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Which factors could explain the low birth weight paradox?

Quais fatores podem explicar o paradoxo do baixo peso ao nascer?

ABSTRACT

OBJECTIVE: Low birth weight children are unusual among well-off families. However, in Brazil, low birth weight rate was higher in a more developed city than in a less developed one. The study objective was to find out the reasons to explain this paradox.

METHODS: A study was carried out in two municipalities, Ribeirão Preto (Southeastern Brazil) and São Luís (Northeastern Brazil), which low birth weight rates were 10.7% and 7.6% respectively. Data from two birth cohorts were analyzed: 2,839 newborns in Ribeirão Preto in 1994 and 2,439 births in São Luís in 1997-1998. Multiple logistic regression analysis was performed, adjusted for confounders.

RESULTS: Low birth weight risk factors in São Luís were primiparity, maternal smoking and maternal age less than 18 years. In Ribeirão Preto, the associated variables were family income between one and three minimum wages, maternal age less than 18 and equal to or more than 35 years, maternal smoking and cesarean section. In a combined model including both cohorts, Ribeirão Preto presented a 45% higher risk of low birth weight than São Luís. When adjusted for maternal smoking habit, the excess risk for low birth weight in Ribeirão Preto compared to São Luís was reduced by 49%, but the confidence interval was marginally significant. Differences in cesarean section rates between both cities contributed to partially explain the paradox.

CONCLUSIONS: Maternal smoking was the most important risk factor for explaining the difference in low birth weight between both cities. The other factors contributed little to explain the difference in low birth weight rates.

KEYWORDS: Infant, low birth weight. Prevalence. Risk factors. Confounders (epidemiology). Socioeconomic factors. Maternal age. Smoking. Cesarean section.

RESUMO

OBJETIVO: O baixo peso ao nascer é incomum em recém-nascidos de maior nível socioeconômico. Contudo, no Brasil, a taxa de baixo peso ao nascer foi maior em cidade mais desenvolvida do que em município menos desenvolvido. O objetivo do estudo foi buscar razões para explicar este paradoxo.

MÉTODOS: O estudo foi realizado em Ribeirão Preto (SP) e em São Luís (MA), cujas taxas de baixo peso ao nascer eram 10,7% e 7,6%, respectivamente. Foram analisados dados de duas coortes de nascimentos: 2.839 recém-nascidos em Ribeirão Preto em 1994 e 2.439 em São Luís em 1997/98. Foi realizada análise de regressão logística múltipla, ajustada para efeito de confusão.

RESULTADOS: Os fatores de risco associados em São Luís foram primiparidade,

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idade materna menor que 18 anos e tabagismo materno. Em Ribeirão Preto, os fatores de risco foram: renda familiar entre um e três salários-mínimos, idade materna menor que 18 e igual ou maior que 35 anos, tabagismo materno e parto cesáreo. Em modelo conjunto incluindo ambas as coortes, Ribeirão Preto apresentou risco 45% maior para em relação a São Luís. Quando ajustado para tabagismo materno, o excesso de risco em Ribeirão Preto, reduziu-se em 49%, mas o intervalo de confiança esteve marginalmente significante. Diferenças nas taxas de cesárea entre as duas cidades contribuíram para explicar uma porção adicional desse paradoxo.

CONCLUSÕES: O tabagismo materno foi o fator de risco mais importante capaz de explicar a diferença no baixo peso ao nascer entre as duas cidades. Os outros fatores pouco contribuíram para explicar a diferença nas taxas de baixo peso ao nascer.

DESCRITORES: Recém-nascido de baixo peso. Prevalência. Fatores de risco. Fatores de confusão (epidemiologia). Fatores socioeconômicos. Idade materna. Tabagismo. Cesárea.

