

Increased burden of respiratory disease in the first six months of life due to prenatal environmental tobacco smoke: Krakow birth cohort study

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The main purpose of our study was to assess the effects of prenatal tobacco smoke on respiratory symptoms and on doctor consultations in a birth cohort of 445 infants who had no smoking mothers and who had no postnatal exposure to environmental tobacco smoke (ETS). Before and after delivery, questionnaires and interviews with mothers were administered to solicit information on prenatal and postnatal ETS exposure. Newborns were followed-up over six months of life, and respiratory outcomes such as runny or stuffed nose, cough with or without cold, difficult (puffed) breathing, wheezing or whistling in the chest irrespective of respiratory infection were considered. In addition, medical visits related to the occurrence of respiratory symptoms were recorded for each child over a six-month study period. In the multivariate Poisson regression analysis, a set of potential confounders has been taken into account such as gender of child, season of birth, gestational age, maternal education, maternal atopy, presence of moulds in households and prenatal level of personal exposure to fine particles. The adjusted rate ratio (RR) estimated for the occurrence of episodes of running nose was significantly higher in infants exposed to prenatal ETS (1.40; 95% confidence interval [CI]: 1.11–1.68) and the corresponding RR estimates for cough, difficult breathing and wheezing were 1.49 (95% CI: 1.15–1.93), 1.96 (95% CI: 1.22–3.16) and 5.12 (95% CI: 2.86–9.16). The rate ratios of doctor consultations attributable to prenatal ETS because of cough was 1.94 (95% CI: 1.49–2.54). The risk estimate for consultations due to difficult breathing was 2.77 (95% CI: 1.76–4.36), and that for wheezing was 5.86 (95% CI: 3.56–9.64). The data strongly support the view about the impact of the *in-utero* effect of passive smoking on children's respiratory health. Higher utilization rates of doctor consultations in infants attributable to prenatal ETS exposure demand the revision of public health policy, which should be focused also on cessation of smoking practices by all household members during and after the pregnancy period.

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Introduction

Postnatal exposure to environmental tobacco smoke (ETS) during the first year of life has been consistently found to have an impact on the respiratory health of children regardless of whether the impact was defined by various respiratory symptoms and specific diseases such as bronchitis/tracheitis or pulmonary function (Fergusson *et al.*, 1981; Tager *et al.*, 1983; Pedreira *et al.*, 1985; McConnochie & Roghmann, 1986; Taylor & Wadsworth 1987; Forastiere *et al.*, 1992; Rona & Chinn, 1993; Stick *et al.*, 1996; Cook & Strachan, 1999; Stein *et al.*, 1999; Jedrychowski *et al.*, 2000; Mannino *et al.*, 2001; Miller *et al.*, 2004; DiFranza *et al.*, 2004). Studies that have evaluated the impact of smoking in children across the different age groups have found the impact on the respiratory symptoms to be the strongest in the first years of life. In children of all ages, ETS exposure has also been found to be associated with increased symptoms of asthma (Gortmaker *et al.*, 1982; Neuspiel *et al.*, 1989; Wetzman *et al.*, 1990; Martinez *et al.*, 1992; Ronchetti *et al.*, 1992; Chilmonczyk *et al.*, 1993; Chen *et al.*, 1996; Strachan & Cook, 1998).

Much debate has occurred on whether the damage caused by ETS exposure occurs through prenatal ETS exposure, postnatal ETS exposure or whether each has an independent effect. It has been difficult to separate these effects because of the high degree of correlation between prenatal and postnatal smoking. Most women who smoke continue to smoke during their pregnancy; only about 40–50% of smoking women quit during pregnancy, and of those who quit 70% restart after delivery—most within three months (Fingerhut *et al.*, 1990).

Although the biological or clinical effects of smoking on infant health have been conclusively demonstrated, it is still unclear to which extent prenatal exposure to ETS brings on higher use of health care services among infants who are exposed. The studies that dealt with utilization of health services in ETS-exposed children found a relationship between the frequency of clinic visits and hospitalizations and exposure to ETS in infancy (Vogt & Schweitzer, 1985; Evans *et al.*, 1987; Robertson *et al.*, 1993; Stoddard & Gray, 1997; Gergen *et al.*, 1998; McBride *et al.*, 1998; Peters *et al.*, 1998; Lam *et al.*, 2001; Tanski *et al.*, 2003). However, most of these studies have considered the effects of parental smoking and not distinguished between prenatal and postnatal exposure.

