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ORIGINAL CONTRIBUTIONS

Environmental Tobacco Smoke and Absenteeism Related to Respiratory Illness in Schoolchildren

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Household environmental tobacco smoke (ETS) exposure accounts for substantial morbidity among young children, but the ETS-associated morbidity burden among school-age children is less well defined. Illness-related school absenteeism is a measure of a broad spectrum of adverse effects of ETS exposure in school-age children. The authors investigated the relations between ETS exposure, asthma status, and illness-related school absenteeism in a cohort of 1,932 fourth-grade schoolchildren from 12 southern California communities during January–June 1996. Incidence rates and adjusted relative risks of illness-related absences were determined by using an active surveillance system. The effects of ETS exposure on absenteeism were assessed by using stratified incidence rates and Poisson regression to adjust for sociodemographic factors. ETS exposure was associated with an increased risk of respiratory-illness-related school absences (relative risk (RR) = 1.27, 95% confidence interval (CI): 1.04, 1.56). Children living in a household with two or more smokers were at increased risk of such absences (RR = 1.75, 95% CI: 1.33, 2.30). Children's asthma status affected their response to ETS. Compared with unexposed children without asthma, children with asthma were at increased risk of respiratory-illness-related school absences when exposed to one (RR = 2.35, 95% CI: 1.49, 3.71) or two or more (RR = 4.45, 95% CI: 2.80, 7.07) household smokers. Children without asthma also had an increased risk if exposed to two or more smokers (RR = 1.44, 95% CI: 1.04, 2.00). Therefore, ETS exposure is associated with increased respiratory-related school absenteeism among children, especially those with asthma.

absenteeism; child; respiratory system; respiratory tract diseases; schools; tobacco smoke pollution

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

Editor's note: *An invited commentary on this article is published on page 870.*

A substantial body of evidence indicates that exposure to environmental tobacco smoke (ETS) contributes to the occurrence of respiratory symptoms and diseases in infants and younger children (1–3). Adverse respiratory health outcomes associated with ETS include increased occurrence and severity of symptoms, transient changes in lung function, increased numbers of respiratory infections, more visits

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to physicians and emergency rooms, and increased hospital admissions. Because illness-related absences from school are common events that represent a broad spectrum of morbidity from mild, transient illnesses to the most severe illnesses requiring emergency room visits or hospital admissions, consideration of school absenteeism may provide a useful integrative assessment of the adverse impact of ETS exposure during childhood (4).

Although most absences are associated with illnesses at the low end of the morbidity spectrum, an absence indicates an illness of sufficient severity to affect the child's daily functioning as well as child and family coping strategies (4–7). Repeated absenteeism is also associated with lower academic performance and poor social adjustment (4, 7, 8). Illness-related absences may also have negative economic effects on families if a parent misses work to care for a sick child. Although illness-related school absenteeism is an important adverse outcome, few studies have investigated the effects of ETS on illness-related absenteeism in children, a group identified as especially sensitive to the adverse effects of tobacco smoke and other air pollutants (9, 10).

The Children's Health Study offers an opportunity to investigate the effects of ETS on respiratory-illness-related absences (11, 12). We conducted a substudy within this study cohort, the Air Pollution and Absence Study, and examined data on the incidence of type-specific absences collected by using an active surveillance system in a cohort of fourth-grade schoolchildren aged 8–12 years who attended schools in the 12 Children's Health Study communities during January–June 1996 (13).

MATERIALS AND METHODS

Study design

The longitudinal Children's Health Study includes schoolchildren who reside in 12 communities within a 200-mile (321.8-km) radius of Los Angeles, California. Details on the design, site selection, subject recruitment, and assessment of health effects are reported elsewhere (11). In this paper, we focus on school absences among 2,081 fourth-grade children during the first 6 months of 1996.

Participant characteristics

Sociodemographic information, indoor exposures, and medical histories were obtained from questionnaires completed by parents or guardians at study entry in the fall of 1995. The subset of participants with asthma was defined by using parent-reported history of physician-diagnosed asthma. Children with wheezing were defined as those with a history of wheezing in the 12 months prior to study entry. Parental education was categorized by using the highest level for the parent or guardian who completed the questionnaire. Information regarding number of hours spent outdoors over a 1-week period was collected by a self-administered questionnaire and was categorized as "more outdoors" or "less outdoors" on the basis of whether the children spent more than or less than the median number of hours (11.25 hours) outside. Weight and height were measured by using standard protocols during interviews at school. Body mass index was categorized into sex-specific quartiles.

