national priority.

Unlike developed countries, such as the United States and the United Kingdom, where the leading isolated cause of death in the neonatal period is congenital malformation[2], the majority of perinatal deaths in Brazil are determined by the pregnant woman's condition and the characteristics of care provided during childbirth and to the newborn[3].

The Apgar score is a rapid method of evaluating the clinical conditions of the newborn. The system proposes a score that varies from zero to 10 and corresponds to the sum of the points obtained by evaluating five criteria: heart rate, respiration, muscle tone, reflex irritability, and color[4]. The ease with which this index can be applied has led to its being used in a large number of studies of perinatal outcomes[5-11]. It is well-known that an Apgar score of less than 7 in the fifth minute of life (Ap5 < 7) is used to evaluate the state of the newborn and indicates a greater possibility of using specialized resources. Recent studies have reinforced its value as a prognostic tool in identifying children at risk[12,13], and in population-based studies, evaluating the Apgar score at the fifth minute is the closest one can get to research on birth conditions[13, 14].

Several studies have described the characteristics of newborns ever since the Information System on Live Births (SINASC, in Portuguese) was implemented by the Ministry of Health in 1994[5,15,16]. These studies have contributed to understanding perinatal and infant mortality and the profile of live births in the places where they are produced. This study evaluates the predisposing factors of Ap5 < 7 in Brazil as a marker of neonatal prognosis and the change in its indexes in the last twenty years. By analyzing the evolution over time, it could help propose strategies aimed at improving perinatal health.

Method

This is a cross-sectional study based on the population of live births in Brazil in 1999 and in the biennium of 2018-2019. The authors evaluated all live birth certificates (DNV, in Portuguese) obtained from the Live Births System database (SINASC, 2017) through the server of the Department of Informatics of the Unified Health System (DATASUS) of Brazil's Ministry of Health.

The biennium of 2018-2019 was chosen in comparison with the year 1999 to obtain a better picture of the changes that occurred in twenty years, with 2019 being the last year available in the SINASC during the research.

There are twenty-seven databases available in the SINASC, corresponding to each of the Brazilian states and the Federal District, which the authors grouped into a single file containing records for the entire country.

Inclusion and exclusion criteria

All DNVs referring to the study period were considered, while those with the following characteristics were excluded: Apgar score in the fifth minute not filled in, Apgar score equal to zero in the fifth minute of life when associated with an Apgar score equal to zero in the first minute, gestational age less than 22 weeks, fetal weight less than 500g, or fetal weight not entered.

Additionally, when examining for specific variables, the DNV in which the completion did not occur or was recorded as having been ignored was excluded from the analysis of that particular variable.

Data analysis

The Statistical Package for Social Sciences software (SPSS for Mac version 27) was used for the statistical analysis. A statistical significance level of 0.05 was considered. Initially, the frequencies of the studied factors, the odds ratios (OR), and the respective 95% confidence intervals (95%CI) were calculated, evaluating the association between the variables through a bivariate analysis. Frequencies were compared between groups using Pearson's chi-square test.

A multivariate logistic regression analysis was performed to investigate the relationship be-

tween an unfavorable outcome (Ap5 < 7) and the other variables. Factors with a significance level greater than 95% remained in the final model.

Ethical issues related to the project

The project was approved by the Ethics and Research Committee of the Hospital Universitário Pedro Ernesto, logged under registration no. CAAE 07660818.6.0000.5259.

Results

In 1999, 3,256,443 DNVs were recorded and 5,794,078 in the biennium of 2018-2019, totaling 9,050,521 DNVs. There was a 13.8% reduction in the number of cases after applying exclusion criteria for 1999, totaling 2,808,341 records, and a 2% reduction in the number of cases for 2018 and 2019, dropping to 5,680,092.

This study found that 58,961 newborns had Ap5 < 7 (2.1%) in 1999. This prevalence dropped to 0.9% in the biennium of 2018-2019, corresponding to 52,731 cases.

A comparison between the two periods showed an increase in the chance of premature birth, low birth weight, and congenital anomalies in the 2018-2019 biennium. Conversely, there was a lower probability of birth after 42 weeks and with a weight greater than 4,000g during the same period. The data are presented in Table 1.

Regarding the maternal variables, there was an increase in maternal age in the biennium of 2018-2019 as compared to 1999, with a lower probability of births among adolescents and a higher probability after 34 years of age. There was also a clear improvement in prenatal care coverage, with fewer women having had no prenatal examinations and more pregnant women with seven or more of these examinations. There was an increase in the number of women with eight or more years of education and a decline in the number of women without education in the comparison between periods. There were also more women who were not married, who had not previously had live births, as well as more fetal losses or previous miscarriages in 2018-2019. The maternal variable data are presented in Table 2.

Regarding the variables related to pregnancy and childbirth, there is a greater chance of twin pregnancy and an increase of nearly 70% in the frequency of Cesarean sections in the biennium of 2018-2019. Home births were also more frequent in this two-year period and, conversely, fewer births in non-hospital healthcare facilities. When looking at the distribution of births according to region, there is an increase in births in the North, Northeast, and Midwest, and a drop in births in the South. Table 3 lists these data.

