The Effects of Environmental Tobacco Smoke on Health Services Utilization in the First Eighteen Months of Life

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ABSTRACT. *Objective.* **To examine the effects of environmental tobacco smoke (ETS) on health services use in Chinese infants with nonsmoking mothers.**

Design. **Prospective, population-based birth cohort.**

Setting. **General population of Hong Kong in 1997–1998.**

Participants. **A total of 8327 parent–infant pairs who were followed up for 18 months.**

Main Outcome Measures. **Doctor consultations and hospitalizations.**

Results. **After adjusting for the age, education level, and employment status of mothers—as well as infants' birth weight, method of delivery, breastfeeding status, and birth order—ETS exposure through the mother in utero was positively associated with higher consultation (adjusted odds ratio [OR]: 1.26; 95% confidence interval [CI]: 1.14, 1.39) and hospitalization (OR: 1.18; 95% CI: 1.05, 1.31) use in infants with nonsmoking mothers attributable to any illness. In addition, postnatal exposure to ETS at home was linked to higher rates of hospitalizations for any illness compared with nonexposed infants (OR: 1.12; 95% CI: 1.00, 1.25), although the relationship did not hold for outpatient consultation visits. The OR for higher hospital use in infants exposed to 2 or more smokers at home was 1.30 (95% CI: 1.08, 1.58).**

Conclusions. **The use of tobacco products by household members, even among nonsmoking mothers, has an enormous adverse impact on the health of children, as well as increases health services use and cost. The present data support the revision of public policy to reflect an evidence-based approach to the promotion of smoking cessation in all household members during and after pregnancy.** *Pediatrics* **2001;107(6). URL: http://www.pediatrics.org/cgi/content/full/107/6/e91;** ***environmental tobacco smoke, health services, infants.***

ABBREVIATIONS. ETS, environmental tobacco smoke; OR, odds ratio; MCHC, Maternal and Child Health Center; CI, confidence interval.

Tobacco companies and smokers often argue that the decision to smoke is a conscious lifestyle choice, where they freely choose to assume the risks of smoking, and should, therefore, be respected as a fundamental right. This, however, cannot be claimed for passive smoking, especially in infants and young children. Two recent systematic reviews have confirmed convincing and accumulating evidence that infant exposure to environmental tobacco smoke (ETS) is associated with higher rates of respiratory illnesses and symptoms as well as middle ear disease.[1,2] DiFranza and Lew[1] calculated pooled risk ratios of 1.19 for the association between parental smoking and otitis media, and 1.43 for asthma prevalence in children of smokers. In another metaanalysis,[2] the summary odds ratio (OR) for lower respiratory illnesses from birth until 2 years old if either parent smoked was reported as 1.57. Although essentially narrative rather than systematic or quantitative, the findings of the 1997 California Environmental Protection Agency review were generally similar.[3]

Although the biological or clinical effects of smoking on infant health have been conclusively demonstrated, it is unclear whether chronic exposure to ETS translates into higher use of health care services by exposed infants and children. The association of ETS exposure with health services use has been sparsely reported in the literature. Of the studies published, the results have been inconsistent. Some reports suggested the increased use of, or expenditure on, medical care services for children exposed to ETS,[4–7] whereas others found no, or even an inverse, relationship between the frequency of clinic visits and hospitalizations and exposure to tobacco smoke in infancy and childhood.[8,9] Furthermore, most of these studies have looked broadly into the effects of parental smoking without clearly distinguishing between maternal, paternal, and other sources.[4,7–9] The remaining 2 articles exclusively studied infants whose mothers were smokers.[5,6] The issue yet to be addressed is the contribution of ETS from fathers and other household contacts to health services use. In Hong Kong, the rate of maternal smoking (4.6%) is very low, compared with other developed countries such as the United States (31.7%),[6] making Hong Kong an ideal environment in which to examine this issue.

We, therefore, conducted a population-based prospective study of Hong Kong families to clarify this potential link. Our objectives were to study the effects of ETS on doctor consultations and hospitalizations in a birth cohort of local Chinese infants who had nonsmoking mothers.

