Maternal smoking in successive pregnancies and recurrence of low birthweight: the 2004 Pelotas birth cohort study, Brazil

Tabagismo materno em sucessivas gestações e recorrência de baixo peso ao nascer: coorte de nascimentos de Pelotas, Rio Grande do Sul, Brasil, 2004

Tabaquismo materno en sucesivas gestaciones y recurrencia de bajo peso al nacer: cohorte de nacimientos de Pelotas, Río Grande do Sul, Brasil, 2004

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Abstract

To evaluate the frequency of maternal smoking in successive pregnancies and its association with repetition of low birthweight, a study was conducted of a subsample of mothers from the 2004 Pelotas Birth Cohort in Brazil. Only women with previous histories of low birthweight newborns were included. Women with ≥ 2 previous births were eligible only if at least one of the two births immediately preceding the 2004 birth had low birthweight. From 4,458 births, 565 were included in this study. Frequency of smoking was 32.4%. Considering past pregnancies, 67.1% of mothers never smoked, 21.4% smoked during all pregnancies, 6.5% were ex-smokers, and 5% smoked only during the current pregnancy. In the adjusted analyses, when compared to mothers who never smoked, those who smoked during all pregnancies had 2.5 times greater probability of low birthweight recurrence in 2004 (PR = 2.5; 95%CI: 1.32-4.80). Smoking persistence is an important factor for the recurrence of low birthweight in successive pregnancies.

Maternal Behavior; Low Birth Weight Infant; Smoking

Resumo

Este estudo foi realizado em uma subamostra de mães da coorte de nascimentos de Pelotas, Rio Grande do Sul, Brasil, de 2004, para avaliar a frequência e associação do tabagismo em sucessivas gestações com repetição de baixo peso ao nascer. Foram incluídas somente mulheres com história pregressa de recém-nascido com baixo peso ao nascer. Mulheres com ≥ 2 partos anteriores eram elegíveis somente se, pelo menos, um dos dois partos imediatamente anteriores ao de 2004 tivesse sido de baixo peso ao nascer. Dos 4.458 nascimentos, 565 foram incluídos. A frequência de tabagismo foi de 32,4%; e, levando em conta as gestações anteriores, 67,1% nunca fumaram; 21,4% sempre fumaram; 6,5% eram ex-fumantes; e 5% fumaram somente na gestação atual. Na análise multivariável, as mães que fumaram em todas as gestações tiveram uma probabilidade 2,5 vezes maior de recorrência de baixo peso ao nascer em 2004, em comparação às que nunca fumaram (RP = 2,5; IC95%: 1,32-4,80). A persistência do tabagismo é um importante fator para a recorrência do baixo peso ao nascer em sucessivas gestações.

Comportamento Materno; Recém-Nascido de Baixo Peso; Tabagismo

Introduction

The adverse effects of maternal smoking for human pregnancy are well known. Smoking during pregnancy is associated with pregnancy complications, intrauterine growth restriction, low birthweight, and prematurity [1,2,3,4,5]. Maternal smoking reduces mean birthweight by about 150-200 grams and doubles the risk of low birthweight, with restriction of intrauterine growth being the main factor involved [6]. Moreover, a dose-response effect has been described, with occurrence of low birthweight increasing with the number of cigarettes smoked per day [7,8].

For one category of mothers, however, the effect of smoking in pregnancy is less clear. These are women with histories of low birthweight and/or preterm birth repetition in successive pregnancies. It is controversial whether the repetition of these events is due to an inherent "tendency" for repetition or persistence of risk factors [4]. Although low birthweight and preterm birth from previous pregnancies are investigated as markers of risk for the recurrence of these outcomes in subsequent pregnancies, this approach does not identify the prognostic factors for such recurrence.

One literature review identified only six studies that addressed prognostic factors for the recurrence of low birthweight, premature birth, or small for gestational age newborn infants [9]. Only one of these studies explored the effect of maternal smoking [10], and the result was unambiguous: compared with those who never smoked, women who smoked only during the second pregnancy had 52% higher risk of repeating low birthweight and, the risk was 85% higher among those who smoked during both pregnancies.