INTRODUCTION

Low birth weight (LBW) is one of the major predictors of neonatal and perinatal morbidity and mortality both in developed and developing countries.[9] It is believed that the better a population socioeconomic development, the better its health indicators, including LBW. However, lower LBW rate of populations with lower socioeconomic levels has been observed compared to populations with better indicators. This is the so-called epidemiological paradox of LBW.[7,19] In regard to ethnic-racial aspects, studies[3,7] have shown that Latin women, despite their socioeconomic disadvantage, are at lower risk of delivering LBW babies than white American women.[7] In turn, Caucasian women, even though of higher socioeconomic level, had higher LBW rates than Samoan women.[3]

In Brazil, data from the *Sistema de Informação de Nascidos Vivos* (SINASC - System of Information about Liveborn Infants) showed higher rate of LBW in the Southeastern region (8.5%) compared to the Northeastern region (6.9%) in 1999. One of the reasons for this paradox may be higher rates of underreporting of live births in the latter region.[12] However, are there any other factors that could be involved?

In São Luís and Ribeirão Preto, cities in the Northeastern and Southeastern Brazil respectively, this epidemiologic paradox has also been verified in two birth cohort studies that included representative samples of at least 94% of deliveries in both cities. LBW rate was 7.6% in São Luís compared to 10.7% in Ribeirão Preto, a city known for its excellent living standards.[15] In this case, underreporting seems to be a less probable explanation for the differences identified.

What risk factors could explain this paradox? The objective of the present study was to investigate risk factors for LBW in two socioeconomically opposed cities in order to identify those factors that might explain why, contrarily to what was expected, LBW rate is higher in a more developed than in a less developed city.

METHODS

Two population cohort studies were conducted in São Luís and Ribeirão Preto in the 1990's, and both cities have marked socioeconomic differences.

Ribeirão Preto, located in the Southeastern region of Brazil, is considered to be one of the most developed Brazilian cities. Its human development index (HDI) was 0.855 in 2000, 6th position in São Paulo's ranking and 22nd position in the national ranking.* The city's economy is based on sugar cane cultivation and industrial processing, commerce and services. Its population was 461,427 inhabitants in 1994. At that time, there were 10 maternities[16] in the city.

São Luís, located in the Northeastern of Brazil, is considered to be one of the poorest state capitals in the country, with only 50% of dwellings having sewage system and only 75% with water supply. Its HDI was 0.778 in 2000, 1st position in Maranhão's ranking but 1,112th position in the national ranking.* Its economic activity consists of aluminum industry, ore export from Carajá Sierra, commerce and services. The population was 781,068 inhabitants in 1996. In 1997, there were 18 maternities[13] in the city.

Singleton live born infants from families residing in

*HDI - Human Development Index 2000. Available from http://www.frigoletto.com.br/GeoEcon/idhsp.htm [access in 2006 Feb 16]

the two municipalities born in public and private facilities were studied. Mothers were administered a standardized questionnaire after obtaining their informed consent. A sample of 2,839 births was obtained in Ribeirão Preto. Data included all births over a period of four consecutive months from March to August 1994, after ruling out the effect of seasonality in the distribution of births in this municipality. Hospital deliveries represented 98% of all births.[4]

In São Luís, a systematic sampling of deliveries was carried out, stratified according to maternity hospital over a period of one year (from March 1997 to February 1998), for a total of 2,439 births. Based on the number of births in the previous year, one in every seven births was systematically selected in each hospital from the birth listings ordered by hour and minutes of birth to complete the desired sample size. Every morning trained personnel (undergraduate medical and nursing students) compiled ordered birth lists, and selected and interviewed the mothers after obtaining their informed consent. Hospital deliveries represented 96.3% of all births. The units where there were less than 100 births in the year 1996 were excluded from the sampling, which meant that 2.2% of births were excluded. Thus, the study initially represented 96.3% of all births but eventually included 94.1%.

At the end of the study, due to refusals or early hospital discharge, there was 3.2% loss in Ribeirão Preto and 5.8% in São Luís, both considered to be low.[13]

Hospital staff weighed newborns shortly after birth on 10 g precision digital infant scales. Validity and reproducibility of measures were high. Infants were weighed without clothing and if they were crying, their weight was obtained during deep inspiration. The scales used in the hospitals were checked periodically and, if a defect was detected, they were replaced. The same techniques were used for both cohorts.