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METHODS

Sources of Data

Data for this article were drawn from a prospective birth cohort study conducted at all 47 Maternal and Child Health Centers (MCHCs) of the Department of Health in 1997. The vast majority of infants in Hong Kong, regardless of ability to pay for private care, visit the MCHCs for preventive care and immunizations. For the index year, 92% of all infants born in Hong Kong attended an MCHC at least once.[10] The sampling frame consisted of all infants brought to an MCHC for their first visit after birth in April and May of 1997. The response rate to our study was 95%, accounting for 88% of all births in the period. There were 8327 mother–infant pairs in the final cohort. The main purpose of the birth cohort study was to investigate the effects of ETS and breastfeeding on health services use attributable to respiratory illnesses during the first 18 months of life. Among other items, mothers provided information on breastfeeding history, household smoking habits, method of delivery (normal vaginal, vaginal assisted with suction or forceps, cesarean section), and other demographic, obstetric, behavioral, and potential confounding variables via a standardized self-administered questionnaire at their first MCHC visit (baseline) and at 3, 9, and 18 months after birth. In particular, questions ascertaining household smoking habits included maternal and paternal smoking as well as smoking by other household members both during pregnancy and after birth. The questionnaire also asked about the number of cigarettes smoked by mothers, fathers, and other cohabiting members. Use of health services was measured by the number of physician consultations and episodes of hospitalizations since the last MCHC follow-up, excluding preventive visits such as vaccination and regular checkups. Mothers were also requested to provide information on the type of illness (respiratory illness, febrile illness, and other conditions) leading to the consultation or hospitalization. To minimize recall bias, parents were given the health services utilization questionnaires to take home and were asked to fill in the form whenever the infant was taken for a consultation or was hospitalized. In this way, the outcomes of interest were documented prospectively and recorded as they occurred. Using telephone interviewing, trained research assistants contacted those who could not complete the questionnaire and followed up those who did not return the questionnaire in time to ensure optimal follow-up.

The project received ethics approval from the University of Hong Kong's Research Ethics Committee.

Statistical Analysis

We used bivariate and multivariate logistic regression analyses[11] to study the association between ETS patterns and doctor consultations and hospitalizations of infant participants as recorded during follow-up visits at 3, 9, and 18 months of age. The analysis was restricted to infants who had nonsmoking mothers (ie, never smoking status since pregnancy), as recorded on the baseline survey. Doctor consultations were dichotomized as either low or high use. Infants were defined as high utilizers of medical services if she/he had more consultations than the median among the sample (rounded to the nearest integer), adjusted for length of follow-up pro rata. Hospitalizations were similarly coded.

For the multivariate analyses, potential predictors were included if they were associated with a P value $<.05$ at bivariate analyses or were selected based on known confounders documented in previous reports.[1,2,12] The following independent variables were included in the multivariate models: breastfeeding practice (ever vs never), birth weight (<2500 g, 2500–2999 g, 3000–3499 g, 3500–3999 g, ≥4000 g), method of delivery (normal vaginal, vaginal assisted with suction or forceps, cesarean section), mother's age (≤24, 25–29, 30–34, ≥35 years), mother's education level (sixth grade or less, seventh to ninth grade, ≥tenth grade), full-time job held by mother (yes or no), birth order of infant (first, second, third, or more), and gender of infant (male or female).

All analyses were conducted using *Stata, Version 6.0*.[13]

RESULTS

Parent–Infant Characteristics

There were 8327 mother-infant pairs in the study sample. Of these, 4948 participants (59.4%) returned for all 3 scheduled follow-up visits, 2114 (25.4%) for 2 of the 3 follow-ups, and 828 (9.9%) for only 1 follow-up. There were 437 infants (5.3%) who never returned after the baseline visit; therefore, these infants were excluded from the present analysis. Overall, 34% initiated breastfeeding with a median duration of 8 weeks. Vaginal delivery with assistance accounted for 16.6% of births, whereas 26.9% of infants were delivered by cesarean section. The majority of women (59.8%) continued formal education beyond the 9-year compulsory duration (ie, up to junior secondary level of ninth grade) required and provided free-of-charge by the government. Approximately half (46.2%) held a full-time job. Most infants (89.0%) were either the first or second child in the family.