Given the paucity of available information regarding the effect of maternal smoking on the recurrence of low birthweight, the present study aimed to evaluate the frequency of this exposure in successive pregnancies and investigate its association with the repetition of low birthweight in a subsample of the 2004 Pelotas birth cohort, Rio Grande do Sul, Brazil.

Methodology

The information presented in this study derived from the 2004 Pelotas birth cohort. Data collection was performed during this cohort's perinatal phase through daily visits to five maternity hospitals in the city of Pelotas. The women were interviewed during their hospital stay by six previously trained interviewers using a standardized questionnaire. Interviewers were reassessed during data collection and alternated periods between hospitals to ensure the quality of interviews. To ensure data quality, about 10% of interviews were repeated by a trained supervisor via telephone. In addition, about 5% of mothers were re-interviewed while still in hospital by a fieldwork supervisor using an abbreviated questionnaire. Detailed information of the 2004 cohort is available elsewhere [11].

Only women with previous histories of low birthweight children were eligible for the study, with nulliparae being excluded. Women with two or more previous births were eligible only if at least one of the two deliveries immediately prior to 2004 was of low birthweight. We excluded mothers of newborns from multiple births or with congenital malformation, whether from the 2004 or prior pregnancies.

We collected information on parity (number of births prior to 2004), maternal education (number of years of formal education completed), and socioeconomic status using the Brazilian Association of Research Companies (ABEP; http://www.abep.org) classification. Because the most extreme categories include small numbers of women, only two socioeconomic groups were distinguished for statistical analyses. The first included classes D and E and the second, classes A, B, and C.

We investigated women's marital status (whether or not living with a husband or partner), age (in years completed at the time of the interview), skin color (classified as white, black, brown, yellow, or indigenous, according to the interviewer's observation), receiving prenatal care (yes/no), gestational age at first prenatal consultation, and number of prenatal care visits (the last two were evaluated for the sake of classification as proposed by Kessner and modified by Takeda) [12]. With regard to its quality, prenatal care was classified as adequate (six or more prenatal visits initiated within the first 20 weeks of gestation), inadequate (less than three consultations after 28 weeks of gestation), and intermediate (all other situations). Because there were few mothers with inadequate prenatal care, the quality of prenatal care was subsequently dichotomized into adequate and intermediate/inappropriate. Likewise, there being few mothers of Asian and indigenous origin, these were subsequently grouped together with black and brown. Consequently, for the purposes of analysis, skin color was dichotomized into white and black/brown/other. Inter-birth interval (months between the current and previous birth) was reported by the mothers.

Maternal smoking (yes/no) was investigated for the current and previous pregnancies,

with women being considered smokers if they smoked daily during each trimester of pregnancy, irrespective of the number of cigarettes. To evaluate the effect of change of smoking habits in successive pregnancies, a variable was created to indicate the "evolution of maternal smoking during pregnancy", with four categories: never smoked, always smoked, ex-smoker, and new smoker. Women with only one pregnancy prior to 2004 were classified as follows: never smoked (women who did not smoke during either of the two pregnancies), always smoked (women who smoked during both pregnancies), ex-smoker (women who smoked during the previous but not the 2004 pregnancy), and new smoker (did not smoke during the previous pregnancy, but did smoke in 2004).

To classify the evolution of smoking for women who had two or more previous pregnancies, only smoking during the two pregnancies immediately preceding 2004 was considered, according to the classification: never smoked (women who did not smoke during any pregnancy), always smoked (women who smoked during both previous pregnancies and the one in 2004), ex-smoker (women who smoked during one or two previous pregnancies but did not smoke in 2004), and new smoker (women who did not smoke in either of the pregnancies immediately preceding 2004, but did smoke in 2004).

