ABSTRACT. Objectives. To study the association between smoking during pregnancy and hospitalization of the child before 8 months of age.


Results. Overall, 158 (8%) of the children were hospitalized during the first 8 months of life. Compared with children whose mothers did not smoke during pregnancy, children with mothers who smoked 1 to 14 cigarettes per day had no increased risk of being hospitalized (relative risk: 1·1; 95% confidence interval: 0·8–1·5), whereas children whose mothers smoked 15 or more cigarettes per day had twice as high a risk of being hospitalized (relative risk: 2·0; 95% confidence interval: 1·2–3·3). When only hospitalizations before 2 months of age were analyzed, smoking during pregnancy was associated with an increased risk similar to that described above. Hospitalization of the child was independent of the smoking habits of the father, and an increased risk of hospitalization associated with smoking was found not only among children with symptoms from the respiratory system but also among children with symptoms from the gastrointestinal system and the skin. The association between smoking during pregnancy and hospitalization of the child persisted after adjustment for postpartum smoking habits and a number of sociodemographic and lifestyle factors.

Conclusions. Smoking 15 or more cigarettes per day during pregnancy influenced the health of the children, and several points indicated that the effect of in utero exposure was independent of postpartum smoking habits. If all pregnant women smoking 15 or more cigarettes per day stopped smoking, ~5% of all admissions to hospitals before 8 months of age could be avoided. Pediatrics 1999;104(4). URL: http://www.pediatrics.org/cgi/content/full/104/4/e46; smoking during pregnancy, hospitalization of children.

ABBREVIATIONS. RR, relative risk; CI, confidence interval.

METHODS

The infants were born between May 1991 and May 1992 and constituted a well defined part of a prenatal cohort established at the Department of Gynaecology and Obstetrics, Aarhus University Hospital, Denmark. Since August 1989, all women attending the routine antenatal care program were invited to participate in the cohort. The department, which is the only maternity ward in the city, serves a well defined geographic area with a population of ~250,000. At the 16th week of gestation, the women were asked to fill in a basic questionnaire about medical and obstetric history and a study entry questionnaire providing information about lifestyle factors and sociodemographic conditions of the family. At the 30th week of gestation, the women were asked to fill in a third questionnaire providing additional information on lifestyle and sociodemographic factors.

The attending midwife filled in a specific registration form providing information about the delivery. The obstetric data were validated by a research midwife who reviewed all of the hospital records. All complications during the first days after delivery were registered.
The women were offered the routine infant care program during the first 8 postnatal months, including 5 to 7 home visits by a health nurse. At the end of this period, the health nurse interviewed the parents about periods of illness, the duration of breastfeeding, the use of day care, and their job status. When the child was 8 months of age, the parent completed a questionnaire that provided information about the mother’s alcohol and smoking habits during the first months postpartum and the periods of illness and hospitalization of the child.

Inclusion criteria for the study were: live-born, singleton, Danish-speaking mothers who participated in the pregnancy study and who were still living in the municipality of Aarhus, Denmark at 8 months postpartum (n = 2526). Children with a birth weight <2500 g (n = 81) and a gestational age <37 completed weeks (n = 71) were excluded. The final study population was restricted further to those with valid information about the smoking habits of the mother during pregnancy (n = 1974).

The women were classified as smokers if they smoked when 30 weeks pregnant. When information about smoking habits at 30 weeks’ gestation was missing, information about smoking habits at 16 weeks’ gestation was used. Only minimal changes in smoking habits appear after 16 weeks’ gestation. Smoking was dichotomized (smokers vs nonsmokers) and categorized into three groups: 0, 1 to 14, and 15 or more cigarettes per day.

### Statistical Analyses

The bivariate association between maternal smoking and hospitalization of the child is presented as relative risk (RR) with 95% confidence interval (CI). Potential confounding variables are categorized in Table 2. They were tested in logistic regression analyses as a number of dummy variables equal to the number of categories minus one. The attributable fraction was calculated from the proportion of children exposed and the RR.

### RESULTS

Smoking habits before and during pregnancy and 8 months postpartum are presented in Table 1. Among the mothers of the 1974 children, 1390 (70%) were nonsmokers during pregnancy and 584 (30%) were smokers. Of the 584 mothers who smoked during pregnancy, 484 (83%) smoked 1 to 14 cigarettes per day and 100 (17%) smoked 15 or more cigarettes per day. Overall 158 (8%) of the 1974 children had been hospitalized during their first 8 months of life.

Bivariate relations between smoking during pregnancy, other sociodemographic and lifestyle factors, and hospitalization of the child are shown in Table 2. The proportion of children who were hospitalized increased with the number of cigarettes smoked per day (nonsmoking mothers, 7%; 1 to 14 cigarettes per day, 8%; and 15 or more cigarettes per day, 15%). The RR for hospitalization of the children of smokers compared with the children of nonsmokers is shown in Table 3.