Table 1 shows the distribution of variables according to parent–infant characteristics and the accompanying unadjusted ORs for doctor consultations and hospitalizations attributable to respiratory or febrile illness and attributable to any illness.

Exposure to Tobacco Smoke

Of the mothers, 4.6% were ever smokers since conception (who were excluded from the analysis), and 33.6% of fathers reported smoking at the baseline MCHC visit. Among the 365 ever smoking mothers, 50.8% had smoked since pregnancy and continued after delivery, whereas 38.5% reported smoking only during pregnancy but not after delivery. The remaining 39 women (10.7%) started to smoke only postpartum. For nonsmoking mothers, 65% reported ETS exposure during pregnancy, composed of 50.5% with occasional exposure and 14.2% with daily exposure. After birth, infant exposure to ETS at home, via smoking by fathers or others, was documented in 41.2% of households.

Utilization of Health Services

Among infants with nonsmoking mothers, Table 2 shows the self-reported incidence of high (defined as above the median number of consultations or hospitalizations within the study sample) health services utilization at the MCHC visits, stratified by exposure to different forms of ETS in the household and by clinical outcomes (respiratory and febrile illness; any illness). In terms of consultation visits, overall, we observed striking similarity in the infants' patterns of use during the study regardless of ETS exposure status, except for maternal ETS exposure during pregnancy. Small differences between the groups in the postnatal exposure categories indicated a consistent pattern of slightly more high users of consultation among infants exposed to ETS than among those not exposed, although none of the differences were statistically significant. There were clearly higher levels of consultation for infants who had been exposed to ETS in utero via mothers' passive smoking attributable to respiratory and febrile illness ($P < .001$) or, more generally, any illness ($P < .001$).

In contrast, high hospital admission rates were significantly more prevalent among infants exposed to ETS either before or after birth, and for respiratory and febrile illness or any illness. Of note, we demonstrated a clear dose–response gradient between

TABLE 1. Crude ORs for High Health Services Utilization According to Mother–Infant Characteristics

Characteristic	%†	Consultation				Hospitalization			
		Respiratory/Fever		Any Illness		Respiratory/Fever		Any Illness	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Maternal education level									
≤Grade 6	12.5	1	***	1		1	*	1	**
Grades 7–9	26.9	0.94	(0.81, 1.10)	0.96	(0.82, 1.12)	1.07	(0.87, 1.31)	1.06	(0.89, 1.26)
Grades 10–11	43.7	0.94	(0.81, 1.09)	1.02	(0.88, 1.18)	1.06	(0.88, 1.29)	1.02	(0.87, 1.20)
Matriculation and/or university	16.8	0.71	(0.60, 0.84)	0.84	(0.71, 1.00)	0.74	(0.59, 0.93)	0.75	(0.62, 0.91)
Maternal full–time employment									
No	52.8	1		1		1		1	
Yes	47.2	1.08	(0.98, 1.18)	1.19	(1.09, 1.31)	0.97	(0.86, 1.09)	0.98	(0.89, 1.09)
Maternal age									
≤24	10.9	1		1		1	***	1	***
25–29	31.2	1.04	(0.88, 1.22)	1.12	(0.95, 1.32)	0.97	(0.79, 1.18)	0.98	(0.83, 1.17)
30–34	39.1	0.98	(0.83, 1.14)	1.09	(0.93, 1.27)	0.80	(0.66, 0.98)	0.85	(0.72, 1.01)
≥35	18.7	0.92	(0.77, 1.10)	0.95	(0.80, 1.13)	0.65	(0.51, 0.81)	0.71	(0.58, 0.86)
Birth order									
1	46.9	1		1		1		1	
2	42.0	1.20	(1.09, 1.33)	1.05	(0.96, 1.16)	0.99	(0.87, 1.12)	0.96	(0.86, 1.07)
≥3	11.1	1.02	(0.87, 1.19)	0.89	(0.76, 1.04)	0.91	(0.74, 1.12)	0.91	(0.77, 1.08)
Method of delivery									
Vaginal	56.4	1		1	**	1	*	1	***
Vaginal with suction or forceps	16.7	0.97	(0.85, 1.10)	1.08	(0.95, 1.23)	1.03	(0.87, 1.21)	1.03	(0.90, 1.19)
Cesarean section	26.9	1.11	(1.00, 1.23)	1.18	(1.06, 1.31)	0.84	(0.73, 0.97)	0.80	(0.71, 0.90)
Birth weight									
<2500 g	47.0	1.09	(0.88, 1.35)	1.07	(0.87, 1.32)	1.63	(1.27, 2.08)	1.92	(1.54, 2.38)
2500–2999 g	5.2	0.89	(0.80, 1.00)	0.93	(0.83, 1.05)	1.09	(0.94, 1.26)	1.15	(1.02, 1.31)
3000–3499 g	23.9	1		1		1		1	
3500–3999 g	20.4	0.95	(0.85, 1.08)	0.95	(0.84, 1.08)	1.03	(0.88, 1.21)	1.00	(0.88, 1.15)
≥4000 g	3.5	1.06	(0.82, 1.36)	0.99	(0.76, 1.27)	1.07	(0.77, 1.49)	1.10	(0.83, 1.46)
Ever breastfeeding									
No	53.8	1		1		1		1	
Yes	46.2	0.82	(0.75, 0.90)	0.83	(0.75, 0.91)	1.01	(0.89, 1.13)	1.14	(1.03, 1.26)