A multivariate analysis showed that risk factors for perinatal asphyxia were practically the same in both periods. Prematurity, low birth weight, and the presence of congenital anomalies continued to be the risk factors with the greatest impact on Ap5 < 7. Although with lesser impact, the variables pertaining to a gestational age equal to or greater than 42 weeks, macrosomia, black race, and male newborns also showed an increased risk for Ap5 < 7.

When considering the maternal variables, the multivariate analysis indicated a higher risk of Ap5 < 7 in pregnant women aged 35 years or older, in those who had never studied or who had less than eight years of study, in single women, in those with fewer than six prenatal examinations, and in those who have had one or more previous pregnancy losses. The previous birth of one or more live children remained a protective factor for Ap5 < 7. Adolescence was a risk factor in 1999, but the fact that the mother was a teenager did not constitute a risk for Ap5 < 7 in the biennium of 2018-2019.

Still regarding the multivariate analysis of the pregnancy and childbirth variables, a change in the scenario was observed over the studied period. Twinning showed a lower association with Ap5 < 7 in the biennium of 2018-2019, which was not present in 1999. Vaginal delivery, which provided protection in 1999, began to be configured as a risk factor in the same biennium. Home birth was no longer a risk factor in the biennium, with only birth in non-hospital healthcare facilities continuing to be a risk. Birth in the North ceased to be a risk factor whereas in the South, it changed from being a protection factor to a risk factor. The data is presented in Table 4.

Discussion

Labor and childbirth are transformative events and do not present high risks in most cases. However, unfavorable neonatal outcomes are observed in a number of cases with an impact on neonatal mortality and morbidity. One study conducted in the state of São Paulo identified that one-half of all infant deaths occur in the early neonatal period (up to the sixth day of life), with asphyxia responsible for 17.4% of these deaths[17].

Table 1. Bivariate analysis of the distribution of live births according to the variables related to newborns after applying the exclusion criteria.

Variable	1999		2018 and 2019		OR[a]	95%CI[b]
	Number	%	Number	%		
5th minute Apgar score	**2,808,341**		**5,680,092**			
< 7	58,961	2.1	52,731	0.9	**0.44**	(0.43 – 0.44)
≥ 7	2,749,380	97.9	5,627,361	99.1	1.00	[c]
Gestational age	**2,765,872**		**5,607,382**			
22 to 27 weeks	10,036	0.4	25,363	0.5	**1.24**	(1.21 – 1.27)
28 to 36 weeks	155,811	5.6	593,840	10.6	**1.87**	(1.86 – 1.88)
37 to 41 weeks	2,381,313	86.1	4,850,615	86.5	1.00	[c]
≥ 42 weeks	218,712	7.9	137,564	2.5	**0.31**	(0.31 – 0.32)
Birth weight	**2,808,341**		**5,680,092**			
500 to 999g	7,747	0.3	26,841	0.5	**1.72**	(1.67 – 1.76)
1,000 to 1,499g	16,771	0.6	43,002	0.8	**1.27**	(1.25 – 1.29)
1,500 to 1,999g	38,991	1.4	92,292	1.6	**1.17**	(1.16 – 1.19)
2,000 to 2,499g	150,412	5.4	315,773	5.6	**1.04**	(1.03 – 1.05)
2,500 to 3,999g	2,433,043	86.6	4,907,907	86.4	1.00	[c]
≥ 4,000g	161,377	5.7	292,277	5.2	**0.90**	(0.89 – 0.90)
Color	**2,188,785**		**5,522,398**			
Black	883,127	40.3	3,496,313	61.6	1.00	[c]
White	1,198,875	54.7	1,961,547	35.5	**0.41**	(0.41 – 0.41)
Others	106,783	4.9	64,538	1.1	**0.15**	(0.15 – 0.15)
Sex	**2,803,208**		**5,680,092**			
Male	1,439,573	51.4	2,908,307	51.2	1.00	(1.00 - 1.00)
Female	1,363,635	48.6	2,770,934	48.8	1.00	[c]
Congenital anomalies	**2,808,341**		**5,573,375**			
Yes	5,262	0.2	49,913	0.9	**4.80**	(4.68 – 4.95)
No	2,803,079	99.8	5,523,462	99.1	1.00	[c]

[a] OR – odds ratio for 1999 as compared to 2018 and 2019 added together. The OR in bold corresponds to $p < 0.05$. [b] 95CI% – 95% confidence interval. [c] Reference categories for the calculation of odds ratios (no bold).

Source: Authors.

Perinatal asphyxia has also been associated with increased neonatal mortality and morbidity, which is the risk factor most consistently associated with cerebral palsy[18].

The Apgar score is a world-renowned system and continues to be an important neonatal prognostic assessment tool that, although alone does not predict long-term outcomes, a score below 7 in the fifth minute of life is strongly related to a greater risk of cerebral palsy and increased mortality in the first week of life due to perinatal asphyxia[10,12, 19-22].

Data from the present study demonstrated a progressive drop over 20 years in Ap5 < 7, with a 57.2% reduction between 1999 and 2019. Based on this information, the aim was to study what changes occurred in risk factors for Ap5 <7 that may have had an impact on such a significant reduction. No significant decrease was observed in several related risk factors. By contrast, some showed a significant increase in the probability of their occurrence, such as twinning, prematurity, low birth weight, and congenital anomalies.