As most epidemiological studies considered mainly the impact of postnatal exposure to ETS on respiratory health of infants, the purpose of our study was to demonstrate the effect of prenatal ETS exposure on the occurrence of various respiratory symptoms over the six-month follow-up in the cohort of newborns being delivered by women who did not smoke tobacco over the pregnancy period and who had no postnatal exposure to ETS. The additional purpose of the study was to assess doctor consultations attributable to prenatal exposure to ETS. The latter problem seemed of great importance as the health care system has to shoulder a high economic burden due to increased utilization of services by those who are exposed to ETS. In the

analysis a set of potential confounders has been taken into account such as gender of child, season of birth, gestational age, maternal education, maternal atopy, presence of moulds in households and prenatal level of personal exposure to fine particles.

Materials and methods

This study uses data from an earlier established Krakow birth cohort of children, being part of a collaborative study with Columbia University in New York. The Ethical Committee of the Jagiellonian University approved the research. Between November 2000 and August 2002, a total of 505 women recruited from ambulatory prenatal clinics and healthy pregnant women in the first and second trimester of pregnancy were eligible. The enrolment included only non-smoking women with singleton pregnancies aged 18–35 years, without illicit drug use and HIV infection, and free from chronic diseases such as diabetes or hypertension. Only the women who permanently lived in Krakow for at least one year prior to pregnancy were eligible for the study. Recruited women were interviewed and given a description of the study and requirements for participation in the project. Upon enrolment, a detailed questionnaire was administered to each subject at entry to the study to solicit information on demographic data, house characteristics, medical and reproductive history, occupational hazards and smoking practices of others present in the home.

After delivery, newborns were followed-up every three months over six months, and trained interviewers carried out standardized interviews on infants' health at each three-month visit. All interviews were performed with the mothers of infants. Respiratory outcome variables included the following symptoms: runny or stuffed nose, ear infections, cough with or without cold, difficult (puffed) breathing, and wheezing or whistling in the chest irrespective of respiratory infection. For each of the symptoms the number of the episodes and duration in days over a given period were recorded in the questionnaire. An episode of respiratory symptom was defined as the occurrence of a specific symptom over at least one full day.

Data on ETS at home and/or at work were obtained by interviews at the prenatal visits and in the follow-up period. The definition of moulds in the household was based on questions regarding noticeable moisture stains and visible mould growth on the walls within the household. Maternal atopy was recognized if the mother reported allergic skin disorders or allergic related respiratory diseases.

Assessment of prenatal personal exposure to fine particles

During the second trimester of pregnancy, a member of the air monitoring staff instructed the women in the use of the personal monitor, which is lightweight, quiet and is worn in a backpack. The woman was asked to wear the monitor during the daytime hours for two consecutive days and to place the monitor near the bed at night. During the morning of the second day, the air monitoring staff-person and interviewer visited the woman's home to change the battery-pack and administer the questionnaire. They also checked to see that the monitor had been running continuously and

that there have been no technical or operating failures. A staff-member returned to the woman's home on the morning of the third day to pick up the equipment.

A Personal Environmental Monitoring Sampler (PEMS) was used to measure particle mass. The PEMS is designed to achieve a particle target size of $\leq 2.5 \mu\text{m}$ at a flow rate of 2.0 litres per minute. Flow rates were calibrated (with filters in place) using a bubble meter prior to the monitoring, and were checked again with a change of the battery-pack on the second day and at the conclusion of the monitoring. Particles were collected on Teflon membrane filter (37 mm Teflon™; Gelman Sciences). The combination of a low pressure drop (permitting use of a low-power sampling pump), low hygroscopicity (minimizing bound water interference in mass measurements) and a low trace element background (improving analytical sensitivity) of these filters make them highly appropriate for personal particle sampling.