* $P < .05$; ** $P < .01$; *** $P < .001$ (test for linear trend).
† Totals within categories may not equal 100% because of rounding.

TABLE 2. Incidence of High Health Services Utilization

	%†	Consultation		Hospitalization	
		Respiratory/Fever	Any Illness	Respiratory/Fever	Any Illness
Exposure to ETS during pregnancy					
No	34.9	43.0	43.8	16.8	26.0
Yes	65.1	47.5	50.0	18.7	29.6
P value		<.001	<.001	.037	<.001
Paternal smoking					
No	68.8	45.4	47.6	17.3	27.4
Yes	31.2	47.0	48.3	19.6	30.5
P value		.215	.606	.014	.005
Smoking by others					
No	85.8	45.9	48.0	17.6	27.7
Yes	14.2	46.4	47.2	20.3	32.7
P value		.747	.653	.038	<.001
Exposure to ETS (by father and others) at home					
No	61.1	45.3	47.5	17.1	27.0
Yes	38.9	46.9	48.1	19.5	30.6
P value		.183	.616	.009	<.001
Total number of smokers at home				**	***
None	61.4	45.3	47.5	17.1	27.0
1	30.7	47.1	48.8	18.9	29.4
≥2	7.9	46.9	46.5	21.7	34.6
P value		.332	.519	.010	<.001

** $P < .01$; *** $P < .001$ (test for linear trend).
† Prevalence of risk factor; totals within categories may not equal 100% because of rounding.

the total number of smokers at home and increased hospitalizations (linear test for trend, $P = .003$ for respiratory and febrile illness; $P < .001$ for any illness).

Table 3 gives the adjusted ORs for the association between health services utilization and various household smoking patterns in infants with nonsmoking mothers. Adjustment for infant age, sex,