The following variables were included in the analysis: birth weight (less than 2,500 g – low weight; 2,500 g or more – non-low weight), newborn sex (male and female), maternal age (<18, 18 to 19, 20 to 34, ≥35 years), marital status (living with or without a partner), parity (one, two to four, ≥5), route of delivery (vaginal or cesarean section), number of cigarettes smoked by the mother per day during pregnancy (none, one to 10, ≥11), maternal schooling (zero to four, five to 11, ≥12 years), type of insurance (private or public) and family income in minimum wages (<1, one to three, >3).

Gestational age was calculated for both cohorts based on the date of the LNMP (last normal menstrual period) reported by the mother. Cases where birth weight was incompatible with the LNMP or gestational age was unlikely were recorded as missing. Since missing cases accounted for 21.2% in Ribeirão Preto and 10.7% in São Luís, all cases with missing or unknown gestational age were imputed with a regression model. The characteristics used to impute gestational age were birth weight, parity, family income, and newborn sex.[17] Newborns with gestational age of less than 37 weeks were classified as preterm. Newborns were classified as small for gestational age (SGA) if their birth weight was below the 10th percentile of the weight for gestational age based on the reference proposed by Williams et al.[20]

A new index of adequacy of prenatal care utilization based on Brazilian Ministry of Health recommendations was used. It was divided into five categories: adequate, intermediate, inadequate, no prenatal care, and unknown. Prenatal care was determined by self-reporting and was considered to be adequate when women started to attend visits up to the sixth month of pregnancy and attended at least six consultations for a term gestation, at least five consultations for a gestation ending between 33 and 36 weeks, four consultations between 29 and 32 weeks, three visits between 24 and 28 weeks and two visits with less than 24 weeks of gestational age. Prenatal care starting up to the sixth month of pregnancy with five visits for a term pregnancy and a smaller number of visits according to gestational age was classified as intermediate. Prenatal care starting after the sixth month of gestation or with a number of visits below the minimum recommended for gestational age was classified as inadequate.[6] This variable takes into account the number of visits according to gestational age to prevent bias as mothers of preterm babies tend to have less prenatal visits.

The Chi-square (categorical) test was used to compare proportions between both cities. Univariable analysis was used for each cohort to identify risk factors for LBW by estimating crude odds ratios (OR) and their 95% confidence interval (CI). After selecting all independent variables that had shown statistical significance in the univariable analysis, a multivariable analysis was conducted to control for confounders. This analysis was carried out by stepwise logistic regression with backward elimination of the variables. Variables with $p<0.20$ in the univariable analysis were entered in the model and those with $p<0.10$ remained in the multivariable analysis. A missing category was added for all variables with missing information.

Variables that were associated with LBW in the

multivariable analysis in at least one of the cities were then analyzed in a combined model, including both cities, each one identified by an indicator variable. The indicator variable referred as "study" was created to represent both cities (zero, as the lowest LBW, was attributed to São Luís, and one to Ribeirão Preto). Initially, the crude OR for the indicator variable "study" indicated the unadjusted difference in LBW between both cities. Then variables were tested one at a time plus the indicator variable "study" and the OR for the indicator variable adjusted for each variable was compared to the crude OR for the indicator variable. If a variable decreased the OR it was considered one of the factors associated with the difference in LBW between both cities. Later on, in a sequential analysis, successive adjustments were performed. The level of significance was set at 0.05. Data were processed and analyzed using Stata 6.0 software.

RESULTS

LBW rate was 7.6% in São Luís and 10.7% in Ribeirão Preto (p<0.001). There was no difference between both cities regarding very low birth weight infants (<1,500 g) (1.1% *vs* 1.3%; p=0.497). Preterm birth rate was not significantly different in both cities (12.5% in Ribeirão Preto and 12.6% in São Luís, p=0.391). Small for gestational age births comprised 14.2% in São Luís and

Table 1 - Demographic, socioeconomic, behavioral and health service variables in the birth cohorts of the municipalities São Luís and Ribeirão Preto, Brazil.

