



Environmental Tobacco Smoke and Breastfeeding Duration

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The effect of smoking on breastfeeding duration was investigated in a population-based birth cohort study of 1,098 Brazilian infants. There were few losses to follow-up (3.2%) in the first 6 months. Maternal smoking was strongly associated with breastfeeding duration, even after adjustment for confounding. Compared with nonsmokers, mothers smoking 20 or more cigarettes daily presented an odds ratio of 1.94 for breastfeeding for less than 6 months. Environmental tobacco smoke was also an independent risk factor. After adjustment for maternal smoking and other confounders, households where more than 10 cigarettes were smoked daily by persons other than the mother presented an odds ratio of 1.48 compared with those without smokers. These results remained unchanged after stratification for maternal smoking. This is the first report of a possible effect of environmental tobacco smoke on breastfeeding duration. *Am J Epidemiol* 1997;146:128-33.

breast feeding; epidemiologic factors; smoking; tobacco smoke pollution

Breast milk has unique antiinfective properties, and there is considerable evidence of a protective effect of breastfeeding against many infectious diseases, especially diarrhea (1). This protection is particularly important in developing countries, where hygienic conditions are poor and weaning foods are usually contaminated (2).

The effect of maternal smoking on breastfeeding duration was first described by Mills in 1950 (3). The shorter lactation among smoking mothers was confirmed by several authors (4-14). Recent studies show that smoking reduces daily milk output about 250-300 ml (15, 16). A probable mechanism for this effect is the increase of dopamine secretion in the hypothalamus leading to a reduction in prolactin levels (17, 18). Because environmental tobacco smoke (ETS) has been implicated as a risk factor for many tobacco-related conditions (19) and we were unable to locate any studies on its effect on breastfeeding duration, we decided to undertake this study to assess the association between maternal exposure to tobacco and breastfeeding duration.

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Abbreviations: CI, confidence interval; ETS, environmental tobacco smoke.

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MATERIALS AND METHODS

With a population of approximately 300,000, Pelotas is a southern Brazilian city where more than 99 percent of all births occur in a hospital (20). In 1993, an attempt was made to interview all mothers giving birth in the five maternity hospitals of the city. After excluding 16 children (nine refusals and seven early hospital discharges; 0.3 percent of the total), 5,304 children were enrolled in the study. After giving verbal informed consent, mothers were interviewed by medical students who had received 2 weeks of previous training. During the interview, a standardized, precoded questionnaire was used that covered socioeconomic, demographic, and other variables including maternal smoking and the presence of other smokers in the household. Birth weight was assessed by the hospital staff using pediatric scales with an accuracy of 10 g, which were calibrated weekly by the research team. Ten percent of the interviews were repeated by a supervisor.

A systematic sample of one in five births, based on the date and hour of birth, was followed up at home when the child was 6 months of age. Only 3.2 percent of the children could not be located. During follow-up, mothers were interviewed regarding smoking in the household (by the mother, father, or others), breastfeeding duration, and additional confounding variables.

Smokers were defined as persons consuming one or more cigarettes every day. ETS exposure was assessed by the daily number of cigarettes smoked within the house by persons other than the mother.

Variables were considered as potential confounders if they were believed to be related both to the exposure and to the outcome (breastfeeding duration). The following variables were considered: monthly family income in US dollars (≤ 70 , 71–210, 211–420, 421–700, > 700); maternal schooling (years completed at school); maternal age in years (< 20 , 20–24, 25–29, 30–34, ≥ 35); skin color (white, nonwhite); marital status (married or with partner, single); parity (none, one, two, three, four or more); preceding birth interval in months (≤ 18 , > 18); use of oral contraceptives with estrogen after delivery (yes, no); low birth weight in grams ($< 2,500$, $\geq 2,500$).