TABLE 3. Adjusted ORs for High Health Services Utilization

	Consultation				Hospitalization			
	Respiratory/Fever		Any Illness		Respiratory/Fever		Any Illness	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Exposure to ETS during pregnancy								
No	1		1		1		1	
Yes	1.19	(1.08, 1.31)	1.26	(1.14, 1.39)	1.11	(0.98, 1.27)	1.18	(1.05, 1.31)
Paternal smoking*								
No	1		1		1		1	
Yes	1.01	(0.91, 1.12)	1.02	(0.91, 1.13)	1.08	(0.94, 1.24)	1.08	(0.96, 1.21)
Smoking by others†								
No	1		1		1		1	
Yes	1.02	(0.88, 1.17)	0.96	(0.84, 1.11)	1.10	(0.93, 1.31)	1.18	(1.01, 1.37)
Exposure to ETS at home								
No	1		1		1		1	
Yes	1.02	(0.92, 1.12)	1.01	(0.91, 1.12)	1.09	(0.96, 1.24)	1.12	(1.00, 1.25)
Total number of smokers at home								
None	1		1		1		1	‡
1	1.02	(0.92, 1.14)	1.03	(0.93, 1.15)	1.06	(0.93, 1.22)	1.07	(0.95, 1.20)
≥2	1.02	(0.85, 1.23)	0.94	(0.78, 1.12)	1.21	(0.97, 1.51)	1.30	(1.08, 1.58)

All analyses are adjusted for maternal education level, maternal full-time employment, maternal age, birth order, method of delivery, birth weight, and breastfeeding.
* Additional adjustment for smoking by others.
† Additional adjustment for paternal smoking.
‡ $P < .05$ (test for linear trend).

birth order, breastfeeding pattern, birth weight, mode of delivery, and maternal age, education level, and full-time employment status did not appreciably influence the results. Specifically, postnatal ETS exposure in any form seemed to have little effect on consultation rates, with all the associated ORs close to unity. Again, prenatal ETS through mothers' exposure to second-hand smoke yielded robust findings of increased consultation use (OR: 1.19; 95% confidence interval [CI]: 1.08, 1.31 for respiratory and febrile illness; OR: 1.26; 95% CI: 1.14, 1.39 for any illness). For hospital inpatient services, we observed relative odds increases of between 6% and 21% attributable to respiratory and febrile illness in infants exposed to various forms of ETS compared with those not exposed, although none of these achieved significance at the 0.05 level. When the outcome variable was for any illness, however, most of the resultant ORs became statistically significant, with relative odds differences of 12% to 30%.

DISCUSSION

The present analyses provide evidence from a Chinese, postindustrialized population that ETS exposure through the mother in utero is positively associated with more consultation visits and higher hospitalization rates in infants with nonsmoking mothers from birth until 18 months of age. In addition, infant exposure to ETS after birth is linked to higher rates of hospitalizations for any illness, than for their nonexposed counterparts, although the relationship does not seem to hold for outpatient consultation visits. The representativeness of the study population base, prospective design, and high rates of coverage and follow-up make it unlikely that the findings described are a result of selection or information bias. Unlike most previous studies examining the effects of ETS on health services use, we made a clear distinction between the different sources of passive smoking, and confounding factors were properly assessed and controlled for.

Our findings about the adverse health effects of mothers' prenatal passive smoking agree with those of 2 previous studies.[14,15] Although both reports dealt only with self-reported symptoms from maternal smoking in utero, we have established an important link with health services use attributable to respiratory or febrile illnesses and to all illnesses combined in nonsmoking mothers who were exposed to ETS during pregnancy. It is difficult to study the effects of prenatal ETS exposure independent of postnatal passive smoking, because most mothers who are exposed to second-hand smoke during pregnancy continue to live in the same environment afterward. Notably, prenatal and postnatal ETS exposure are so highly correlated that there may be little power to separate the 2 effects. Consequently, we have not adopted, in Table 3, the results of the regression models with prenatal and postnatal ETS exposure controlling for each other, attributable to the collinearity created. However, when we tried to control additionally for exposure to ETS at home in the regression model with exposure to ETS during pregnancy as the dependent variable to ascertain the independent effects of prenatal ETS, the revised ORs remained primarily unchanged and continued to be significant. In fact, the ORs for consultations increased to 1.21 (95% CI: 1.09, 1.34) for respiratory and febrile illnesses and to 1.29 (95% CI: 1.16, 1.44) for any illness. For hospitalizations, the corresponding ORs were 1.09 (95% CI: 0.95, 1.25) and 1.15 (95% CI: 1.02, 1.29). These findings suggest that in our population, ETS exposure during pregnancy has a significant influence on health services use during an infant's first 18 months of life, independent of postnatal ETS exposure. One possible explanation for this is that prenatal ETS exposure alters lung development and function in utero. Hanrahan and col-