As a positive point, the analysis also shows that the number of excluded cases dropped from 13.8% to 2%, indicating better quality of the data presented in the DNVs.

A close examination of the variables related to the fetus showed a rise in the occurrence of low birth weight, prematurity, and the presence of congenital anomalies, as well as a reduction in the risk of deliveries after 42 weeks and of macrosomic fetuses. The adoption of new protocols, the greater availability of diagnostic methods to assess fetal well-being, and the increased availability and resources of neonatal units, has allowed for more

Table 2. Bivariate analysis of the distribution of the live births according to the variables related to the mothers after applying the exclusion criteria,

Variable	1999		2018 and 2019		OR[a]	95%CI[b]
	Number	%	Number	%		
Maternal age	**2,782,520**		**5,679,957**			
10 to 19	641,946	23.1	851,455	15.0	**0.64**	(0.64 – 0.65)
20 to 34	1,908,258	68.6	3,924,607	69.1	1.00	[c]
35 and over	232,316	8.3	903,895	15.9	**1.89**	(1.88 – 1.90)
Number of years of study	**1,877,107**		**5,613,351**			
None	91,897	4.9	18,247	0.3	**0.25**	(0.25 – 0.25)
1 to 7 years	1,153,125	61.4	912,979	16.3	1.00	[c]
8 and over	632,085	33.7	4,682,125	83.4	**9.36**	(9.32 – 9.39)
Number of pre-natal visits	**2,612,010**		**5,656,916**			
None	129,492	4.9	83,359	1.5	**0.49**	(0.49 – 0.50)
1 to 6	1,135,659	43.5	1,475,226	26.1	1.00	[c]
7 or more	1,346,859	51.6	4,098,331	72.4	**2.34**	(2.33 – 2.35)
Marital status	**1,084,932**		**5,629,274**			
Single	385,084	35.5	2,515,808	44.7	**1.48**	(1.47 – 1.49)
Has been married	13,101	1.2	85,083	1.5	**1.47**	(1.45 – 1.50)
Is currently married	686,747	63.3	3,028,383	53.8	1.00	[c]
Number of live births had previously	**2,517,402**		**5,529,090**			
None	855,411	34.0	2,322,981	42.0	**1.89**	(1.88 – 1.90)
1 to 2	1,286,332	51.1	2,666,554	48.2	**1.44**	(1.44 – 1.45)
More than 2	375,659	14.9	539,555	9.5	1.00	[c]
Fetal losses and miscarriages	**2,218,070**		**5,442,001**			
None	1,933,479	87.2	4,390,192	80.7	1.00	[c]
1 ore more	284,591	12.8	1,051,809	19.3	**1.63**	(1.62 – 1.63)

[a] OR – odds ratio for 1999 as compared to 2018 and 2019 added together. The OR in bold corresponds to $p < 0.05$. [b] 95CI% – 95% confidence interval. [c] Reference categories for the calculation of odds ratios (no bold).

Source: Authors.

diagnoses to be made and more timely interventions in these pregnancies. As an example, one could accelerate childbirth in intrauterine growth restriction and propose elective intervention after 41 weeks of pregnancy, the first being responsible for the increase in premature and low birth weight births and the second for the decrease in births after 42 weeks and with weight above 4,000g. Furthermore, the increase in maternal age may also have exerted an effect since the older the age group, the greater the possibility of clinical and obstetric complications, which, in turn, elevate the risk of low birth weight and prematurity. The greater occurrence of congenital anomalies may be related to this increase in maternal age, as well as to the greater number of these diagnoses.

When evaluating the variables related to women, one can see an increase in maternal age in the biennium of 2018-2019, with a greater number of pregnant women over 34 years of age and a smaller number of adolescents. In this regard, it is important to note that adolescence ceased to be a risk factor in this two-year period, with a maternal age greater than 34 years seen as an increased risk for the outcome. The increased risk caused by a more advanced maternal age is related to a greater probability of maternal clinical and obstetric complications, as well as fetal complications, such as aneuploidy and growth restriction[23-25]. In the vast majority of cases, adolescents are healthy and active, and a central issue in pregnancy in this age group is adherence to prenatal care and striking a balance between school work and daily activities. The greater availability of information, adequate guidance, and access to the healthcare system provide better prenatal care for these young women, which has a positive effect on improving outcomes[26].

Table 3. Bivariate analysis of the distribution of live births according to the variables related to pregnancy and to births after applying the exclusion criteria.