Children weighing less than 2500 grams at birth were considered to have low birthweight. In the bivariate and multivariate analyses, prevalence ratios (PR) were obtained using Poisson regression with robust variance, since the outcome was binary and frequent. In the multivariate analysis, the variables were introduced according to a model defined a priori. Being strongly associated with birthweight, the parity variable entered the model's first (more distal) level [13,14]. In the second level were socioeconomic variables (socioeconomic status, maternal education, and marital status). The third level included age and maternal skin color. Entering into the fourth level were quality of prenatal care and sex of the newborn. Maternal smoking entered in the fifth level. We ran two adjusted models according to the exposure of interest. The first assessed the effect of current smoking during pregnancy (yes, no) and the second assessed the effect of a change of smoking habit for subsequent pregnancies. For each level, regression by backward elimination was performed, discarding variables with $p > 0.20$. Confounding variables that could bias the estimates were defined according to p-values ≤ 0.20.

The study was approved by the Pelotas Federal University Ethics Committee. Mothers signed a consent form after being informed of the study objectives and before beginning interviews.

Results

We identified 4,558 births in Pelotas in 2004, of which 565 met the eligibility criteria (singleton newborns of mothers with one or more previous deliveries with low birthweight). Of these, 86 (15.2%) had low birthweight.

Table 1 shows that repetition of low birthweight was more common among girls and newborns of mothers with two or more previous deliveries, pertaining to poorer economic groups, with less education, and having received prenatal care of intermediate or poor quality. As for smoking, repetition of low birthweight was more prevalent among newborns of mothers who smoked during pregnancy and continued smoking since previous pregnancies. The likelihood of repetition of low birthweight was 75% higher among women with two or more previous births than among those with only one (PR = 1.75; 95%CI: 1.18-2.60). Among mothers belonging to social classes D/E, repetition of low birthweight was nearly three times more frequent than among families in the economic groups A/B/C (PR = 2.79; 95%CI: 1.47-5.27). For women with less formal education (0-4 years) and who received intermediary/inappropriate prenatal care, recurrence of low birthweight was about two times higher, as compared to those with more education and adequate prenatal care, respectively.

The recurrence of low birthweight was 73% higher (95%CI: 1.17-2.54) among women who smoked during the 2004 pregnancy as compared to those who did not. More than two thirds of mothers (67.1%) had never smoked during pregnancy and of these, 8.5% repeated low birthweight. However, among the 121 mothers who smoked during all pregnancies, the recurrence of low birthweight was nearly four times higher (PR = 3.71; 95%CI: 2.43-5.68). In the categories ex-smokers and new smokers, the repetition of low birthweight was intermediate, around 25%, but still about three times higher than among women who never smoked.

Table 2 shows the distribution of smoking during pregnancy according to selected maternal characteristics. Among women with only one birth prior to 2004, 83.2% had never smoked and 10.2% smoked during both pregnancies. Among women with two or more previous births, the frequency of smoking in all pregnancies was 36.2%. The frequency of smoking in all pregnancies was three times higher in the lower social

Table 1

Prevalence of repetition of low birthweight and crude prevalence ratios (PR) by maternal characteristics and sex of the newborn (N = 565).