Social class was assessed using the classification proposed by Bronfman et al. (21), including six categories based on the occupation of the head of household: underproletariat (unemployed or seasonal laborers); typical proletariat (unskilled and semiskilled workers in manual occupations: industry, construction, and so forth); atypical proletariat (unskilled and semiskilled workers in commerce and services); traditional small bourgeoisie (self-employed, small business owners); new small bourgeoisie (university-trained professionals); and bourgeoisie (large business owners). This classification has been used in several Brazilian studies and has been shown to be closely associated with maternal and child health indicators (21), as well as with family income (Pearson's correlation coefficient between ordinal social class scale and family income was equal to 0.49).

The adequacy of antenatal care was assessed in three categories reflecting the number of visits and the gestational age at the first attendance according to a slight modification of the classification proposed by Kessner (22): inadequate (less than three visits, or first attendance after 28 weeks of gestation), adequate (six or more attendances with the first visit before 20 weeks of gestation), intermediate (all other situations).

Statistical analysis included Cox regression for breastfeeding duration expressed in days and logistic regression for stopping breastfeeding before the age of 6 months. One-tailed tests for linear trend were calculated for ordinal exposure variables, including the number of cigarettes smoked by the mother and by other persons. Relative risks were estimated through the hazard and odds ratios, respectively. All potential confounding variables listed above were assessed, and those resulting in a change of 10 percent or greater in the relative risk estimates were included in the final model (23).

RESULTS

A total of 1,098 infants were followed up until 6 months. About 96 percent of the infants started to breastfeed; however, at 6 months, only 37.1 percent were still on the breast. The median duration was 14.4 weeks. Of the mothers, 22.6 percent smoked throughout the first 6 months after giving birth, and another 6.0 percent started smoking during this period. Among smoking mothers, 44.8 percent smoked fewer than 10 cigarettes a day, 30.6 percent from 10 to 19, and 24.5 percent 20 or more. Smoking by persons other than the mother took place in about half of the households: In 17.1 percent, 10 or more cigarettes were smoked daily; and in 30.3 percent, fewer than 10.

In table 1 is shown the distribution of the variables that, when added to the logistic regression equation containing the ETS variable, resulted in a change of 10 percent or more in the odds ratio associated with ETS. The following variables were also considered as potential confounders but did not fulfill this criterion: family income, maternal and paternal education, marital status of mother, maternal skin color, prepregnancy weight, number of antenatal care attendances, and type of delivery.

The association between maternal smoking and breastfeeding initiation was significant ($p = 0.03$) but not consistent: Smokers of fewer than 10 cigarettes a day were more likely (99.3 percent) to start breastfeeding than either nonsmokers (94.7 percent), smokers of 10–20 cigarettes a day (98.9 percent), or smokers of more than 20 cigarettes a day (94.7 percent). There was no association between ETS and initiation of breastfeeding.

In table 2 are shown the results of the logistic regression analyses, including those adjusted for confounding factors. Children whose mothers smoked were 1.34 (95 percent confidence interval (CI) 1.00–1.80) times more likely to not have been breastfed at 6 months. A clear and significant dose-response pattern was present for the daily number of cigarettes smoked by the mother. Mothers who smoked throughout the first 6 months tended to breastfeed for shorter periods than those who began smoking during this period (odds ratio 1.44, 95 percent CI 1.04–1.99). A clear dose-response effect was also present for ETS: After adjustment for confounding variables and maternal smoking, the odds ratio for households with 10 or more daily cigarettes smoked was equal to 1.48. When the number of cigarettes smoked by the mother was added to those smoked by others (table 2), a dose-response effect was also evident.

TABLE 1. Distribution of breastfeeding study sample according to confounding infant and maternal variables, Pelotas, Brazil, 1993