Weighing operations of filters before and after air sampling were carried out at the Harvard School of Public Health, where the samples were conditioned for 48 hours in a temperature-controlled and humidity-controlled room (18–24°C, $40 \pm 5\%$ relative humidity). Then they were weighed using a microbalance (Mettler Model MT5) with a limit of detection of $6 \mu\text{g}$. All filters were weighted twice and the average weight was used as the filter weight. When the difference in the duplicate filters weights exceeded $5 \mu\text{g}$, the filter was weighted again and the average of two closest weights was used.

Statistical analysis

Bivariate and multivariate Poisson regression models were used to analyse the association between prenatal ETS and the occurrence of respiratory symptoms and the utilization of the health care system recorded over the follow-up. Dependent variables were the observed counts of episodes, the observed total number of days a given symptom was present or the number of doctor consultation visits of infants due to a given respiratory symptom as recorded by interviews with mothers during the follow-up at three and six months of age. As mentioned earlier, the analysis has been restricted to infants who had non-smoking mothers (never-smoking status during pregnancy) as recorded at the baseline survey and who were not exposed to ETS in the postnatal period. For the multivariate analyses, potential predictors were included such as gender of child, season of birth, gestational age, maternal education, maternal atopy, presence of moulds in households and prenatal level of personal exposure to fine particles. The season of birth and the presence of moulds in household were introduced in the regression models as dummy variables, where summer has been defined as the reference level for season and no visible moulds on the walls of the apartment as the reference level for moulds. As the distribution of the fine particles was skewed, the $\text{PM}_{2.5}$ values were logarithmic transformed prior to entry into the regression models. In the regression models the main effects and interaction terms were considered. In all statistical analyses, the significance level was assumed as $p < 0.5$. Statistical analyses were performed with NCSS software for windows (Hintze, 2001).

Results

Out of 505 women recruited over pregnancy, there were 493 that twice completed interviews in the follow-up of newborns for whom the personal fine particle measurements were carried out. In the recruited sample there were 132 women who declared ETS exposure over the whole pregnancy period but 89 of them declared that the child was not exposed to ETS in the postnatal period. Out of 361 women who denied ETS exposure in pregnancy, five confirmed that the child was exposed to ETS in the postnatal period. Hence, the study sample consisted of 445 infants, out of whom 89 were exposed prenatally to ETS but not in the postnatal period, and 356 children were without exposure both in the prenatal and postnatal periods.

Table 1 presents the distribution of variables according to mother–infant characteristics and respiratory symptoms across the ETS exposure status. There was no difference in characteristics of mothers who reported ETS exposure during pregnancy at home and/or at work, except for the fact that those with exposure to ETS were less educated. Birth outcomes in terms of birth weight, length and head circumference did not differ across the groups. However, the geometric mean of personal exposure to PM_{25} $\mu\text{g}/\text{m}^3$ was significantly higher in the group of infants with reported exposure to ETS (mean PM_{25} $\mu\text{g}/\text{m}^3 = 44.7$; 95% confidence interval [CI]: 39.5–50.6 PM_{25} $\mu\text{g}/\text{m}^3$) than in those without it (mean PM_{25} $\mu\text{g}/\text{m}^3 = 34.9$; 95% CI: 32.9–37.1 PM_{25} $\mu\text{g}/\text{m}^3$).

We observed a higher occurrence of cough (42%) than other symptoms such as difficult breathing (14%) or wheezing (9%). The average duration of an episode was longer for difficult breathing (11.4 days) and wheezing (11.5 days) than for cough (6.7 days). The number of episodes and duration of respiratory symptoms was higher in those infants who were exposed to prenatal ETS (Table 2). Over the six-month follow-up, 86% of infants with cough were consulted by a medical doctor, 76% with difficult breathing and 93% were babies with wheezing. There were on average 2.3 medical visits per child among those infants who presented wheezing; and 1.9 visits in babies who had cough or difficult breathing.