Characteristics	n (%)	n (% repetition of low birthweight)	Crude PR (95%CI)	p-value
Parity (N = 565)				
1 previous birth	322 (57.0)	37 (11.5)	1.00	0.005
≥ 2 previous births	243 (43.0)	49 (20.2)	1.75 (1.18-2.60)	
Socioeconomic status (N = 408)				
D/E	231 (56.6)	40 (17.3)	1.00	0.001
A/B/C	177 (43.4)	11 (6.2)	0.35 (0.18-0.67)	
Maternal education (years) (N = 563)				
≥ 5	431 (76.5)	54 (12.5)	1.00	0.001
0-4	132 (23.5)	32 (24.3)	1.93 (1.30-2.86)	
Marital status (N = 565)				
Without spouse	65 (11.5)	9 (13.9)	1.00	0.74
With spouse	500 (88.5)	77 (15.4)	1.11 (0.58-2.11)	
Maternal age (years) (N = 564)				
< 20	51 (9.0)	7 (13.7)	1.00	0.96
20-29	297 (52.7)	47 (15.8)	1.15 (0.55-2.40)	
30-34	124 (22.0)	18 (14.5)	1.05 (0.47-2.37)	
≥ 35	92 (16.3)	13 (14.1)	1.02 (0.43-2.41)	
Maternal skin color (N = 565)				
White	384 (68.0)	61 (15.9)	1.00	0.52
Black/Brown/Other	181 (32.0)	25 (13.8)	0.86 (0.56-1.33)	
Prenatal care (N = 565)				
Adequate	320 (56.6)	33 (10.3)	1.00	0.000
Intermediate/Inadequate	245 (43.4)	53 (21.6)	2.09 (1.40-3.13)	
Inter-birth period (months) (N = 544)				
≥ 24	427 (78.5)	60 (14.0)	1.00	0.28
< 24	117 (21.5)	21 (17.9)	1.27 (0.81-2.00)	
Sex of newborn (N = 563)				
Male	286 (50.8)	29 (10.1)	1.00	0.001
Female	277 (49.2)	56 (22.2)	1.99 (1.31-3.02)	
Maternal smoking during current pregnancy (N = 565)				
Smoker	183 (32.4)	39 (21.3)	1.73 (1.17-2.54)	0.005
Nonsmoker	382 (67.6)	47 (12.3)	1.00	
Maternal smoking during pregnancies				
Never	379 (67.1)	32 (8.5)	1.00	0.000
Ex-smoker	37 (6.5)	9 (24.3)	2.88 (1.49-5.56)	
New smoker	28 (5.0)	7 (25.0)	2.96 (1.43-6.10)	
Always	121 (21.4)	38 (31.4)	3.71 (2.43-5.68)	

95%CI: 95% confidence level.

classes as opposed to the higher classes, with the proportion of women who started smoking during their 2004 pregnancies being nearly double that observed for classes A/B/C. Also, quitting was 29% lower in the classes D/E. The highest smoking frequency during all pregnancies was observed among women with up to four years of formal education and who received intermediate/inappropriate prenatal care.

Table 3 presents the results of multivariate analysis of the association between smoking during the current pregnancy and evolution of maternal smoking during successive pregnancies with repetition of low birthweight. When analyzing only the exposure status during gestation of the 2004 newborn, after adjusting for parity, socioeconomic status, maternal education, adequacy of prenatal care, and sex of the

Table 2

Smoking during prior and current pregnancies, by socioeconomic status, maternal characteristics, and quality of prenatal care.

Characteristics	Smoking during consecutive pregnancies				p-value
	Never	Always	Ex-smoker	New smoker	
Parity (N = 565)					
1 previous birth	268 (83.2)	33 (10.2)	12 (3.7)	9 (2.8)	0.000
≥ 2 previous births	111 (45.7)	88 (36.2)	25 (10.3)	19 (7.8)	
Socioeconomic status (N = 408)					
D/E	139 (60.2)	64 (27.7)	12 (5.2)	16 (6.9)	0.000
A/B/C	142 (80.2)	16 (9.0)	13 (7.3)	6 (3.4)	
Maternal education (years) (N = 563)					
≥ 5	314 (72.8)	72 (16.7)	23 (5.3)	22 (5.1)	0.000
0-4	64 (48.5)	48 (36.4)	14 (10.6)	6 (4.5)	
Marital status (N = 565)					
Without spouse	39 (60.0)	18 (27.7)	3 (4.6)	5 (7.7)	0.33
With spouse	340 (68.8)	103 (20.6)	34 (6.8)	23 (4.6)	
Maternal age (years) (N = 564)					
< 20	35 (68.6)	10 (19.6)	3 (5.9)	3 (5.9)	0.67
20-29	199 (67.0)	61 (20.5)	18 (6.1)	19 (6.4)	
30-34	85 (68.5)	25 (20.2)	11 (8.9)	3 (2.4)	
≥ 35	59 (64.1)	25 (27.2)	5 (5.4)	3 (3.3)	
Maternal skin color (N = 565)					
White	274 (71.3)	70 (18.2)	24 (6.3)	16 (4.2)	0.014
Black/Brown/Other	105 (58.0)	51 (28.2)	13 (7.2)	12 (6.6)	
Prenatal care (N = 565)					
Adequate	246 (76.9)	47 (14.7)	15 (4.7)	12 (3.8)	0.000
Intermediate/Inadequate	133 (54.3)	74 (30.2)	22 (9.0)	16 (6.5)	

Table 3

Adjusted prevalence rates (PR) * and 95% confidence intervals (95%CI) for low birthweight repetition by maternal smoking habit during previous and current pregnancies.