Variable	1999		2018 and 2019		OR[a]	95%CI[b]
	Number	%	Number	%		
Single or twinning pregnancy	**2,800,555**		**5,676,538**			
Single	2,750,156	98.2	5,553,541	97.8	1.00	[c]
Twinning	50,399	1.8	122,997	2.2	**1.21**	(1.20 – 1.22)
Type of childbirth	**2,797,402**		**5,676,828**			
Vaginal	1,699,757	60.8	2,456,343	43.3	1.00	[c]
C-section	1,097,645	39.2	3,220,485	56.7	**2.03**	(2.02 – 2.04)
Location of birth	**2,805,280**		**5,676,959**			
Hospital	2,758,705	98.3	5,630,335	99.1	1.00	[c]
Others (health establishments of 99 and estab+others 14-15)	42,942	1.5	37,905	0.7	**0.43**	(0.43 – 0.44)
Home	3,633	0.1	11,719	0.2	**1.58**	(1.52 – 1.64)
Region	**2,808,341**		**5,680,092**			
North	254,084	9.0	607,529	10.7	**1.32**	(1.32 – 1.33)
Northeast	656,577	23.4	1,592,710	28.0	**1.34**	(1.34 - 1.35)
Southeast	1,231,248	43.8	2,222,610	39.1	1.00	[c]
South	456,026	16.2	776,191	13.7	**0.94**	(0.94 – 0.95)
MIdwest	210,406	7.5	481,052	8.5	**1.26**	(1.26 – 1.27)

[a] OR – odds ratio for 1999 as compared to 2018 and 2019 added together. The OR in bold corresponds to $p < 0.05$. [b] 95CI% – 95% confidence interval. [c] Reference categories for the calculation of odds ratios (no bold).

Source: Authors.

With regard to the variables related to pregnancy and childbirth, there was a decline in the number of vaginal deliveries, from 60.8% in 1999 to 43.3% in the biennium of 2018-2019, with a consequent rise in the number of C-sections. It was also observed that almost all births (98.3% in 1999 and 99.1% in 2018-2019) occurred in a hospital environment, despite the increased probability of home births in this two-year period. There are reports in the literature suggesting that home birth is associated with an eleven-fold increase in the risk of Apgar < 6 in the fifth minute, as well as a lower rate of recovery of the low Apgar score from the first to the fifth minute, indicating a greater risk in these newborns[27], which was not confirmed in the present study. One possible explanation for this observation is the greater selection of cases, with home birth occurring in selected low-risk cases, which possibly did not happen twenty years ago when home birth was an emergency and accidental event.

Vaginal delivery, in turn, which was considered a protective factor in the 1999 multivariate analysis, was configured as a risk factor in 2018 and 2019, a fact that could possibly be related to the quality of care, since with the "C-section culture", negligence is observed in providing adequate care during labor. Zaiden et al. (2020) showed that, in areas outside the capital cities, in mixed hospitals of lesser complexity and with fewer than 1,500 births per year, the probability of a pregnant woman undergoing an elective C-section is greater[28]. This information reinforces the perception that training for adequate childbirth care has been neglected; in other words, the art of midwifery has been "unlearned". The rise in cesarean rates has important social and cultural elements, such as the perception by many women that it is a virtually risk-free procedure[29,30]. Encouraging vaginal delivery should be a change to be implemented, as this method of delivery is proven to have lower maternal and fetal risks[21,22]. However, labor is often inadequately monitored, whether due to negligence or malpractice, which directly affects neonatal care and outcome.

A change in the risk profile between regions was observed, with birth in the South being configured as a risk factor and birth in the North no longer being seen this way, associated with a higher birth rate in the North, Northeast,

Table 4. Factors associated with the 5th minute Apgar score less than 7 in Brazil – multivariate analysis.

Variables		1999		2018 - 2019	
		OR[a]	95% CI[b]	OR[a]	95% CI[b]
Gestational age	**22 to 27 weeks**	**5.10**	(4.59 - 5.67)	**6.64**	(6.20 - 7.10)
	28 to 36 weeks	**1.98**	(1.89 - 2.08)	**4.37**	(4.31 – 4.43)
	37 to 41 weeks	1.00	[c]	1.00	[c]
	≥ 42 weeks	**1.22**	(1.15 - 1.30)	**1.40**	(1.30 - 1.49)
Birth weight	**500-999 g**	**33.23**	(29.93 - 36.90)	**15.67**	(14.68 - 16.74)
	1,000-1,499 g	**13.23**	(12.29 - 14.24)	**6.96**	(6.58 - 7.37)
	1,500-1,999 g	**5.64**	(5.29 - 6.02)	**4.12**	(3.93 - 4.31)
	2,000-2,499 g	**2.17**	(2.06 - 2.28)	**1.99**	(1.92 - 2.07)
	2,500-3,999 g	1.00	[c]	1.00	[c]
	≥ 4000 g	**1.24**	(1.16 - 1.32)	**1.35**	(1.29 - 1.42)
Color	Black	1.00	[c]	1.00	[c]
	White	**0.57**	(0.56 - 0.58)	**0.81**	(0.79 - 0.83)
	Others	**1.07**	(1.03 - 1.12)	**1.38**	(1.27 - 1.49)
Sex	Female	1.00	[c]	1.00	[c]
	Male	**1.24**	(1.21 - 1.28)	**1.26**	(1.23 - 1.28)
Congenital anomalies	Absent	1.00	[c]	1.00	[c]
	Presentes	**5,44**	(4,88 - 6,06)	**8,30**	(7,99 - 8,63)
Maternal age	**10 to 19 years**	**1.05**	(1.01 - 1.08)	1.00	[d] **(0.97 - 1.03)**
	20 to 34 years	1.00	[c]	1.00	[c]
	35 years or over	**1.12**	(1.06 - 1.18)	**1.05**	(1.02 - 1.08)
Number of years of study	**None**	**1.54**	(1.44 - 1.64)	**1.56**	(1.39 - 1.83)
	1 to 7 years	**1.25**	(1.21 - 1.29)	**1.19**	(1.16 - 1.23)
	≥ 8 years	1.00	[c]	1.00	[c]
Number of pre-natal visits	**None**	**1.37**	(1.29 - 1.45)	**1.77**	(1.66 - 1.88)
	1 to 6	**1.32**	(1.28 - 1.37)	**1.09**	(1.06 - 1.11)
	≥ 7	1.00	[c]	1.00	[c]
Number of live children	None	1.00	[c]	1.00	[c]
	1 to 2	**0.83**	(0.80 - 0.85)	**0.88**	(0.83 - 0.87)
	More than 2	**0.84**	(0.80 - 0.85)	**0.87**	(0.84 - 0.90)
Deceased children	None	1.00	[c]	1.00	[c]
	One or more	**1.13**	(1.09 - 1.18)	**1.04**	(1.02 - 1.07)