The multivariate Poisson regression has shown that the self-reported incidence of respiratory episodes and their duration (in days) was significantly associated with the prenatal exposure to ETS (Tables 3 and 4). The adjusted rate ratio for episodes of running nose among those exposed was 1.40 (95% CI: 1.11–1.68), for episodes of cough was 1.49 (95% CI: 1.15–1.93), for difficult breathing was 1.96 (95% CI: 1.22–3.16) and for wheezing was 5.12 (95% CI: 2.86–9.16). The corresponding rate ratios for duration of symptoms were 1.31 (95% CI: 1.21–1.41), 1.28 (95% CI: 1.15–1.42), 1.57 (95% CI: 1.35–1.81) and 2.87 (95% CI: 2.40–3.43). In none of the multivariate regression models did interaction between ETS and personal exposure to fine particles appear to be significant.

The reported utilization of doctor consultations due to various respiratory symptoms is presented in Table 5. It can be seen that the number of consultations due to a running nose was not significantly related to the prenatal ETS exposure. However, the rate ratio of doctor consultations because of cough was 1.94 (95% CI: 1.49–2.54),

Table 1. The distribution of variables according to mother–infant characteristics and respiratory episodes across the ETS exposure in infants under study

	Total (n = 445)	Prenatal ETS exposure		P*
		ETS-negative (n = 356)	ETS-positive (n = 89)	
Mother's age (years) (mean ± SD)	27.760 ± 3.444	28.154 ± 3.226	26.180 ± 3.833	0.0000
Mother's education				
Grammar/medium [n (%)]	138 (31.0%)	97 (27.2%)	41 (46.1%)	0.0006
Higher [n (%)]	307 (69.0%)	259 (72.8%)	48 (53.9%)	
Gender				
Boys [n (%)]	226 (50.8%)	178 (50.0%)	48 (53.9%)	0.5069
Girls [n (%)]	219 (49.2%)	178 (50.0%)	41 (46.1%)	
Gestational age (weeks) (mean ± SD)	39.33 ± 1.61	39.31 ± 1.62	39.416 ± 1.56	0.5653
Birth weight (g) (mean ± SD)	3413.5 ± 498.7	3411.0 ± 505.2	3423.7 ± 474.7	0.8298
Length at birth (cm) (mean ± SD)	54.60 ± 2.99	54.62 ± 3.02	54.48 ± 2.91	0.6927
Head circumference (cm) (mean ± SD)	33.82 ± 1.52	33.83 ± 1.53	33.82 ± 1.47	0.9751
PM _{2.5} (µg/m ³):				
Mean	42.47	40.64	49.80	0.0128
SD	28.94	25.39	39.48	
Minimum	10.34	10.34	11.49	
Maximum	285.94	166.26	285.94	
Missing data	60	48	12	
Log (PM _{2.5})				
Mean	1.552	1.540	1.601	0.0554
SD	0.251	0.241	0.285	
Minimum	1.014	1.014	1.061	
Maximum	2.456	2.221	2.456	
Missing data	60	48	12	
Season of birth				
1 (spring + summer)	230 (51.7%)	185 (52.0%)	45 (50.6%)	0.8125
2 (autumn + winter)	215 (48.3%)	171 (48.0%)	44 (49.4%)	

Table 1. (continued)

	Total (n = 445)	Prenatal ETS exposure		P*
		ETS-negative (n = 356)	ETS-positive (n = 89)	
Running nose (episodes)				
0	180 (40.4%)	150 (42.1%)	30 (33.7%)	0.0117
1	123 (27.6%)	103 (28.9%)	20 (22.5%)	
2	75 (16.9%)	59 (16.6%)	16 (18.0%)	
3+	67 (15.1%)	44 (12.4%)	23 (25.8%)	
Otitis (episodes)				
0	419 (94.2%)	337 (94.7%)	82 (92.1%)	0.1627
1	21 (4.7%)	14 (3.9%)	7 (7.9%)	
2+	5 (1.1%)	5 (1.4%)	0 (0.0%)	
Cough (episodes)				
0	259 (58.2%)	220 (61.8%)	39 (43.8%)	0.0044
1	115 (25.8%)	89 (25.0%)	26 (29.2%)	
2	39 (8.8%)	25 (7.0%)	14 (15.7%)	
3+	32 (7.2%)	22 (6.2%)	10 (11.2%)	
Difficult breathing (episodes)				
0	383 (86.1%)	311 (87.4%)	72 (80.9%)	
1	45 (10.1%)	34 (9.6%)	11 (12.4%)	
2+	17 (3.8%)	11 (3.1%)	6 (6.7%)	
Wheezing (episodes)				
0	405 (91.0%)	333 (93.5%)	72 (80.9%)	0.0003
1	30 (6.7%)	19 (5.3%)	11 (12.4%)	
2+	10 (2.2%)	4 (1.1%)	6 (6.7%)	

*p level for difference in distribution of variables across the ETS groups (chi-square).

