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# Life Course Association of Maternal Smoking During Pregnancy and Offspring's Height: Data From the 1993 Pelotas (Brazil) Birth Cohort

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A B S T R A C T

**Purpose:** To evaluate the effect of (1) maternal smoking during pregnancy; and (2) partner smoking on offspring's height in infancy, childhood, and adolescence.
**Methods:** All hospital live births from 1993 (5,249) were identified, and these infants were followed up at several ages. Height for age, expressed as z-scores using the World Health Organization growth curves, was measured at all follow-up visits. Maternal smoking during pregnancy was collected retrospectively at birth and analyzed as number of cigarettes/day smoked categorized in four categories (never smoked, <10, 10–19, and ≥20 cigarettes/day). Partner smoking was analyzed as a dichotomous variable (No/Yes). Unadjusted and adjusted analyses were performed by use of linear regression.
**Results:** The prevalence of self-reported maternal smoking during pregnancy was 33.5%. In the crude analysis, the number of cigarettes/day smoked by the mother during pregnancy negatively affected offspring's height in infancy, childhood, and adolescence. After adjustment for confounders and mediators, this association remained statistically significant, although the magnitude of the regression coefficients was reduced. Paternal smoking was not associated with offspring's height in the adjusted analyses.
**Conclusions:** In addition to the well-known harmful effects of smoking, maternal smoking during pregnancy negatively affects offspring's height. Public health policies aimed at continuing to reduce the prevalence of maternal smoking during pregnancy must be encouraged.


**IMPLICATIONS AND CONTRIBUTION**

Maternal smoking during pregnancy negatively affects offspring's height in infancy, childhood, and adolescence. This association is partially explained by impaired birth weight and birth size. No effects of partner smoking on offspring's height were found.

The effect of modifiable variables early in life on several outcomes in later periods of life is an important aspect of public health. These early variables affect maternal and child undernutrition, which in turn have negative short-term and long-term consequences for the offspring's health [1–3].

According to the review published by Swanson et al. in 2009 [1], there is evidence of the harmful effects of maternal smoking during pregnancy on infant health, as well as in later stages of development. For that reason, programs to reduce maternal smoking rates have been strongly recommended [1]. Another review published in 2008 by Victora et al. [2] showed that maternal and fetal undernutrition have a negative effect on height and human capital of the offspring over the life course. In addition, maternal smoking during pregnancy has been described as associated with intrauterine growth restriction and low birth weight [4], offspring's obesity [5–9] with a dose-response effect in childhood [10], and with shorter height [11] and stunting [12].

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Previous reports from the 1993 and 2004 Pelotas birth cohorts in Brazil and from the ALSPAC birth cohort in the United Kingdom found that maternal smoking during pregnancy was related to impaired linear growth in the first years of life and childhood and also was associated with height components [13] and overweight in childhood [5,6] and with psychological disorders [14]. However, Leary et al. observed that because of to the observational nature of most previous studies in this field, the possibility of residual confounding cannot be ruled out because of the social patterning of smoking [5,13].

In fact, there is a gap in the knowledge of the negative effects of maternal smoking during pregnancy, and also of partner smoking, on the height of the offspring; few studies have discussed this topic, especially using longitudinal data. The purpose of this study was to evaluate the effect of the number of cigarettes/day smoked by the mother during pregnancy and by the partner on the offspring's height. It was also aimed at evaluating the role of birth weight and birth size as mediators of this association, using longitudinal data from the 1993 Pelotas (Brazil) birth cohort study [15].

## Methods

Pelotas is a city of 340,000 inhabitants located in the extreme south of Brazil. A birth cohort study including all children whose families lived in the urban area of the city was launched in 1993. They originally comprised 5,249 individuals. Mothers were approached at the hospital, and a structured interview was carried out. Members of the 1993 Pelotas birth cohort were visited at 1, 3, and 6 months and at 1, 4, 11, and 15 years. Detailed methodologic information on the Pelotas birth cohort studies is available elsewhere [15].

Height was measured at all follow-up visits and standardized by use of World Health Organiztion growth curves, transforming it to a continuous z-score of height for age. Prenatal maternal smoking was collected retrospectively at birth by asking the mother if she had smoked during pregnancy. The number of cigarettes/day smoked by the mother during pregnancy was also collected and categorized in four categories: never smoked, <10 cigarettes/day, 10–19 cigarettes/day, and ≥20 cigarettes/day. Partner smoking was also collected retrospectively and used as dichotomous (No/Yes).