	%	Breastfeeding <6 months	
		OR*	95% CI*
Social class			
Bourgeoisie and new small bourgeoisie	5.4	Reference	
Traditional small bourgeoisie	17.5	1.82	0.99–3.37
Atypical proletariat	42.9	1.42	0.81–2.49
Typical proletariat	25.4	1.69	0.94–3.05
Underproletariat	8.8	1.79	0.90–3.56
Maternal age (years)			
<20	15.8	2.89	1.76–4.77
20–24	27.8	1.63	1.06–2.52
25–29	26.9	2.11	1.36–3.27
30–34	19.1	1.44	0.91–2.27
≥35	10.5	Reference	
Parity			
0	33.8	Reference	
1	28.0	0.67	0.49–0.93
2	20.6	0.54	0.38–0.76
3	7.3	0.67	0.41–1.11
≥4	10.4	0.73	0.47–1.14
Birth interval (months)			
≤18	10.1	1.66	0.95–2.87
>18	89.9	Reference	
Antenatal care adequacy			
Adequate	83.5	Reference	
Intermediate	9.0	1.34	0.86–2.09
Inadequate	7.5	1.48	0.90–2.42
Birth weight (g)			
<2,500	9.1	1.73	1.08–2.75
≥2,500	90.9	Reference	
Use of oral contraceptives with estrogen			
Yes	35.0	1.42	1.09–1.84
No	65.0		
Total	1,098	Reference	

* OR, odds ratio; CI, confidence interval.

The analyses were further stratified by maternal smoking status (table 3). The presence of another smoker in the house was associated with an odds ratio for stopping breastfeeding by 6 months of 1.31 when the mother did not smoke and of 1.21 when she did. The odds ratios associated with 10 or more cigarettes a day (excluding those smoked by the mother) were 1.48 and 1.55, respectively. The test for linear trend for the variable reflecting the number of cigarettes smoked was significant ($p = 0.04$) for nonsmoking mothers and nonsignificant ($p = 0.16$) for smokers.

These findings are confirmed by the survival analysis for breastfeeding duration (figure 1). There was again a clear dose-response trend. The hazard ratio for stopping breastfeeding in households where 10 or more daily cigarettes were smoked by persons other than the mother, relative to those without other smokers, were equal to 1.29 (95 percent CI 1.04–1.59; $p =$

0.02) after adjusting for confounding and 1.26 (95 percent CI 1.01–1.57; $p = 0.04$) after adjusting for confounding and maternal smoking. The adjusted hazard ratios were very similar when the mother was a nonsmoker (1.28, 95 percent CI 0.96–1.69) or a smoker (1.29, 95 percent CI 0.88–1.90).

DISCUSSION

The prospective nature of the study, its population base, and the high rates of follow-up make it unlikely that the findings described above are a result of selection or information bias. Unlike most previous studies on breastfeeding and smoking, confounding factors were assessed and controlled for. The possibility that indoor pollution might also be a confounding variable was considered, but wood was used as a fuel in only 2.7 percent of the households studied.

TABLE 2. Odds ratios (ORs) and 95% confidence intervals (CIs) for breastfeeding <6 months according to maternal and environmental tobacco smoking, Pelotas, Brazil, 1993

	Prevalence of breastfeeding at 6 months	Crude		Adjusted†		Total
		OR	95% CI	OR	95% CI	
Maternal smoking						
No	40.4	Reference		Reference		742
Yes	34.7	1.27	0.97–1.68	1.34	1.00–1.80	308
Daily no. of cigarettes smoked by the mother						
Nonsmokers	40.4	Reference		Reference		742
<10	41.3	0.96	0.66–1.39	0.99	0.67–1.45	142
10–19	30.9	1.52	0.95–2.40	1.61	1.00–2.61	94
≥20	27.8	1.76	1.03–3.00	1.94	1.10–3.39	72
Beginning of maternal smoking						
Nonsmokers	40.4	Reference		Reference		742
Started after delivery	40.9	0.98	0.59–1.64	1.06	0.62–1.82	66
Smoked since pregnancy	33.1	1.37	1.01–1.86	1.44	1.04–1.99	242
Environmental tobacco smoking‡						
No	42.2	Reference		Reference		554
Yes	34.9	1.37	1.06–1.75	1.27	0.97–1.66	496
Daily no. of cigarettes smoked inside the house‡						
None	42.2	Reference		Reference		554
1–9	37.3	1.23	0.93–1.63	1.17	0.87–1.59	319
≥10	30.5	1.66	1.16–2.39	1.48	1.01–2.18	177
Exposure to tobacco smoke (environmental + maternal)						
None	43.0	Reference		Reference		456
1–9	39.2	1.17	0.86–1.58	1.15	0.84–1.58	283
10–19	33.6	1.49	1.01–2.21	1.58	1.05–2.37	143
20–29	32.7	1.55	0.98–2.45	1.67	1.04–2.69	101
≥30	28.4	1.90	1.08–3.34	1.70	0.94–3.09	67
Total						1,050

* $p < 0.05$ (test for linear trend).