Table 2. Number of doctor consultations due to respiratory symptoms that occurred in infants over the study period

Category of symptoms	Total (<i>n</i> = 445)	Prenatal ETS		<i>p</i> *
		ETS-negative (<i>n</i> = 356)	ETS-positive (<i>n</i> = 89)	
Running nose				
0	225 (50.6%)	181 (50.8%)	44 (49.4%)	0.2228
1	107 (24.0%)	91 (25.6%)	16 (18.0%)	
2	44 (9.9%)	34 (9.6%)	10 (11.2%)	
3+	69 (15.5%)	50 (14.0%)	19 (21.3%)	
Ear infections				
0	419 (94.2%)	337 (94.7%)	82 (92.1%)	0.6608
1	15 (3.4%)	11 (3.1%)	4 (4.5%)	
2+	11 (2.5%)	8 (2.2%)	3 (3.4%)	
Cough				
0	286 (64.3%)	239 (67.1%)	47 (52.8%)	0.0004
1	82 (18.4%)	69 (19.4%)	13 (14.6%)	
2	41 (9.2%)	26 (7.3%)	15 (16.9%)	
3+	36 (8.1%)	22 (6.2%)	14 (15.7%)	
Difficult breathing				
0	398 (89.4%)	324 (91.0%)	74 (83.1%)	0.0326
1	22 (4.9%)	17 (4.8%)	5 (5.6%)	
2+	25 (5.6%)	15 (4.2%)	10 (11.2%)	
Wheezing				
0	408 (91.7%)	335 (94.1%)	73 (82.0%)	0.0002
1	12 (2.7%)	9 (2.5%)	3 (3.4%)	
2+	25 (5.6%)	12 (3.4%)	13 (14.6%)	

**p* level for difference in distribution of variables across the ETS groups (chi-square).

Table 3. Rate ratios of episodes of various respiratory symptoms in infants associated with the prenatal ETS exposure

Independent variables	Regression coefficients	Rate ratio	Lower 95% confidence limit	Upper 95% confidence limit
Running nose	0.314	1.37	1.11	1.68
Cough	0.396	1.49	1.15	1.93
Difficult breathing	0.674	1.96	1.22	3.16
Wheezing	1.634	5.12	2.86	9.16

Rate ratios were estimated in the Poisson multivariate regression models and adjusted to potential confounding variables (gender of child, maternal education, maternal atopy, gestational age, season of birth, prenatal exposure to fine particles and presence of moulds in the house).

Table 4. Rate ratios of days with various respiratory symptoms in infants associated with the prenatal ETS exposure

Independent variables	Regression coefficients	Rate ratio	Lower 95% confidence limit	Upper 95% confidence limit
Running nose	0.267	1.31	1.21	1.41
Cough	0.248	1.28	1.15	1.42
Difficult breathing	0.449	1.57	1.35	1.82
Wheezing	1.054	2.87	2.40	3.43

Rate ratios were estimated in the Poisson multivariate regression models and adjusted to potential confounding factors (gender of child, maternal education, maternal atopy, gestational age, season of birth, prenatal exposure to fine particles and presence of moulds in the house).

while for difficult breathing it was 2.77 (95% CI: 1.76–4.36). The adjusted rate ratio for consultations due to wheezing was much higher and amounted to 5.86 (95% CI: 3.56–9.64).