Variable	São Luís - 1997/98		Ribeirão Preto - 1994		p-value
	n	%*	n	%*	
Birth weight (g)					<0.001
500-1,499	26	1.1	36	1.3	
1,500-2,499	160	6.6	267	9.4	
2,500-2,999	580	23.8	734	25.9	
≥3,000	1,673	68.6	1,802	63.5	
Newborn sex					0.005
Female	1,104	45.2	1,395	49.1	
Male	1,335	54.8	1,443	50.8	
Unknown	0	–	1	0.1	
Maternal age (years)					<0.001
<18	319	13.1	211	7.4	
18-19	398	16.3	287	10.1	
20-34	1,618	66.3	2,065	72.7	
≥35	102	4.2	269	9.5	
Unknown	2	0.1	7	0.2	
Marital status					<0.001
Living with a partner	1,847	75.7	2,375	83.7	
Living without a partner	591	24.2	346	12.2	
Unknown	1	0.1	118	4.2	
Parity					<0.001
1	1,187	48.7	1,154	40.7	
2 to 4	1,148	47.0	1,492	52.6	
≥5	104	4.3	165	5.8	
Unknown	0	–	28	1.0	
Adequacy of prenatal care utilization index					<0.001
Adequate	1,253	51.4	1,835	64.6	
Intermediate	372	15.3	307	10.8	
Inadequate	578	23.7	278	9.8	
No prenatal care	201	8.2	75	2.6	
Unknown	35	1.4	344	12.1	
Route of delivery					<0.001
Vaginal	1,616	66.3	1,394	49.2	
Cesarean section	823	33.7	1,445	50.8	
Number of cigarettes smoked by the mother per day during pregnancy					<0.001
0	2,299	94.3	2,157	76.0	
1 to 10	127	5.2	294	10.4	
≥11	13	0.5	186	6.5	
Unknown	0	–	202	7.1	
Maternal schooling (years)					<0.001
0 to 4	418	17.1	631	22.2	
5 to 11	1,896	77.7	1,649	58.1	
≥12	119	4.9	368	13.0	
Unknown	6	0.3	191	6.7	
Family income (minimum wages)					<0.001
Up to 1	786	32.3	237	8.4	
>1 to 3	718	29.4	593	20.9	
>3	772	31,6	1,179	41.5	
Unknown	163	6.7	830	29.2	
Type of insurance					<0.001
Private	269	11.0	1,001	35.3	
Public	2,170	89.0	1,695	59.7	
Unknown	0	–	143	5.0	
Total	2,439	100	2,839	100	

*Percentages may not add up to 100% because of rounding

12.8% in Ribeirão Preto but this difference was not statistically significant (p=0.137).

Table 1 shows the distribution of variables in both cities. In São Luís, there was a predominance of male newborns, mothers younger than 20 years of age and primiparae, single mothers (twice the prevalence observed in Ribeirão Preto), families with income of up to one minimum wage, high inadequate prenatal care use and public insurance. In Ribeirão Preto, there was a larger number of women aged 35 years or more, with family income higher than three minimum wages, with 12 years of schooling or more (three times higher than in São Luís) and high prevalence of cesarean deliveries. Cigarette smoking was much more prevalent in Ribeirão Preto than in São Luís (p<0.001) (Table 1).

Table 2 shows the univariable analysis and crude OR for LBW in each city. The variables associated with LBW in São Luís were: primiparity, public insurance and maternal age (mothers aged less than 18 years were at higher risk of LBW); family income was marginally associated with LBW (p-value between 0.05 and 0.10) and maternal smoking was not associated to higher risk of LBW. In Ribeirão Preto, more variables were involved: maternal age <18 years and ≥35 years, living without a partner, multiparity, maternal smoking habit, family income up to one minimum wage or one to three minimum wages, maternal schooling from zero to four years, no prenatal care and public insurance.