† Adjusted for social class, maternal age, parity, birth interval, adequacy of antenatal care, use of oral contraceptive with estrogen, and birth weight.

‡ Excluding cigarettes smoked by the mother and adjusted for maternal smoking.

The consistency with previous studies on maternal smoking and the dose-response effects support the hypothesis of a causal association between ETS and breastfeeding duration. If ETS affects the mother, it could influence breastfeeding either by an effect on prolactin production, which has been documented for maternal smoking (see beginning of article), or perhaps by changing the taste of human milk, in a similar way to alcohol and foods such as garlic, mint, or vanilla (24), making it less palatable to children.

If one assumes that the effect of ETS on breastfeeding operates through the mother, some plausibility issues are raised by the present finding of a similar magnitude of the effects of both maternal and ETS. The higher levels of cotinine in active smokers, compared with passive smokers (25, 26), would suggest a

stronger effect of maternal smoking. However, there are some indications that the present results are not incompatible with a stronger effect of maternal smoking, as follows:

- 1) The odds ratio for stopping breastfeeding, associated with the mother smoking more than 10 cigarettes a day (obtained by pooling the 10–19 and ≥20 categories in table 2), was 1.74, which is slightly larger than that for ETS, which was 1.48.
- 2) Both variables have wide confidence intervals, and the results are not incompatible with a greater effect of maternal smoking.
- 3) Although the possibility of residual confounding cannot be ruled out, 11 potential confounders were assessed and, if necessary, adjusted for. The lack of

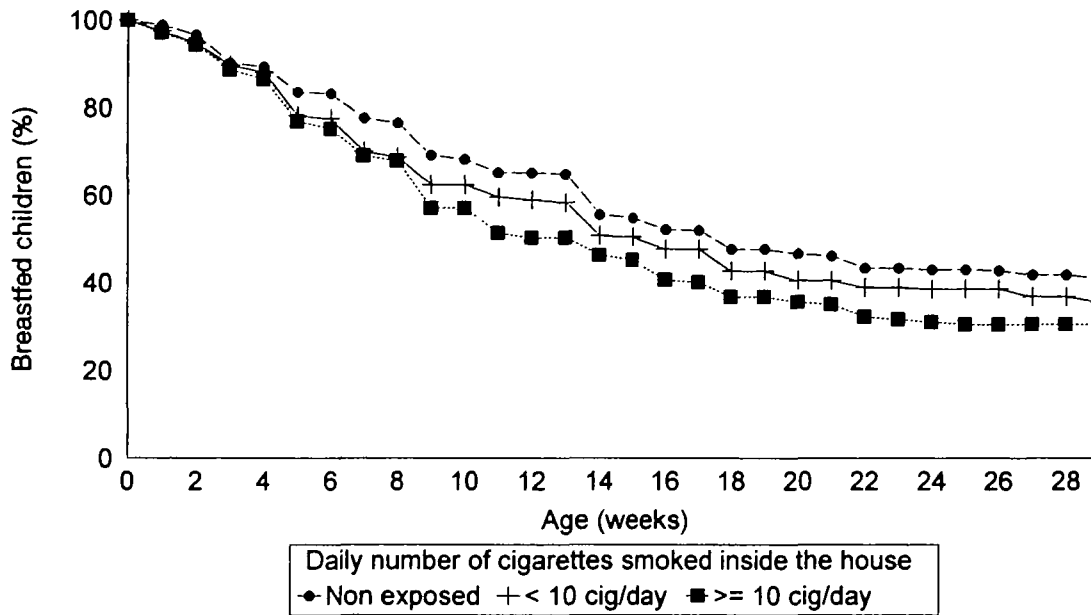


FIGURE 1. Proportion of children breastfed according to exposure to environmental tobacco smoking, Pelotas, Brazil, 1993. Values are adjusted for social class, maternal age, parity, birth interval, adequacy of antenatal care, use of oral contraceptives with estrogen, birth weight, and maternal smoking. cig, cigarettes.