it continues

and Midwest. This fact may be secondary to the migration occurring within the country and improvements in the quality of obstetric care in the North and Northeast over these twenty years.

Twinning, a recognized risk factor, was configured as a protective factor in the biennium of 2018-2019, which may be the result of improved care in these cases, with physicians making appropriate referrals to specialized centers.

A close look at the variables related to pregnant women, especially those pertaining to socioeconomic conditions, revealed signs of improvement. There was an increase in the number of years of women's education, with the percentage of mothers with eight years or more of education rising from 33.7% to 83.4%, as well as a drop from 4.9% to 0.3% of mothers who had never studied. The mother's level of education is strongly associated with higher rates of Ap5 < 7[31-33]. Evaluating the effect of this change in profile is important, since both years of education and the number of prenatal examinations are protective factors, according to this study.

Several aspects of the improvements cited here are strongly related to the quality of prenatal care. Appropriate referrals to specialized centers

Table 4. Factors associated with the 5th minute Apgar score less than 7 in Brazil – multivariate analysis.

Variables		1999		2018 - 2019	
		OR[a]	95% CI[b]	OR[a]	95% CI[b]
Pregnancy	Single	1.00	[c]	1.00	[c]
	Twinning	0.95	(0.88 - 1.02)[d]	**0.70**	(0.67 - 0.74)
Type of birth	**Vaginal**	**0.92**	(0.90 - 0.95)	**1.42**	(1.39 - 1.46)
	C-section	1.00	[c]	1.00	[c]
Location of birth	Hospital	1.00	[c]	1.00	[c]
	Non-hospital Health Estab.	**1.34**	(1.03 - 1.75)	**1.41**	(1.24 - 1.61)
	Home	**1.71**	(1.54 - 1.89)	**1.36**	(1.13 - 1.65)
Region	**North**	**1.47**	(1.39 - 1.56)	1.03	(0.99 - 1.07)[d]
	Northeast	**1.67**	(1.61 – 1.73)	**1.23**	(1.20 – 1.26)
	Southeast	1.00	[c]	1.00	[c]
	South	**0.90**	(0.86 – 0.94)	**1.21**	(1.17 – 1.25)
	Midwest	1.00	(0.92 – 1.08)[d]	1.00	(0.96 – 1.04)[d]

Number of analyzed cases: 1,164,226 in 1999 and 4,929,467 in 2018-2019. 69.7% of the observations correctly classified by the model in 1999 and 99.0% of the observations correctly classified by the model in 2018-2019 (confer these 99%). [a] OR – odds ratio for 1999 as compared to 2018 and 2019 added together. The OR in bold corresponds to $p < 0.05$. [b] 95CI% – 95% confidence interval. [c] Reference categories for the calculation of odds ratios (no bold). [d] $p > 0.05$. [e] Categories not evaluated by multivariate analysis during the assigned period.

Source: Authors.

would result in well-established protocols being put in place and referrals to maternity hospitals would lead to better prenatal care throughout the pregnancy and reduce the risk of adverse neonatal outcomes[31]. In fact, there was an increase in the number of pregnant women seeking prenatal care by scheduling seven or more examinations and only 1.5% who went without this type of care.

The best quality prenatal examinations and care for pregnant women during childbirth and newborns directly interfere with neonatal mortality[34-36]. The deaths of full-term newborns due to intrapartum asphyxia point to the inadequate quality of prenatal and hospital care, given that these deaths would be preventable if that same care were improved. A decline in the infant mortality rate observed in the state of São Paulo from 1996 to 2012 primarily occurred in the early neonatal period and especially in the preventable causes group[17]. Similarly, a study from Rio Grande do Sul emphasized the importance of adequate and quality access to prenatal care as being responsible for the improvement in neonatal outcomes[19].

Favorable outcomes in childbirth care depend on a hospital network with adequate human resources and an appropriate structure to provide such care. A study by Bittencourt et al. determined that only 34% of the hospitals were considered adequate, with a support structure and appropriate medical professionals to meet the proposed profile[37]. This disparity is even more pronounced in the North and Northeast and in areas far from the capital cities, where more than half of the pregnant women considered to be at high risk were attended in hospitals that lacked specialized care and an ICU[37].