leagues[16] demonstrated that maternal prenatal smoking was associated with lower levels of lung function during infancy than those with nonsmoking mothers. Low levels of lung function are strongly associated with subsequent viral-induced wheeze, among other illnesses.[16] Extending this reasoning to mothers' ETS exposure during pregnancy, it is possible to link low levels of lung function with more respiratory illnesses and, therefore, higher rates of consultations and hospitalizations among exposed infants. New studies currently examining lung function in infants and children should help clarify the physiologic mechanisms associated with respiratory and other illnesses in early life.[15]

In contrast, contrary to conventional thinking and other previous studies,[4–7] infants exposed postnatally to ETS from household contacts were not heavier users of ambulatory health services than those not exposed. However, these findings echo those of 2 other similar large-scale studies in the United States and suggest that higher rates of morbidity among children exposed to ETS may not necessarily be reflected in higher rates of outpatient consultations.[8,9] There are several possibilities accounting for these results. First, as White and colleagues[17] pointed out in their classic article on the ecology of medical care, only a fraction of those with symptoms present to the doctor's office. This iceberg concept of disease is well recognized and provides an explanation for the apparent disconnect between self-reported symptomatology and the use of health services. Second, parents are the gatekeepers for their children's access to health care services, and we have, thus far, implicitly assumed that smoking parents use health care services to a similar degree as nonsmoking parents, given the same set of symptoms. However, it has been acknowledged that the lower preventive orientation of adult smokers contributes to their decreased use of discretionary health services.[9,18] This may translate into underutilization of services for their children as well, especially for nonlife-threatening, less serious outpatient consultations as demonstrated by our sample. It also explains our observation that hospitalizations, presumably much more serious and nondiscretionary in nature, were significantly associated with ETS exposure, especially for all illnesses combined, where the power is most adequate to detect differences between the 2 groups. The only exception to this set of findings was for the risk of paternal smoking. We believe that fathers who smoked were more conscious of the negative health effects than were other smoking members of the household (eg, grandparents), and, therefore, perhaps tried not to smoke as much in the presence of the infant. Moreover, most fathers worked outside the home for most of the day and, therefore, the ETS dose to the infant was limited, compared with grandparents, who were often brought into the home to take care of the infant. Additional study is required to determine whether parents who smoke underutilize health services for their children or use services differently from nonsmoking families and whether these differences have cost implications.

CONCLUSION

We found that prenatal ETS exposure through nonsmoking mothers is a major risk factor for higher health services use in the first 18 months of life. This significant association may be attributable to an in utero effect of smoking on airway function. We also identified higher hospitalization rates in infants who had been exposed to ETS postnatally, although the effect did not extend to outpatient consultation visits, possibly because of different doctor-seeking behavior patterns between families with smokers and those without, especially for less serious ambulatory complaints. The present data support the revision of public policy to reflect an evidence-based approach to the promotion of smoking cessation in all household members, during as well as after pregnancy, for reducing health services use among infants. Specifically, that exposure to tobacco smoke throughout pregnancy and beyond, from all family members even in infants with nonsmoking mothers, alters the public health agenda. It broadens the issue from maternal smoking to that of family and other household members, and, hence, health promotion activities aimed at these other individuals become important. It is likely to prove difficult to promote household changes in these groups if education is solely channeled through mothers because of marked imbalances of power within the family structure. Currently, few campaigns outside the United States have highlighted the susceptibility of infants and children to ETS exposure. The challenge is to get this message across, and clinicians, in their daily interactions with parents, have the power to advance this cause substantially. In addition, we have shown that ETS exposure in infants is not only an important public health issue, but also carries serious economic consequences for the health care system as a whole because of increased utilization. Given that these costs are considerable, it would seem prudent for health care administrators to consider the economic benefits of providing smoking prevention and smoking cessation services to parents and others who live with infants and children. Publicizing the health hazards and potential cost to the family in increase medical expenditures from household ETS exposure would also seem to be a valid and potentially effective preventive health strategy.

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