TABLE 3. Odds ratios (ORs) and 95% confidence intervals (CIs) for breastfeeding <6 months according to environmental tobacco smoking, Pelotas, Brazil, 1993

	Maternal smoker†		Maternal nonsmoker†	
	OR	95% CI	OR	95% CI
Environmental tobacco smoking‡				
No		Reference		Reference
Yes	1.21	0.71–2.08	1.31	0.95–1.80
Daily no. of cigarettes smoked inside the house‡				
None		Reference		Reference
1–9	1.07	0.60–1.92	1.23	0.86–1.78
≥10	1.55	0.77–3.12	1.48	0.90–2.41
Total		308		742

* *p*, 0.05 (test for linear trend).
 † Adjusted for social class, maternal age, parity, birth interval, adequacy of antenatal care, use of oral contraceptive with estrogen, and birth weight.
 ‡ Excluding cigarettes smoked by the mother.

association between breastfeeding initiation and either maternal smoking or ETS also suggests that confounding may not explain the present findings. 4) The slightly greater odds ratio for ETS when the mother was a nonsmoker also supports the plausibility of an independent effect. “Heavy ETS” (≥10 cigarettes/day) was associated with shorter breastfeeding regardless of maternal smoking status, whereas “light ETS” (<10 cigarettes a day) had a possible effect only when the mother did not smoke. All confidence intervals are wide, so these small differences should be interpreted with caution.

There is also a possibility that ETS might affect the feeding behavior of the child, as well as maternal milk production. Both maternal smoking and ETS may increase the frequency and severity of respiratory infections (27–29), thus affecting the child’s appetite and leading to reduced nipple stimulation and lower milk production (30). If this is the case, one would expect less of a difference between the effects of smoking by the mother or by another person.

Taken together, these results suggest that environmental tobacco smoking may affect breastfeeding duration. This effect has not yet been described in the

literature and should be confirmed by additional studies, preferably using improved measurement of ETS exposure such as urine cotinine or nicotine in hair (31). This potential hazard of ETS adds to its well-documented negative impact on child health, including that on low birth weight (32) and respiratory infections (27–29). If confirmed by other studies, the present results will support the avoidance of smoking as a useful adjunct measure for breastfeeding promotion. This is particularly relevant for less developed countries where smoking is increasingly common and where breastfeeding constitutes an essential child survival measure.