Discussion

Our study demonstrated a high number of episodes of various respiratory symptoms in infants over the six-month follow-up. The highest occurrence was recorded for cough, difficult breathing and wheezing. The average duration per episode was higher for difficult breathing and wheezing than for cough symptoms. It was shown that prenatal exposure to ETS was positively associated with the number of episodes and duration of various respiratory symptoms. The adjusted rate ratio estimated in the Poisson regression models for episodes of running nose was 1.40 (95% CI: 1.11–1.68), for cough was 1.49 (95% CI: 1.15–1.93) and for difficult breathing was 1.96 (95% CI: 1.22–3.16), but was much higher for wheezing (5.12; 95% CI: 2.86–9.16). The similar relationship has been found for rate ratios estimated for the duration of various respiratory symptoms.

Table 5. Rate ratios of doctor consultations due to various respiratory symptoms in infants associated with the prenatal ETS exposure

Independent variables	Regression coefficients	Rate ratio	Lower 95% confidence limit	Upper 95% confidence limit
Running nose	0.223	1.25	1.00	1.57
Cough	0.667	1.95	1.49	2.54
Difficult breathing	1.020	2.77	1.76	4.36
Wheezing	1.768	5.86	3.56	9.65

Rate ratios were estimated in the Poisson multivariate regression models and adjusted to potential confounding factors (gender of child, maternal education, maternal atopy, gestational age, season of birth, prenatal exposure to fine particles and presence of moulds in the house).

We found more doctor consultations due to respiratory symptoms in infants who were prenatally exposed to ETS. The reported utilization of medical consultations due to respiratory symptoms except for running nose was significantly related to prenatal ETS. Again the adjusted rate ratio of consultations because of wheezing was particularly excessive (5.86; 95% CI: 3.56–9.64). Relatively wide confidence limits resulted from the relatively small number of cases with wheezing. The excessive risk of doctor consultations due to wheezing symptoms in comparison with other symptoms possibly results from the fact that parents are particularly worried about these symptoms as in their opinion they may lead to asthma or some other serious respiratory disorders in later life.

The significant association found in our study between prenatal exposure to ETS and occurrence of respiratory symptoms at six months of age is another strong argument supporting the view about the impact of *in-utero* effects of smoking on child health. The higher incidence of respiratory infections in early life may be one of the predisposing factors to lower airway function in later life; however, the long-term consequences of these findings remain to be determined in the planned five-year follow-up.

The results of our study are in consent with the evidence in the literature that not only postnatal but also prenatal exposure affects the respiratory system. Studies looking at pulmonary function tests done within three days of birth (Stick *et al.*, 1996) and within six months of life (Hanrahan *et al.*, 1992) have found reduced pulmonary function in children exposed to ETS *in utero*. Our findings about the adverse health effects of passive smoking are also in good agreement with previous studies on incidence of respiratory symptoms in infants and young children (Fergusson *et al.*, 1981; Tager *et al.*, 1983; Pedreira *et al.*, 1985; McConnochie & Roghmann, 1986; Taylor & Wadsworth 1987; Forastiere *et al.*, 1992; Rona & Chinn, 1993; Stick *et al.*, 1996; Cook & Strachan, 1999; Stein *et al.*, 1999; Jedrychowski *et al.*, 2000; Mannino *et al.*, 2001; Miller *et al.*, 2004; DiFranza *et al.*, 2004).

The evidence from our study support the results of other studies on utilization of health care system by infants who were exposed to ETS (Evans *et al.*, 1987; Stoddard & Gray, 1997; Gergen *et al.*, 1998; Lam *et al.*, 2001). However, unlike some previous studies examining the effects of ETS on respiratory health and medical care services use, we were able to make a very clear distinction of the infants with only prenatal passive smoking. Moreover, we took into account a set of additional important confounders such as maternal atopy, season of birth and prenatal exposure to fine particles or moulds. It is worthwhile to underline that the great advantage of the study is the fact that observations were carried out over the first six months of life that followed the prenatal exposure to ETS. In this postnatal period the infants are relatively well protected against other hazards mainly coming from outdoors, which could eventually confound the effect of prenatal exposure to ETS.