Tobacco smoke exposure information was collected by using questionnaire items about the current and past household smoking status of each participant's mother, father, other adult household members, and regular household visitors. The current number of household smokers (1, 2, 3, 4, 5, 6 or more) was recorded. Based on the distribution of responses, the number of smokers was categorized as 0, 1, and 2 or more household smokers. Personal smoking habits on the previous day, week, and month were assessed during a private interview with each child.

Absence surveillance

We collected school absence reports from 27 elementary schools attended by the newly recruited fourth-grade children for the period January 1, 1996, to June 30, 1996. Of the 2,081 children in the fourth-grade group, 2,068 were eligible for absence surveillance because they were enrolled in the Children's Health Study at the beginning of the surveillance period. Of these 2,068 children, 135 were excluded from the analysis for the following reasons: 32 withdrew from the study, 90 changed schools during the study period, and 13 did not have absence data because of administrative errors.

Daily absence information was collected by using methods described previously (12). Briefly, attendance reports were requested from schools every 2–4 weeks, with the interval depending on the availability of personnel and electronic data systems at individual schools. An absence was defined as a day or an adjacent series of school days on which a participant did not attend school when it was in session. Over the study period, we ascertained 5,665 absences.

We established an active surveillance system by using telephone interviews to collect information about the reasons for absences, categorized absences as illness related and nonillness related (including injuries), and classified illness-related absences into gastrointestinal and respiratory categories. To ensure adequate parental recall of events associated with the absence of interest, interviews were conducted only for those absences reported within 4 weeks of occurrence. Of the 3,294 absences reported within 4 weeks, 536 were classified as nonillness related based on school reports, and 2,758 absences required telephone follow-up.

Parents were contacted after each absence reported within 4 weeks to inquire whether it was illness related and, if so, what the symptoms were. Each illness-related absence was classified as respiratory or nonrespiratory on the basis of the reported symptoms. A respiratory illness was defined as an illness that included one or more of the following symptoms: runny nose/sneezing, sore throat, cough (any, wet, or dry), earache, wheezing, or asthma attack. Respiratory absences were further classified into non-mutually-exclusive categories of upper respiratory and/or as one of two types of lower respiratory illnesses: lower respiratory illness with wet cough or lower respiratory illness with wet cough/wheeze/asthma. An upper respiratory illness was defined as a respiratory illness that included one or more of the following symptoms: runny nose/sneezing, sore throat, or earache. Gastrointestinal-related illnesses included illnesses that

included "stomach problems" such as vomiting and diarrhea as one of the reported symptoms.

Absence incidence rates

Each absence day was categorized as an incident or prevalent absence day by using absence reports and school calendars to identify the days on which each school was in session. An incident absence day was defined as one that followed attendance on the preceding school day. A prevalent absence day was defined as one that occurred after an absence on the preceding school day. Absences on Mondays were considered incident if the child attended school on the preceding Friday. The date of an absence occurrence was assigned to the incident day of each series of absence days.

The daily number of incident absences in each community and the corresponding daily number of children at risk of an absence in each community were used to calculate daily community-specific incident absence rates. The number of at-risk students attending a school was defined as the number of participants enrolled in a school on a day that the school was in session minus the number of prevalent absences. Daily community-specific incidence rates of absences were calculated by pooling the data from the reporting schools in each community and dividing the community-specific number of incident absences by the number of students attending schools in that community on the day of interest. The average incidence rate for school absences was computed for each community by averaging daily rates and, for the entire cohort, by averaging across days and communities. Stratified rates (e.g., by asthma status) were calculated by identifying the number of absences and number of students at risk within each stratum and calculating daily community-specific rates and average rates as described.

On the basis of data collected by the active surveillance system, absences were divided into three mutually exclusive outcomes: non-illness-related absences, illness-related absences, and absences of unknown type (due to failure to obtain necessary classification information). Because some absences were of unknown type, the type-specific absence incidence rates were adjusted for ascertainment failure. To adjust type-specific incident absence rates, a daily community-specific information success ratio was calculated, which was defined as the daily proportion of timely absence reports in each community for which sufficient information was obtained to assign the absence as illness or nonillness related. This success ratio was smoothed over time to reduce the random fluctuation due to the limited number of events on each day within a community, but in such a way not to substantially alter the overall trend in the data or the observed values. A symptom-specific incidence rate corrected for ascertainment was calculated as follows: (number of incident cases)/(number at risk $\times$ smoothed success ratio).