After adjusting for confounders in the multivariable analysis, primiparity and public insurance remained associated with LBW in São Luís. In addition, family income, maternal age, cesarean delivery, and maternal smoking were marginally associated with LBW; mothers aged <18 years and who smoked one to 10 cigarettes per day during pregnancy had higher risk of LBW in São Luís. In Ribeirão Preto, the variables that continued to be associated with LBW were: maternal smoking habit, maternal age <18 years or ≥35 years, cesarean delivery, and family income between one to three minimum wages (Table 3).

The variables that might be involved in LBW rate difference in both cities (because they were associated with LBW in at least one of them) were: maternal smoking habit, maternal age, route of delivery, type of in-

Table 2 - Univariable analysis of risk factors for low birth weight in São Luís and Ribeirão Preto, Brazil.

Variable	São Luís - 1997/98 Crude OR (95% CI)	São Luís - 1997/98 p-value	Ribeirão Preto - 1994 Crude OR (95% CI)	Ribeirão Preto - 1994 p-value
Newborn sex		0.667		0.179
Female	1.00		1.00	
Male	0.93 (0.69-1.26)		0.85 (0.67-1.08)	
Maternal age		0.001		<0.001
<18	2.06 (1.41-3.00)		1.96 (1.34-2.88)	
18-19	0.95 (0.61-1.48)		0.80 (0.51-1.26)	
20-34	1.00		1.00	
≥35	1.00 (0.45-2.21)		1.66 (1.15-2.38)	
Marital status		0.604		0.007
Living with a partner	1.00		1.00	
Living without a partner	1.09 (0.78-1.54)		1.56 (1.13-2.15)	
Parity		0.001		0.004
1	1.82 (1.32-2.49)		1.02 (0.79-1.32)	
2 to 4	1.00		1.00	
≥5	1.22 (0.55-2.74)		2.04 (1.33-3.12)	
Adequacy of prenatal care utilization index		0.861		<0.001
Adequate	1.00		1.00	
Intermediate	0.82 (0.52-1.31)		1.01 (0.68-1.51)	
Inadequate	0.98 (0.68-1.42)		1.30 (0.88-1.91)	
No prenatal care	1.17 (0.69-1.98)		3.28 (1.92-5.60)	
Unknown	1.12 (0.34-3.71)		0.99 (0.67-1.46)	
Route of delivery		0.601		0.286
Vaginal	1.00		1.00	
Cesarean section	1.08 (0.79-1.49)		1.14 (0.90-1.45)	
Number of cigarettes smoked by the mother per day during pregnancy		0.238		<0.001
0	1.00		1.00	
1 to 10	1.68 (0.98-2.94)		2.76 (2.00-3.81)	
≥11	1.04 (0.13-8.07)		3.11 (2.13-4.54)	
Unknown	–		1.41 (0.89-2.24)	
Maternal schooling (years)		0.218		0.001
0 to 4	2.46 (0.86-7.10)		2.02 (1.30-3.13)	
5 to11	2.45 (0.89-6.74)		1.29 (0.85-1.95)	
≥12	1.00		1.00	
Family income (minimum wages)		0.062		0.003
Up to 1	1.17 (0.81-1.69)		1.70 (1.10-2.61)	
>1 to 3	0.80 (0.53-1.20)		1.63 (1.19-2.25)	
>3	1.00		1.00	
Unknown	1.66 (0.96-2.87)		1.56 (1.16-2.10)	
Type of insurance		0.041		0.039
Private	1.00		1.00	
Public	1.87 (1.03-3.40)		1.32 (1.02-1.72)	

Table 3 - Final multivariable logistic regression model of risk factors for low birth weight in São Luís and Ribeirão Preto, Brazil.