Characteristic	PR (95%CI)	p-value
Maternal smoking during current pregnancy		
Smoker	1.05 (0.62-1.80)	0.83
Nonsmoker	1.00	
Maternal smoking during pregnancies		
Never	1.00	0.04
Ex-smoker	1.37 (0.44-4.26)	
New smoker	1.43 (0.45-4.54)	
Always	2.51 (1.32-4.80)	

* Adjusted for parity, socioeconomic status, maternal education, adequacy of prenatal care, and sex of the newborn.

newborn, there was no association between maternal smoking and recurrence of low birthweight (PR = 1.05, 95%CI: 0.62-1.80). When taking into account the evolution of exposure to smoking in successive pregnancies, mothers who smoked during all pregnancies presented PR = 2.51 (95%CI: 1.32-4.80) for recurrence of low birthweight as compared to those who never

smoked. There was a linear trend in the association between changes in smoking habits between successive pregnancies and recurrence of low birthweight, increasing from 1.37 among former smokers to 1.43 among new smokers and 2.51 among those who always smoked.

Discussion

This study involved 565 births by mothers with histories of newborns with low birthweight. The representativeness of the population was ensured by the method utilized to identify pregnant women in the city's hospitals and the occurrence of more than 99% of births in hospitals. The main limitation of the study is potential information bias resulting from the reporting of events that occurred in the past, such as smoking histories and low birthweight children from previous pregnancies. A study comparing birthweight in 1993, measured by the Pelotas birth cohort research team from that year, with maternal reporting of birthweight 11 years later showed that the percentage of agreement in the detection of low birthweight was 95.2% for the total sample (kappa = 0.73), although it was lower among mothers with low education [15]. Although the recall time in the current study was not as long, since the average interval between previous births and those that occurred in 2004 was 66 months [16], it is possible that some eligible mothers were not included in the sample.

Studies evaluating the validity of maternal information on smoking during pregnancy against biochemical tests showed that accuracy varied depending on where the study was conducted [17,18,19,20]. However, a study of English pregnant women showed that there is great variation in the frequency and intensity of smoking during pregnancy (with mothers repeatedly trying to stop or decrease the number of cigarettes smoked per day). Consequently, self-reporting was shown to have greater validity than urinary cotinine concentration, which only measures recent exposure [21]. There is no guarantee, however, that this finding applies to other populations, since smoking information may be more precise among highly educated women, as is the case in most developed countries.

Another limitation of the study stems from the fact that the group of low birthweight newborns includes infants born prematurely, with growth restriction (IUGR), or both, and the determinants of recurrent prematurity and IUGR tend to differ. The sample size, however, did not allow separate analyzes to be performed to ascertain whether mothers of children born at term with low birthweight before 2004 had a different prognosis than mothers of children with low birthweight born prematurely. For the same reason, in this study we were unable to explore factors associated with the severity of low birthweight (birthweight between 1,500 and 2,499 grams versus under than 1,500 grams).

The frequency of smoking during the current pregnancy (32.4%) was higher in our sample than was observed in the entire 2004 cohort (27.5%) [16]. Regarding the distribution of current smoking by socioeconomic status, education, ethnicity, and quality of prenatal care, the findings of the present study are consistent with the pattern observed among the other mothers of the 2004 cohort [16] and the findings of other Pelotas birth cohorts [22,23].