Statistical analysis

Poisson regression models that accounted for overdispersion were used to estimate the relative risk of school absences from ETS exposure adjusted for potential confounding covariates (14). The outcome variable—the observed number of absence counts—was modeled as a function of ETS exposure and other individual-level covariates. The log-transformed value of the expected number of absence counts over the study period was included in the model as an offset term, essentially resulting in a log-linear model for the ratio of the observed and expected absence counts. The expected number of absences per subject was calculated by summing the community- and day-specific expected number of absences for the days that a given subject was at risk. The community- and day-specific expected number of absences per subject was obtained by

TABLE 1. Selected characteristics of participants in the Air Pollution and Absence Study, southern California, January–June 1996

Characteristic	No. of subjects	%
Age group (years)		
≤9	1,111	57.5
10	725	37.5
≥11	31	1.6
Ethnicity		
Non-Hispanic White	977	50.6
Hispanic White	632	32.7
African American	99	5.1
Asian/Pacific Islander	96	5.0
Other	96	5.0
Sex: male	966	49.9
Wheeze (in the last 12 months)	606	33.3
Diagnosed asthma*	273	14.6
Current smokers†		
Any smokers	359	18.6
Mother	199	10.6
Father	195	10.4
Other	86	4.6
Yearly parental income ($)		
<7,500	112	5.8
7,500–14,999	204	10.6
15,000–29,999	276	14.3
30,000–49,999	390	20.2
50,000–99,999	538	27.8
≥100,000	101	5.2
Parental education		
<12th grade	247	12.8
12th grade	368	19.0
Some college	836	43.3
College graduate	200	10.4
Postgraduate	187	9.7
Health insurance: yes	1,590	82.3

* Physician-diagnosed asthma (information on asthma was missing for 58 subjects).

† Household smokers excluding the child (information on household smoking was missing for 65 subjects).

TABLE 2. Adjusted incidence rates of school absences (per 100 children-days) by selected participant characteristics, Air Pollution and Absence Study, southern California, January–June 1996

	Nonillness related	Illness related	Respiratory illness	Upper respiratory illness	Lower respiratory illness	Lower respiratory illness with wheeze	Gastrointestinal symptoms
All	1.34	1.65	1.04	0.94	0.18	0.30	0.63
Sex							
Female	1.36	1.71	1.09	1.00	0.19	0.30	0.65
Male	1.31	1.57	0.98	0.86	0.18	0.31	0.62
Ethnicity							
Data missing	1.75	0.11	0.11	0.11	0.00	0.00	0.00
White/non-Hispanic	1.28	1.74	1.07	0.98	0.21	0.33	0.75
Hispanic	1.40	1.65	1.08	0.98	0.19	0.26	0.57
African American	1.35	0.86	0.75	0.68	0.13	0.47	0.21
Asian/Pacific Islander	0.45	1.00	0.79	0.68	0.10	0.17	0.14
Other	2.11	2.01	1.13	1.01	0.25	0.34	0.82
Parental education							
Data missing	1.29	1.51	0.63	0.59	0.13	0.17	0.77
<12th grade	1.79	1.66	1.22	0.93	0.21	0.44	0.50
12th grade	1.40	1.96	1.17	1.04	0.22	0.36	0.72
Some college/technical school	1.35	1.67	1.07	0.97	0.18	0.31	0.65
4 years of college	1.76	1.47	1.10	0.99	0.14	0.38	0.48
Postgraduate	0.82	1.46	1.01	1.01	0.28	0.29	0.63
Diagnosed asthma*							
Data missing	1.80	1.53	1.02	0.94	0.35	0.42	0.66
No	1.34	1.55	0.95	0.89	0.16	0.20	0.61
Yes	1.25	2.28	1.58	1.25	0.30	0.89	0.76
Reported wheeze†							
Data missing	1.15	1.10	0.73	0.71	0.09	0.11	0.50
No	1.28	1.52	0.88	0.82	0.14	0.17	0.61
Yes	1.53	2.05	1.44	1.24	0.28	0.59	0.68
Any ETS‡ exposure							
Data missing	1.90	1.27	0.59	0.44	0.07	0.19	0.69
No	1.23	1.57	1.01	0.92	0.18	0.28	0.59
Yes	1.62	2.17	1.35	1.21	0.23	0.46	0.82
Mother smokes							
Data missing	2.01	1.24	0.52	0.43	0.05	0.17	0.66
No	1.26	1.55	0.99	0.90	0.18	0.28	0.59
Yes	1.64	2.63	1.64	1.49	0.25	0.61	0.99
Father smokes							
Data missing	2.01	1.24	0.52	0.43	0.05	0.17	0.66
No	1.28	1.62	1.04	0.94	0.19	0.30	0.62
Yes	1.49	1.98	1.20	1.06	0.19	0.37	0.68
Others smoke							
Data missing	2.01	1.24	0.52	0.43	0.05	0.17	0.66
No	1.30	1.65	1.05	0.95	0.19	0.30	0.62
Yes	1.89	1.70	1.12	0.97	0.20	0.39	0.94