REFERENCES

1. Victora CG, Vaughan JP, Lombardi C, et al. Evidence for protection by breast-feeding against infant deaths from infectious diseases in Brazil. *Lancet* 1987;2:319–21.
2. Rowland MGM, Barrel RAE, Whitehead RG. The weaning's dilemma: bacterial contamination in traditional Gambian weaning foods. *Lancet* 1978;1:316–18.
3. Mills CA. Tobacco smoking: some hints of its biologic hazards. *Ohio St Med J* 1950;46:1165–70.
4. Meyer MB. Breast-feeding and smoking. *Lancet* 1979;1:975–6.
5. Whichelow MJ, King BE. Breast feeding and smoking. (Letter). *Arch Dis Child* 1979;54:240–1.
6. Lyon AJ. The effects of smoking on breast feeding. *Arch Dis Child* 1983;58:378–80.
7. Florack E, Obermann-De Boer G, Kampen-Donker M, et al. Breast-feeding, bottle-feeding and related factors: the Leiden Pre-School Children Study. *Acta Paediatr Scand* 1984;73:789–95.
8. Andersen AN, Scholer V. Influence of breast-feeding on pituitary-ovarian axis of women in an industrialized community. *Am J Obstet Gynecol* 1982;143:673–7.
9. Rutishauser IHE, Carlin JB. Body mass index and duration of breast feeding: a survival analysis during the first six months of life. *J Epidemiol Commun Health* 1992;46:559–65.
10. Woodward A, Hand K. Smoking and reduced duration of breast-feeding. *Med J Aust* 1988;148:477–8.
11. Matheson I, Rivrud GN. The effect of smoking on lactation and infantile colic. *JAMA* 1989;261:42–3.
12. Vio F, Albala C, Salinas J, et al. Influencia del habito de fumar en la lactancia materna. (In Spanish). *Rev Med Chil* 1987;115:611–15.
13. Mansbach IK, Greenbaum CW, Sulkes J. Onset and duration of breast feeding among Israeli mothers: relationship with smoking and type of delivery. *Soc Sci Med* 1991;33:1391–7.
14. Hadani PE, Seidman DS, Manor O, et al. Breast feeding in Israel: maternal factors associated with choice and duration. *J Epidemiol Commun Health* 1994;48:281–5.
15. Vio F, Salazar G, Infante C. Smoking during pregnancy and lactation and its effects on breast-milk volume. *Am J Clin Nutr* 1991;54:1011–16.
16. Hopkinson JM, Schanler RJ, Fraley JK, et al. Milk production by mothers of premature infants: influence of cigarette smoking. *Pediatrics* 1992;90:934–8.
17. Blake CA, Sawyer CH. Nicotine blocks the suckling-induced rise in circulating prolactin in lactating rats. *Science* 1972;177:619–21.
18. Jansson A, Andersson K, Bjelke B, et al. Effects of a postnatal exposure to cigarette smoke on hypothalamic catecholamine nerve terminal systems and on neuroendocrine function in the postnatal and adult male rat: evidence for long-term modulation of anterior pituitary function. *Acta Physiol Scand* 1992;144:453–62.
19. Weiss ST, Tager IB, Schenker M, et al. The health effects of involuntary smoking. *Am Rev Respir Dis* 1983;128:933–42.
20. Barros FC, Victora CG, Vaughan JP. The Pelotas birth cohort study, 1982–1987: strategies for following up 6,000 children in a developing country. *Pediatr Perinat Epidemiol* 1990;4:267–82.
21. Bronfman M, Lombardi C, Facchini LA, et al. Operacionalización do conceito de classe social em estudos epidemiológicos. (In Spanish). *Rev Saúde Públ* 1988;22:253–65.
22. Quick JD, Roghmann KJ. Prenatal care and pregnancy outcome in an HMO and general population: a multivariate cohort analysis. *Am J Public Health* 1981;71:381–90.
23. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. *Am J Epidemiol* 1993;138:923–36.
24. Mennella JA. Mother's milk: a medium for early flavor experiences. *J Hum Lactation* 1995;11:39–45.
25. Wall MA, Johnson J, Jacob P, et al. Cotinine in the serum, saliva and urine of nonsmokers, passive smokers and active smokers. *Am J Public Health* 1988;78:699–701.
26. Pirkle JL, Flegal KM, Bernert JT, et al. Exposure of the US population to environmental tobacco smoke: the Third National Health and Nutrition Examination Survey, 1988 to 1991. *JAMA* 1996;275:1233–40.
27. Committee on Environmental Hazards: involuntary smoking—a hazard to children. *Pediatrics* 1986;77:755–7.
28. Law MR, Hackshaw AK. Environmental tobacco smoke. *Br Med Bull* 1996;52:22–34.
29. Bakoula CG, Kafritsa YJ, Kavadias GD, et al. Objective passive-smoking indicators and respiratory morbidity in young children. *Lancet* 1995;346:280–1.
30. Akre J, ed. Infant feeding: the physiological basis. *Bull WHO* 1989;67(suppl):1–108.
31. Nafstad P, Botten G, Hagen JA, et al. Comparison of three methods for estimating tobacco smoke exposure among children aged between 12 and 36 months. *Int J Epidemiol* 1995;1:88–94.
32. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. *Bull WHO* 1987;65:663–737.