There is a good body of evidence that respiratory diseases are a major health issue for the health care system as they account for leading causes of visits to physicians, with hospitalization with asthma being one of the main and increasing causes of hospitalization in young children and adolescents in many countries. A wide variety of

factors have been identified as risks for respiratory disease. As our study demonstrated that higher utilization rates of doctor consultation in infants may be attributed to prenatal ETS exposure, the revision of public health policy seems to be fully justified. The promotion of smoking cessation programmes among all household members, during and after pregnancy, should widely be introduced. The task is not easy to promote household changes within the family structure. The important is to get this message not only through to doctors, but also across the public at large. The power to put forward this health promotion issue in a much better and efficient way than through other communication channels rests in the hands of medical doctors.

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References

- Chen, Y., Rennie, D. C. & Dosman, J. A. (1996) Influence of environmental tobacco smoke on asthma in nonallergic and allergic children, *Epidemiology*, 7(5), 536–539.
- Chilmonczyk, B. A., Salmun, L. M., Megathlin, K. N., Neveux, L. M., Palomaki, G. E., Knight, G. J. *et al.* (1993) Association between exposure to environmental tobacco smoke and exacerbations of asthma in children, *New England Journal of Medicine*, 328, 1665–1669.
- Cook, D. G. & Strachan, D. P. (1999) Summary of effects of parental smoking on the respiratory health of children and implications for research, *Thorax*, 54, 357–366.
- DiFranza, J. R., Aligne, C. A. & Weitzman, M. (2004) Prenatal and postnatal environmental tobacco smoke exposure and children's health, *Pediatrics*, 113, 1007–1015.
- Evans, D., Levison, M. J., Feldman, C. H. *et al.* (1987) The impact of passive smoking on emergency room visits of urban children with asthma, *American Review of Respiratory Diseases*, 135, 567–572.
- Fergusson, D. M., Horwood, L. J., Shannon, F. T. & Taylor, B. (1981) Parental smoking and lower respiratory illness in the first three years of life, *Journal of Epidemiology and Community Health*, 35, 180–184.
- Fingerhut, L. A., Kleinman, J. C. & Kendrick, J. S. (1990) Smoking before, during, and after pregnancy, *American Journal of Public Health*, 80, 541–544.
- Forastiere, F., Corbo, G. M., Michelozzi, P., Pistelli, R., Agabiti, N., Brancato, G. *et al.* (1992) Effects of environment and passive smoking on the respiratory health of children, *International Journal of Epidemiol*, 21(1), 66–73.
- Gergen, P. J., Fowler, J. A., Maurer, K. R., Davis, W. W. & Overpeck, M. D. (1998) The burden of environmental tobacco smoke exposure on the respiratory health of children 2 months through 5 years of age in the United States: Third National Health and Nutrition Examination Survey, 1988 to 1994, *Pediatrics*, 101(2). Available online at: <http://www.pediatrics.org/cgi/content/full/101/2/e8> (accessed 9 May 2006).
- Gortmaker, S. L., Walker, D. K., Jacobs, F. H. & Ruch-Ross, H. (1982) Parental smoking and the risk of childhood asthma, *American Journal of Public Health*, 72, 574–579.