A survey entitled *Nascer no Brasil: pesquisa nacional sobre parto e nascimento (Birth in Brazil: a national research on labor and birth*) showed that only 59% of the women had been properly directed to a good quality maternity hospital and almost one-fifth of them sought more than one service for admission during labor, which was associated with an increased risk of death and other neonatal complications[31,38]. Problems with the adequacy of prenatal care have been reported by various local and national studies[39,40]. Domingues et al. identified a growing gradient of adequate prenatal care with more years of study and economic class, with it being twice as high in those belonging to economic classes A or B and in those with twelve years or more of formal education[41]. These issues may be impairing the effectiveness of prenatal care to prevent negative perinatal outcomes.

Prenatal care is a unique opportunity to apply preventive interventions in maternal-fetal health.

In addition to the screening and treatment of clinical and obstetric complications, it is also a good time to address topics and guidelines, such as healthy eating and behavior, preparation and encouragement for childbirth and breastfeeding, and information on warning signs. A well-informed pregnant woman will undoubtedly have more tools to seek help in unfavorable situations with direct repercussions on better maternal and fetal outcomes[31,42,43]. Thus, an improvement in educational levels and an increase in the number of prenatal examinations (an indirect marker of the quality of prenatal care) may favor a reduction in Ap5 < 7.

Leal et al. showed that there was a gradient of improvement in prenatal and childbirth care among black, brown, and white women that remained after controlling for socioeconomic variables, resulting in distinct benefits and opportunities according to race, to the detriment of those with a darker skin color[19, 39]. This study corroborates these observations, demonstrating a higher risk of Ap5 < 7 among black women. In this group of women, which includes black and brown women, it is evident that skin color continues to be a risk factor as compared to white women, even after controlling for other variables. Furthermore, it demonstrates an increased risk among yellow and indigenous populations, emphasizing this gradient of care with less favored populations. The DNV was completed through the self-declaration of color and there was a significant increase in the declaration of non-white races in the period, signaling an important cultural change that recognizes Brazilians' mixed roots. Nonetheless, racial disparities in the care for pregnant women and during childbirth continue to contribute to disparities in the final health indicators, which serves as another example of the importance of analyzing individual markers of pregnant women and the effect skin color still have on maternal and perinatal health.

There are several limitations to the present study, among them being the low sensitivity of the Apgar score as a neonatal prognosis marker; however, despite this criticism, it continues to be used in clinical practice and, in a population-based study with more than nine million cases, it is the closest marker this study could obtain in the neonatal prognosis investigation[13,22,44,45].

In addition, there is a lack of information on the causes of prematurity, many of which are associated with pregnancies after the age of 35 and birth by C- section, thus hampering the ability to analyze the influence of the delivery method on Ap5 < 7. As a strong point, this study emphasizes the size of the database with the survey and primary analysis of 9,050,521 declarations of live births, including all eligible births in Brazil during the studied periods, avoiding selection bias. Moreover, it was possible to adjust several confounding factors through the multivariate analysis. The evaluation of such a large number of cases allows one to observe the changes that occurred in the risk factors and epidemiological profile of the patients, thus signaling areas where greater investment and attention could further improve the results.

Conclusion

The present study showed a reduction in the incidence of Ap5 < 7. A multivariate analysis indicated that twinning and teenage pregnancy are no longer risk factors for Ap5 < 7.

A rise in prematurity, low birth weight, and congenital anomalies were among the observed risk factors for this neonatal evaluation marker. A significant improvement was also found in maternal markers, in particular an increase in the number of prenatal examinations and in the years of education. Such findings underscore the importance of interventions during pregnancy, such as having adequate prenatal access along with follow-ups and investments in improving the socioeconomic conditions of the population as an effective strategy to reduce neonatal morbidity and mortality.

Collaborations

ALC Magalhães worked on the design and writing of the article, study design, research, analysis and data interpretation. DLM Monteiro contributed to the conception and writing of the article, study design and final revision of the text. AJB Trajano worked on the design and writing of the article, final revision of the text and approval of the final version. FM Souza worked on the design and writing of the article, study and research design, data analysis and interpretation.