Variable	São Luís - 1997/98		Ribeirão Preto - 1994	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Family income		0.061		0.051
Up to 1	1.07 (0.72-1.59)		1.50 (0.95-2.39)	
>1 to 3	0.71 (0.46-1.09)		1.52 (1.08-2.15)	
>3	1.00		1.00	
Unknown	1.52 (0.86-2.68)		1.44 (1.04-1.99)	
Parity		0.007		NS
1	1.74 (1.23-2.45)			
2 a 4	1.00			
≥5	1.09 (0,47-2,56)			
Maternal age		0.056		<0.001
<18	1.61 (1.06-2.43)		2.00 (1.31-3.05)	
18-19	0.83 (0.52-1.30)		0.85 (0.53-1.35)	
20-34	1.00		1.00	
≥35	1.12 (0.49-2.59)		1.66 (1.13-2.45)	
Number of cigarettes smoked by the mother per day during pregnancy		0.100		<0.001
0	1.00		1.00	
1 to 10	1.90 (1.06-3.39)		2.95 (2.11-4.13)	
≥11	1.34 (0.17-10.58)		3.17 (2.13-4.71)	
Unknown	–		1.32 (0.69-2.53)	
Route of delivery		0.052		0.032
Vaginal	1.00		1.00	
Cesarean section	1.40 (1.00-1.98)		1.34 (1.03-1.75)	
Type of insurance		0.014		NS
Private	1.00			
Public	2.31 (1.18-4.52)			

NS: Non-significant

surance, parity, and family income. Table 4 shows the results of the combined model. The OR (1.45) for the indicator variable "study" indicated that the crude risk of LBW was 45% higher for Ribeirão Preto compared to São Luís. When the OR was adjusted separately for each variable plus the indicator variable "study", it was possible to detect the variables that would increase or decrease the difference in the risk of LBW between São Luís and Ribeirão Preto. When adjusted for maternal smoking habit, the risk for LBW in Ribeirão Preto was reduced by 49%, from 1.45 to 1.23 and the confidence interval became marginally significant (95% CI: 1.00-1.50). This shows that maternal smoking habit was a factor contributing to explain the difference in LBW between both cities.

In the model adjusted for cesarean delivery plus the indicator variable "study", the risk of LBW between both cities was reduced by 7%, from 1.45 to 1.42, suggesting that cesarean section plays a small role for LBW difference. The remaining variables, however, had the opposite effect; for example, when the model was adjusted for preterm birth, the difference in LBW rates increased (OR increased from 1.45 to 1.56). When simultaneous adjustment for cigarette smoking and route of delivery was performed, the difference in LBW between both cities was practically eliminated (OR=1.19; 95% CI: 0.97-1.46). Further sequential adjustments contributed little to explain the difference (OR changed in the opposite direction).

DISCUSSION

Maternal smoking was the most important risk factor accounting for the epidemiologic paradox of LBW seen in Ribeirão Preto and São Luís. In a combined model, adjusting for maternal smoking decreased the difference in the risk of LBW between Ribeirão Preto and São Luís from 45% to 23%.

It has been well established that smoking during pregnancy is a preventable cause of LBW and is associated with preterm birth and increased perinatal mortality.[18] Several studies have pointed out maternal smoking as a risk factor for LBW.[1,11] However, Fuentes-Afflick et al,[7] after studying the epidemiological paradox of LBW between Latino and white American women, concluded that smoking did not contribute to explain the paradox; this difference in LBW was probably originated by cultural, behavioral and nutritional factors of these ethnic subgroups.

Risk of LBW according to the number of cigarettes smoked by the mother per day during pregnancy was higher in Ribeirão Preto than in São Luís. However, confidence intervals of the estimates found in São Luís were wider due to small number of smokers in this city. Further studies are needed to explore why risk of LBW associated with cigarette smoking was lower in São Luís.

Cesarean delivery was significantly associated with higher risk of LBW in Ribeirão Preto and marginally in São Luís. It has been shown that, in 1998, there has been an increase in cesarean rates in Ribeirão Preto mainly due to iatrogenic practices, elective cesarean deliveries, and greater utilization of ultrasound to estimate gestational age in the third trimester.[8] This

Table 4 - Sequentially adjusted models including the indicator variable "study" to test for the difference in low birth weight between Ribeirão Preto and São Luís, Brazil.