Statistical analyses were performed by analysis of variance or *t*-test for bivariate associations. After that, multivariable analyses were performed by use of linear regression. The significance level of the tests was 95% ($p < .05$). Power (1-β) was calculated after the analyses and showed values higher than 90%. Analyses using data from follow-up visits of children at 1 and 4 years old were weighed because of an oversampling of low-birth-weight children. Statistical interactions between maternal and partner smoking and also among sex were tested. Statistical models included a crude analysis, a model adjusted for confounders (model 1) and two other models adjusted for mediators: model 2 (adjusted for height-for-age z-score at birth) and model 3 (adjusted for weight-for-age z-score at birth).

Potential confounders in model 1 were as follows: income (categorized into quintiles), maternal height (centimeters), maternal age (years), and skin color (white/nonwhite). All confounders were collected at birth. All analyses including adolescents at 15 years old were adjusted for the cohort member's cigarette consumption and for pubertal status.

Informed consent was obtained from the mother or caretaker at each follow-up visit. All follow-up visits were approved by the ethical committee of the Federal University of Pelotas.

## Results

The prevalence of self-reported maternal smoking during pregnancy was 33.5% in the 1993 Pelotas birth cohort. A description of the sample is shown in Table 1. The proportion of mothers who never smoked was 66.6% and of those who smoked ≥20 cigarettes/day during pregnancy was 5.0%. In addition, 49.5% of partners were smokers.

The mean schooling level of mothers in each maternal smoking category was as follows: never smokers, 7.2 years (standard deviation [SD] = 3.7); <10 cigarettes/day, 6.0 years (SD = 3.4); 10–19 cigarettes/day, 6.0 (SD = 3.1); and ≥20 cigarettes/day, 5.5 years (SD = 3.2) ($p < .001$). The mean maternal height was 160.0 cm (SD = 6.8), 159.3 cm (SD = 6.5), 159.8 cm (SD = 6.6), and 159.1 cm (SD = 6.8) for never smoked and <10, 10–19, and ≥20 cigarettes/day, respectively ($p = .017$) (data not shown in tables). Table 2 presents the description of the z-score height-for-age according to the number of cigarettes/day smoked by the mother during pregnancy and by the partner. A negative trend association between the number of cigarettes/day smoked by the mother during pregnancy and height-for-age z-score was detected in all ages ($p < .001$). In addition, the mean height-for-age z-score among offspring of mothers who had a smoker partner during pregnancy was lower than among mothers without a smoker partner for all ages ($p < .001$).

The results of the crude and adjusted linear regression are shown in Table 3. In the crude analyses, the number of cigarettes/day smoked by the mother was negatively associated with

**Table 1**
Description of the participants from the 1993 Pelotas (Brazil) birth cohort study

| Variables | 1993 | |
|---|---|---|
| | N | Prevalence (95% CI) |
| Number of cigarettes/day smoked by the mother during pregnancy | | |
| Never smoked | 3,496 | 66.6 (65.4;67.9) |
| <10 cigarettes/day | 1,114 | 21.2 (20.1;22.3) |
| 10–19 cigarettes/day | 376 | 7.2 (6.5;7.9) |
| ≥20 cigarettes/day | 260 | 5.0 (4.4;5.5) |
| Partner smoking | | |
| No | 2,428 | 50.5 (48.5–52.5) |
| Yes | 1,378 | 49.5 (46.8–52.2) |
| Sex | | |
| Female | 2,606 | 49.7 (47.7–51.6) |
| Male | 2,642 | 50.3 (48.4–52.2) |
| Skin color | | |
| White | 4,058 | 77.3 (76.0–78.6) |
| Nonwhite | 1,189 | 22.7 (20.4–25.3) |
| Family income (quintiles) | | |
| 1 (poorest) | 1,031 | 20.1 (17.7–22.6) |
| 2 | 1,195 | 23.3 (20.9–25.8) |
| 3 | 889 | 17.3 (14.8–20.0) |
| 4 | 1,001 | 19.5 (17.1–22.1) |
| 5 (wealthiest) | 1,021 | 19.8 (17.4–22.4) |
| Tanner's stage | | |
| 1 | 89 | 2.5 (.3–7.9) |
| 2 | 386 | 11.1 (8.2–14.7) |
| 3 | 1,212 | 34.7 (32.0–37.5) |
| 4 | 1,241 | 35.6 (32.9–38.4) |
| 5 | 561 | 16.1 (13.1–19.3) |

CI = confidence interval.