References

1. Brasil. Ministério da Saúde (MS). Tabnet – demográficas e socioeconômicas. (acessado 2022 maio 10). Disponível em: http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sim/cnv/inf10uf.def
2. Lehtonen L, Gimeno A, Parra-Llorca A, Vento M. Early neonatal death: a challenge worldwide. *Semin Fetal Neonatal Med* 2017; 22(3):153-160.
3. Almeida MFB, Kawakami MD, Moreira LMO, Santos RMV, Anchieta LM, Guinsburg R. Early neonatal deaths associated with perinatal asphyxia in infants ≥ 2,500g in Brazil. *J Pediatr* 2017;93(6):576-584.
4. Apgar V. A proposal for a new method of evaluation of the newborn infant. *Curr Res Anesth Analg* 1953; 32(4):260-267.
5. Garcia LP, Fernandes CM, Traebert J. Risk factors for neonatal death in the capital city with the lowest infant mortality rate in Brazil. *J Pediatr (Rio J)*. 2019; 95(2):194-200.
6. Li F, Wu T, Lei X, Zhang H, Mao M, Zhang J. The Apgar score and infant mortality. *PLoS One* 2013; 8(7):e69072.
7. Lie KK, Groholt EK, Eskild A. Association of cerebral palsy with Apgar score in low and normal birthweight infants: population-based cohort study. *BMJ* 2010; 341(6):c4990.
8. Herrera CA, Silver RM. Perinatal asphyxia from the obstetric standpoint: diagnosis and interventions. *Clin Perinatol* 2016; 43(3):423-438.
9. Li C, Miao JK, Xu Y, Hua YY, Ma Q, Zhou LL, Liu HJ, Chen QX. Prenatal, perinatal and neonatal risk factors for perinatal arterial ischaemic stroke: a systematic review and meta-analysis. *Eur J Neurol* 2017; 24(8):1006-1015.
10. Casey BM, McIntire DD, Leveno KJ. The continuing value of the Apgar score for the assessment of newborn infants. *N Engl J Med* 2001; 344(7):467-471.
11. Park JH, Chang YS, Ahn SY, Sung SI, Park WS. Predicting mortality in extremely low birth weight infants: comparison between gestational age, birth weight, Apgar score, CRIB II score, initial and lowest sérum albumin levels. *PLoS One* 2018; 13(2):e0192232.
12. Moster D, Lie RT, Irgens LM, Bjerkedal T, Markestad T. The association of Apgar score with subsequent death and cerebral palsy: a population based study in term infants. *J Pediatr* 2001; 138(6):798-803.
13. Thorngren-Jerneck K, Herbst A. Low 5-minute Apgar score: a population based register study of 1 million term births. *Obstet Gynecol* 2001; 98(1):65-70.
14. Woday A, Muluneh A, St Denis C. Birth asphyxia and its associated factors among newborns in public hospital, northeast Amhara, Ethiopia. *PLoS One* 2019; 14(12):e0226891.
15. Mello Jorge MHP, Gotlieb SLD. O sistema de informação de atenção básica como fonte de dados para os sistemas de informações sobre mortalidade e sobre nascidos vivos. *Info Epidemiol SUS* 2001; 10(1):7-18.
16. Rodrigues CS, Magalhães Junior HM, Evangelista PA, Ladeira RM, Laudares S. Perfil dos nascidos vivos no município de Belo Horizonte, 1992-1994. *Cad Saude Publica* 2002; 13(1):53-57.