Variable	Ribeirão Preto (1994) *vs* São Luís (1997/98) OR (95% CI)
Crude OR (including only the indicator variable "study")	1.45 (1.20-1.75)
Adjusted for study plus parity	1.48 (1.22-1.79)
Adjusted for study plus maternal age	1.48 (1.22-1.80)
Adjusted for study plus family income	1.47 (1.19-1.81)
Adjusted for study plus route of delivery	1.42 (1.17-1.72)
Adjusted for type of insurance	1.58 (1.29-1.93)
Adjusted for study plus number of cigarettes smoked by the mother per day during pregnancy	1.23 (1.00-1.50)
Adjusted for study plus small for gestational age birth	1.64 (1.33-2.03)
Adjusted for study plus preterm birth	1.56 (1.27-1.93)
Adjusted for study, number of cigarettes smoked by the mother per day during pregnancy and route of delivery	1.19 (0.97-1.46)
Adjusted for study, number of cigarettes smoked by the mother per day during pregnancy, route of delivery, parity, maternal age, type of insurance and family income	1.27 (1.02-1.60)
Adjusted for study, number of cigarettes smoked by the mother per day during pregnancy, route of delivery, parity, maternal age, type of insurance and family income and preterm birth	1.34 (1.04-1.72)
Adjusted for study, number of cigarettes smoked by the mother per day during pregnancy, route of delivery, parity, maternal age, type of insurance and family income and small for gestational age birth	1.35 (1.04-1.72)

latter factor is closely associated with increasing LBW rate.[14,16] In the present study, cesarean delivery explained part of the difference in LBW between both cities. This observation is also in line with recent findings in other Brazilian city, Pelotas, where an increase in LBW has also been attributed to a rise in preterm birth mainly due to excessive medicalization (cesarean section and labor induction). [2]

Primiparity was more frequent in São Luís and was strongly associated with LBW. In Ribeirão Preto, however, there was a higher rate of multiparous women, which was associated with LBW. Buekens et al[5] reported lower prevalence of LBW among babies born to African immigrants in Belgium than among Belgian women, with multiparity representing a protective factor against LBW in the African group. In the present study, parity did not explain the paradox.

Maternal age less than 18 years was also another variable associated with LBW in São Luís. In Ribeirão Preto, not only maternal age less than 18 years but also maternal age equal to 35 years or more continued to be associated with LBW after adjustment. In the study of Latin women, maternal age above 34 years represented the highest attributable risk for very low birth weight infants in both subgroups.[7] However, in the present study adjusting for maternal age in a combined model did not reduce the OR for the indicator variable "study", showing that maternal age did not explain the difference in LBW between both cohorts.

With regard to family income, a large number of well-off families lived in Ribeirão Preto. It is known that in these social strata there is a higher rate of cesarean sections, a fact that might explain this variable association with LBW.[8] Although family income remained in the uni- and multivariable analyses as a risk factor for LBW, it did not explain the difference in LBW between both cohorts.

Adjusting either for preterm birth rate or small for gestational age births did not change the higher risk of LBW observed in Ribeirão Preto and thus these variables were not able to explain the LBW paradox. Since gestational age was determined based on the LNMP and errors in gestational age estimation are more common in poor settings, the preterm birth rate might have been overestimated in São Luís.[10,17] This may explain why adjusting for preterm birth and small for gestational age rates did not reduce the difference in LBW rates between both cities.

The fact that data in both cities were collected within a 3-year-interval may have slightly affected the comparisons, although it is very improbable that differences in LBW would have changed significantly over such a brief period of time. Since both studies were able to include at least 94% of all births in the cities, underreporting of live births may explain only a small proportion of differences in LBW rates.

As a conclusion, maternal smoking during pregnancy was the most important risk factor to explain the difference in LBW rates between both cities. Data also suggest that obstetric interventions like cesarean section had a small role in explaining this difference.

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