- Hanrahan, J. P., Tager, I. B., Segal, M. R. *et al.* (1992) The effects of maternal smoking during pregnancy on early lung function, *American Review of Respiratory Diseases*, 145, 1129–1135.
- Hintze, J. L. (2001) *NCSS statistical system for windows*, Kaysville, Utah.
- Jedrychowski, W., Maugeri, U. & Jedrychowska, I. (2000) *In search for epidemiologic evidence on air quality and health in children and adults* (Luxembourg, Center for Research and Studies in Biomedicine), 89–102.
- Lam, T. H., Leung, G. M. & Ho, L. M. (2001) The effects of environmental tobacco smoke on health services utilization in the first eighteen months of life, *Pediatric*, 107, 91–97.
- Mannino, D. M., Moorman, J. E., Kingsley, B., Rose, D. & Repace, J. (2001) Health effects related to environmental tobacco smoke exposure in children in the United States: data from the third National Health and Nutrition Examination Survey, *Archives of Pediatric and Adolescent Medicine*, 155(1), 36–41.
- Martinez, F. D., Cline, M. & Burrows, B. (1992) Increased incidence of asthma in children of smoking mothers, *Pediatrics*, 89, 21–26.
- McConnochie, K. M. & Roghmann, K. J. (1986) Parental smoking, presence of older siblings, and family history of asthma increase risk of bronchiolitis, *American Journal of Diseases in Childhood*, 140(8), 806–812.
- Miller, R. I., Garfinkel, R., Horton, M., Camann, D., Perera, F. P., Whyatt, R. & Kinney, P. L. (2004) Polycyclic aromatic hydrocarbons, environmental tobacco smoke, and respiratory symptoms in an inner-city birth cohort, *Chest*, 126, 1071–1078.
- McBride, C. M., Lozano, P., Curry, S. J., Rosner, D. & Grothaus, L. C. (1998) Use of health services by children of smokers and nonsmokers in a health maintenance organization, *American Journal of Public Health*, 88, 897–902.
- Neuspiel, D. R., Rush, D., Butler, N. R., Golding, J., Bijur, P. E. & Kurzon, M. (1989) Parental smoking and post-infancy wheezing in children: a prospective study, *American Journal of Public Health*, 79, 168–171.
- Pedreira, F. A., Guandolo, V. L., Feroli, E. J., Mella, G. W. & Weiss, I. P. (1985) Involuntary smoking and incidence of respiratory illness during the first year of life, *Pediatrics*, 75, 594–597.
- Peters, J., McCabe, C. J., Hedley, A. J., Lam, T. H. & Wong, C. M. (1998) Economic burden of environmental tobacco smoke on Hong Kong families: scale and impact, *Journal of Epidemiology and Community Health*, 52, 53–58.
- Robertson, J., Pattemore, P. K. & Ford, R. P. K. (1993) The effect of maternal smoking on admission to hospital in infancy, *New Zealand Medical Journal*, 106, 476–477.
- Rona, R. J. & Chinn, S. (1993) Lung function, respiratory illness, and passive smoking in British primary school children, *Thorax*, 48, 21–25.
- Ronchetti, R., Bonci, E., Cutrera, R., de Castro, G., Indinnimeo, L., Midulla, F., Tancredi, G. & Martinez, F. D. (1992) Enhanced allergic sensitization related to parental smoking, *Archives of Diseases in Childhood*, 67, 496–500.
- Stein, R. T., Holberg, C. J., Sherrill, D., Wright, A. L., Morgan, W. J., Taussig, L., Martinez, F. D. (1999) Influence of parental smoking on respiratory symptoms during the first decade of life: the Tucson Children's Respiratory Study, *American Journal of Epidemiology*, 149, 1030–1037.
- Stick, S. M., Burton, P. R., Gurrin, L., Sly, P. D. & LeSouef, P. N. (1996) Effects of maternal smoking during pregnancy and a family history of asthma on respiratory function in newborn infants, *Lancet*, 348, 1060–1064.
- Stoddard, J. J. & Gray, B. (1997) Maternal smoking and medical expenditures for childhood respiratory illness, *American Journal of Public Health*, 87, 205–209.
- Strachan, D. P. & Cook, D. G. (1998) Health effects of passive smoking. Parental smoking and allergic sensitisation in children, *Thorax*, 53(2), 117–123.
- Tager, I. B., Weiss, S. T., Munoz, A., Rosner, B. & Speizer, F. E. (1983) Longitudinal study of the effects of maternal smoking on pulmonary function in children, *New England Journal of Medicine*, 309, 699–703.

- Tanski, S. E., Klein, J. D., Winickoff, J. P., Auinger, P. & Weitzman, M. (2003) Tobacco counseling at well-child and tobacco-influenced illness visits: opportunities for improvement, *Pediatrics*, 111, 162–167.
- Taylor, B. & Wadsworth, J. (1987) Maternal smoking during pregnancy and lower respiratory tract illness in early life, *Archives of Diseases in Childhood*, 62, 766–791.
- Vogt, T. M. & Schweitzer, S. O. (1985) Medical costs of cigarette smoking in a health maintenance organization, *American Journal of Epidemiology*, 122, 1060–1066.
- Weitzman, M., Gortmaker, S., Walker, D. K. & Sobol, A. (1990) Maternal smoking and childhood asthma, *Pediatrics*, 85, 505–511.