17. Areco KCN, Konstantyner T, Taddei JAAC. Tendência secular da mortalidade infantil, componentes etários e evitabilidade no Estado de São Paulo – 1996 a 2012. *Rev Paul Pediatr* 2016; 34(3):263-270.
18. Mcintyre S, Taitz D, Keogh J, Goldsmith S, Badawi N, Blair E. A systematic review of risk factors for cerebral palsy in children born at term in developed countries. *Dev Med Child Neurol* 2013; 55(6):499-508.
19. Varela AR, Schneider BC, Bubach S, Silveira MF, Bertoldi AD, Duarte LSM, Menezes AMB, Domingues MR, Bassani DG. Fetal, neonatal, and post-neonatal mortality in the 2015 Pelotas (Brazil) birth cohort and associated factors. *Cad Saude Publica* 2019; 35(7):e00072918.
20. Iliodromiti S, Mackay DF, Smith GCS, Pell JP, Nelson SM. Apgar score and the risk of cause-specific infant mortality: a population-based cohort study. *Lancet* 2014: 385(9956):1749-55.
21. Persson M, Razaz N, Tedroff K, Joseph KS, Cnattingius S. Five and 10 minute Apgar scores and risks of cerebral palsy and epilepsy: a population based cohort study in Sweden. *BMJ* 2018; 360:k207.
22. Razaz N, Cnattingius S, Joseph KS. Association between Apgar scores of 7 to 9 and neonatal mortality and morbidity: population based cohort study of term infants in Sweden. *BMJ* 2019; 365:l1656.
23. Abdo RA, Halil HM, Kebede BA, Anshebo AA, Gejo NG. Prevalence and contributing factors of birth asphyxia among the neonates delivered at Nigist Eleni Mohammed memorial teaching hospital, Southern Ethiopia: a cross-sectional study. *BMC Preg Childbirth* 2019; 19(1):536.
24. Laopaiboon M, Lumbiganon P, Intarut N, Mori R, Ganchimeg T, Vogel JP, Souza JP, Gülmezoglu AM, WHO Multicountry Survey on Maternal Newborn Health Research Network. Advanced maternal age and pregnancy outcomes: a multicountry assessment. *BJOG* 2014; 121(Suppl. 1):49-56.
25. Almeida NK, Almeida RM, Pedreira CE. Adverse perinatal outcomes for advanced maternal age: a cross-sectional study of Brazilian births. *J Pediatr* 2015; 91(5):493-498.
26. Monteiro DLM, Miranda FRD, Lacerda IMS, Taquette SR, Ramos JAS, Souza FM et al. Increase in fertility rate before the age of 14 in Brazil from 1996 to 2018. *Rev Assoc Med Bras* 2021; 67(11):1712-1718.
27. Bessa JF, Bonatto N. Apagar scoring system in Brazil's live birth records: diferences between home and hospital births. *Rev Bras Ginecol Obstet* 2019; 41(2):76-83.
28. Zaiden L, Nakamura-Pereira M, Gomes MAM, Esteves-Pereira AP, Leal MC. Influence of hospital characteristics on the performance of elective cesareans in Southeast Brazil. *Cad Saude Publica* 2020; 36(1):e00218218.
29. Mylonas I, Friese K. Indications for and risks of elective cesarean section. *Dtsch Arztebl Int* 2015; 112(29-30):489-495.
30. Domingues RMSM, Dias MAB, Nakamura-Pereira M, Torres JA, d'Orsi E, Pereira APE, Schilithz AOC, Leal MC. Processo f decision making regarding the mode of birth in Brazil: from the initial preference of women to the final mode of birth. *Cad Saude Publica* 2014; 30(Suppl. 1):S101-S116.
31. Anggondowati T, El-Mohandes AA, Qomariyah SN, Kiely M, Ryon JJ, Gipson RF, Zinner B, Achadi A, Wright LL. Maternal characteristics and obstetrical complications impact neonatal outcomes in Indonesia: a prospective study. *BMC Preg Childbirth* 2017; 17(1):100.
32. Tasew H, Zemicheal M, Teklay G, Mariye T, Ayele E. Risk factors of birth asphyxia among newborns in public hospitals of central zone, Tigray, Ethiopia 2018. *BMC Res Notes* 2018; 11(1):496.
33. Opitasari C, Andayasari L. Maternal education, prematurity and the risk of birth asphyxia in selected hospitals in Jakarta. *Health Sci J Indones* 2015; 6(2):111-115.
34. Lansky S, Friche AA, Silva AA, Campos D, Bittencourt SD, Carvalho ML, Frias PG, Cavalcante RS, Cunha AJLA. Pesquisa nascer no Brasil: perfil da mortalidade neonatal e avaliação da assistência à gestante e ao recém-nascido. *Cad Saude Publica* 2014; 30(Suppl. 1):S192-S207.
35. Hofmeyr GJ, Hodnett ED. Antenatal care packages with reduced visits and perinatal mortality: a secondary analysis of the WHO antenatal care trial. *Reprod Health* 2013; 10:20.
36. Wondemagegn AT, Alebel A, Tesema C, Abie W. The effect of antenatal care follow-up on neonatal health outcomes: a systematic review and meta-analysis. *Public Health Rev* 2018; 39:33.
37. Bittencourt SDA, Domingues RMSM, Reis LGC, Ramos MM, Leal MC. Adequacy of public maternal care services in Brazil. *Reprod Health* 2016; 13(Suppl. 1):120.
38. Carmo Leal M, da Silva AA, Dias MA, da Gama SG, Rattner D, Moreira ME, Filha MM, Domingues RM, Pereira AP, Torres JA, Bittencourt SD, D'orsi E, Cunha AJ, Leite AJ, Cavalcante RS, Lansky S, Diniz CS, Szwarcwald CL. Birth in Brazil: national survey into labor and birth. *Reprod Health* 2012; 9:15.
39. Leal MC, Gama SGN, Pereira APE, Pacheco VE, Carmo CN, Santos RV. A cor da dor: iniquidades raciais na atenção pré-natal e ao parto no Brasil. *Cad Saude Publica* 2017; 33(Suppl. 1):e00078816.
40. Martinelli KG, Santos Neto ET, Gama SGN, Oliveira AE. Access to prenatal care: inequalities in a region with high maternal mortality in southeastern Brazil. *Cien Saude Colet* 2016; 21(5):1647-1657.
41. Domingues RMSM, Viellas EF, Dias MAB, Torres JA, Theme-Filha MM, Gama SGN, Leal MC. Adequação da assistência pré-natal segundo as características maternas no Brasil. *Rev Panam Salud Publica*. 2015; 37(3):140-147.
42. World Health Organization (WHO). *WHO recommendations on antenatal care for a positive pregnancy experience*. Geneva: WHO; 2016.

43. Ministério da Saúde (MS). *Programa de humanização do parto: humanização no pré-natal e nascimento*. Brasília: MS; 2002.
44. Siddiqui A, Cuttini M, Wood R, Velebil P, Delnord M, Zile I, Barros H, Gissler M, Hindori-Mohangoo AD, Blondel B, Zeitlin J, Euro-Peristat Scientific Committee. Can the Apgar score be used for international comparisons of newborn health? *Paediatr Perinat Epidemiol* 2017; 31(4):338-345.
45. Bovbjerg ML, Dissanayake MV, Cheyney M, Brown J, Snowden JM. Utility of the 5-minute Apgar score as a research endpoint. *Am J Epidemiol* 2019; 188(9):1695-1704.

Article submitted 27/03/2022
Approved 26/07/2022
Final version submitted 28/07/2022

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva

This is an Open Access article distributed under the terms of the Creative Commons Attribution License