Among children whose mothers were nonsmokers during pregnancy, 2% were hospitalized before 2

### TABLE 1. Smoking Habits Before and During Pregnancy and 8 Months Postpartum Among the Mothers of 1974 Children, Aarhus, Denmark, 1991–1992

<table>
<thead>
<tr>
<th>Smoking</th>
<th>Before Pregnancy</th>
<th>During Pregnancy</th>
<th>8 Months Postpartum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonsmokers</td>
<td>1156 (59%)</td>
<td>1390 (70%)</td>
<td>1282 (65%)</td>
</tr>
<tr>
<td>Smokers</td>
<td>818 (41%)</td>
<td>584 (30%)</td>
<td>658 (33%)</td>
</tr>
<tr>
<td>Missing information</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>1–14 cigarettes/d</td>
<td>426 (52%)</td>
<td>484 (83%)</td>
<td>402 (61%)</td>
</tr>
<tr>
<td>15+ cigarettes/d</td>
<td>392 (48%)</td>
<td>100 (17%)</td>
<td>256 (39%)</td>
</tr>
</tbody>
</table>

months of age, compared with 5% among children whose mothers smoked 15 or more cigarettes per day (Table 4). The proportion of children who were hospitalized with symptoms from the respiratory and
gastrointestinal systems and the skin was higher in children whose mothers had smoked during pregnancy than in children of nonsmokers. The risk associated with smoking was independent of the gender of the child and the smoking habits of the father. Adjustment for parity, maternal age, marital status, educational level, work status, alcohol and caffeine intake during pregnancy, breastfeeding and use of day care in early infant life, and smoking habits of the mother 8 months after pregnancy did not change the results.

**DISCUSSION**

Children whose mothers smoked 15 or more cigarettes per day during pregnancy experienced twice the risk of being hospitalized during their first 8 months of life compared with children whose mothers did not smoke during pregnancy.

We were not able to study hospitalization among children whose mothers changed smoking habits after delivery because so few women stopped or started smoking after delivery. However, adjustment in a multivariate analysis of smoking habits of the mother 8 months after delivery apparently could not explain our results. Furthermore, the rate of admission to the hospital was independent of the smoking habits of the father. This also indicates that passive exposure to cigarette smoking after delivery is less important than exposure in utero within the period of observation of the present study.

We found that smoking during pregnancy significantly increased the risk of hospitalization attributable to illnesses related to different organs. If passive exposure to cigarette smoking after delivery should explain our findings, only the risk of hospitalization attributable to respiratory illness should be increased. Furthermore, when only hospitalizations before 2 months of age were analyzed, we found the same association between smoking during pregnancy and hospitalization as at 8 months of age. Before 2 months of age, the passive exposure postnatally possibly would have had a minor effect compared with intrauterine exposure.

Because of careful collection of information about maternal lifestyle factors prenatally and postnatally, sociodemographic factors, and variables such as breastfeeding and use of day care in early infancy, we could adjust for potential confounders, which has not been possible in previous studies.  

However, none of these variables could explain our results. Furthermore, we collected information about smoking habits during pregnancy prospectively. Thus, our information could not be biased by the parents' knowledge about hospital admissions of the child. Admissions to the hospital during early childhood are likely to be recalled readily, because it is a traumatic experience for all parents. We were able to categorize smoking habits into low and high exposure by the number of cigarettes smoked, and, because of knowledge about smoking habits 8 months after delivery, we could also adjust for smoking habits postnatally.

Our findings are in accordance with results from other studies. Two previous studies collected information about smoking habits during pregnancy prospectively,  

but none of these studies adjusted for changes in smoking habits after delivery. Rantakallio categorized smoking habits into low (<15 cigarettes per day) and high (≥10 cigarettes per day) exposure, and in agreement with our findings, she found that children who had been exposed highly in utero had an increased risk of admission to hospital before 1 year of age. Taylor and Wadsworth, who collected information about maternal smoking habits during pregnancy retrospectively, found that maternal smoking during pregnancy significantly increased the risk of admission to hospital with lower respiratory tract illness. Adjustment for duration of postnatal exposure to smoking did not change their results, indicating that the primary effect came from exposure in utero. Similar findings have been reported by Harlap. She found that rates of hospital admission with bronchitis and pneumonia, but not with gastroenteritis or other infectious diseases, were increased in children whose mothers had smoked during pregnancy compared with children of nonsmokers.

The present study provides additional evidence of the harmful effects of smoking during pregnancy by indicating a generally increased likelihood of childhood illness reflected by increased rates of admission to the hospital. If our results reflect a true association between exposure to smoking in utero and hospitalization of the child, ~5% of all admissions to hospitals before 8 months of age could be avoided if all pregnant women smoking 15 or more cigarettes per day stopped smoking.

**ACKNOWLEDGMENT**

This study was funded by the Ronald McDonald Bornefond, Ronald McDonald House Charities.

**REFERENCES**


**TABLE 4. Risk of Hospitalization of the Child During the First 2 Months of Life According to Mothers’ Smoking Habits During Pregnancy, Aarhus, Denmark, 1991–1992**

<table>
<thead>
<tr>
<th>n</th>
<th>Hospitalized</th>
<th>%</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1390</td>
<td>34</td>
<td>2</td>
<td>Reference</td>
</tr>
<tr>
<td>1–14 cigarettes/d</td>
<td>484</td>
<td>10</td>
<td>0.8</td>
<td>0.4–1.7</td>
</tr>
<tr>
<td>15+ cigarettes/d</td>
<td>100</td>
<td>5</td>
<td>2.0</td>
<td>0.8–5.1</td>
</tr>
</tbody>
</table>
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