The main contribution of this study relates to how smoking exposure was assessed both during the current pregnancy and in previous pregnancies, which allowed us to evaluate the repetition of low birthweight according to the change or persistence of smoking status. The results of this study showed that analysis of current smoking without consideration of smoking during previous pregnancies can lead to the conclusion that smoking is not associated with recurrence of low birthweight. By considering the evolution of smoking in sequential pregnancies it became evident that the recurrence of low birthweight observed among mothers who had never smoked (8.5%) was more similar to the prevalence of low birthweight observed for the entire cohort of 2004 (10%) [24]. Moreover, among those who smoked during all pregnancies, the recurrence of low birthweight was three times higher than was observed for the cohort as a whole.

The greater repetition of low birthweight documented for women who smoked during all pregnancies is consistent with that found by Bakewell et al. [10], which analyzed 70,701 women in the United States who had their first two children between 1978 and 1990 and found an odds ratio of 1.85 for low birthweight repetition if the woman had smoked during both pregnancies.

Although the number of mothers who quitted smoking or that started smoking during the 2004 pregnancy was small in our sample (37 and 28, respectively), the proportion who repeated the experience of having a newborn with low birthweight was similar (about a quarter of the mothers in each group), showing that, given the multiple causality of low birthweight, other factors are involved in its etiology. In 1987, Kramer [4] identified 42 possible risk factors for low birthweight in addition to maternal smoking during the pregnancy. However, the persistence of smoking among mothers with previous experi-

ence of low birthweight children more than doubles the risk of recurrence.

It is striking that, despite previous history of newborns with low birthweight, more than a quarter of mothers (21.4%) continued to smoke during the pregnancy that ended in 2004. Two-thirds of mothers who smoked in 2004 were already smokers during previous pregnancies. Smoking cessation in pregnancy is not an easy task. Besides there being restrictions on the use of medication, tested behavioral strategies had only modest effect on smoking cessation among pregnant smokers [25,26]. A systematic review involving more than 70 randomized trials for smoking cessation in pregnancy showed reductions in maternal smoking (RR = 0.94; 95%CI: 0.93-0.96) and lower prevalence rates of both low birthweight (RR = 0.83; 95% I: 0.73-0.95) and preterm births (RR = 0.86; 95%CI: 0.74-0.98) [27]. The recommendation to stop smoking should be emphasized during the prenatal period, particularly among women with histories of low birthweight newborns. In the current study, the calculation of attributable risk among mothers who smoked during all pregnancies showed that 24% of the risk of low birthweight recurrence could have been avoided had they stopped smoking during pregnancy the child born in 2004.

Resumen

Este estudio fue realizado en una submuestra de madres de la cohorte de nacimientos de Pelotas, Río Grande do Sul, Brasil, de 2004 para evaluar la frecuencia y asociación del tabaquismo en sucesivas gestaciones con el fenómeno de repetición del bajo peso al nacer. Se incluyeron solamente mujeres con antecedentes en el historial médico de recién nacidos con bajo peso al nacer. Se elegían a mujeres con ≥ 2 partos anteriores, solamente, si por lo menos uno de los dos partos inmediatamente anteriores al de 2004 hubiera sido de bajo peso al nacer. De los 4.458 nacimientos, 565 fueron incluidos en la muestra. La frecuencia de tabaquismo fue de un 32,4% y, teniendo en consideración las gestaciones anteriores, un 67,1% nunca fumaron; un 21,4% siempre fumaron; un 6,5% eran ex-fumadoras; y un 5,0% fumaron solamente en la gestación actual. En el análisis multivariable, las madres que fumaron en todas las gestaciones tuvieron una probabilidad 2,5 veces mayor de recurrencia de bajo peso al nacer en 2004, en comparación con las que nunca fumaron (RP = 2,5; IC95%: 1,32-4,80). La persistencia del tabaquismo es un factor importante para la recurrencia del bajo peso al nacer en sucesivas gestaciones.

Conducta Materna; Recién Nacido de Bajo Peso; Tabaquismo

Contributors

I. S. Santos formulated the study hypothesis and supervised analyses, interpretation of findings, and manuscript writing. I. K. T. Sclowitz formulated the research hypothesis, conducted statistical analyzes, and wrote the first version of the article. M. R. Domingues contributed to data collection, analysis, and manuscript revision. A. Matijasevich and A. J. D. Barros contributed to interpretation of results and manuscript revision.

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