* Lifetime history (information on wheezing was missing for 114 subjects).
† Physician-diagnosed asthma (information on asthma was missing for 58 subjects).
‡ ETS, environmental tobacco smoke.

multiplying the day-specific average rate of absences for all communities by the number of children at risk in the given community on the given day. The expected number of absences was corrected for incomplete ascertainment of absence type by using the community- and day-specific success ratio.

Poisson models were fitted to estimate the relative risk of absences for asthma and wheezing outcomes, and various ETS exposure metrics were used to adjust for potential confounders including age, sex, ethnicity, parental education, health insurance status, family income, body mass index, and time activity patterns. Children who reported smoking at least one cigarette in the previous month were excluded. Dose-response relations were assessed by using significance of linear terms for number of household smokers and model fit comparing dichotomous ETS exposure with models that included categories for number of smokers. Modification of the effects of ETS by asthma or wheeze status was assessed by using nested models and likelihood ratio tests. All analyses were conducted with the GENMOD procedure in SAS software (15).

RESULTS

Of the 1,932 fourth-grade participants (table 1), 57.5 percent were 9 years of age at study entry. Non-Hispanic and Hispanic White children accounted for 50.6 percent and 32.7 percent of the study population, respectively. One third of the study participants experienced wheezing during the 12 months prior to the baseline interview. Fifteen percent were diagnosed with asthma by a physician, and more than 8 percent experienced severe asthma. At study entry, more than 18 percent of the children were exposed to household smokers. The majority of children came from families that had health insurance, at least some post-high-school education, and yearly incomes higher than $30,000. None of the children reported smoking in the previous 24 hours, and 60 reported smoking at least one cigarette in the previous month.

The median number of incident school absences per child was two, and the range was 0 (18.2 percent) to 17. Forty-one percent reported at least one illness-related absence, and 30 percent had at least one respiratory-illness-related absence over the 6-month study period. Incidence rates for nonillness absences (1.34/100 children-days) and illness-related absences (1.65/100 children-days) were relatively low (table 2). Rates varied among children of different ethnicities, parental educational levels, asthma and wheezing statuses, and ETS exposures (table 2). Asian children had the lowest rates of all types of absences. Children whose parents had graduate levels of education had lower rates of both illness- and non-illness-related absences than those who did not complete 12th grade. The rates for children with a history of asthma or wheezing were higher in every illness-related category than for children without asthma or wheezing. Those currently exposed to household ETS also had higher rates of all types of illness-related absences. We found little evidence that incidence rates varied substantially or consistently by age, sex, family education, health insurance, or body mass index (table 3). Children from middle-income families were found to have a small increase in the relative rates of absences compared with families whose annual income was less than $7,500 or more than $100,000. Children with a family history of asthma among parents had an increased risk of absences that was highest for respiratory-related absences.

After adjustment for community, ethnicity, sex, age, education of the parent/guardian who completed the questionnaire, health insurance, family income, body mass index, and time spent outdoors, children with physician-diagnosed asthma or wheezing had substantially higher risks of illness-related absences and respiratory-illness-related absences (table 4). An increased risk was also evident among children currently exposed to any ETS across all categories of absences, with an elevated risk for illness-related absences from exposure to maternal and both maternal and paternal smoking. Risk for illness-related ($p < 0.01$) and respiratory-illness-related ($p < 0.01$) absences increased significantly as the number of household smokers increased. Exposure to ETS was also associated with an increased risk of gastrointestinal-illness-related absences (relative risk (RR) = 1.43, 95 percent confidence interval (CI): 1.12, 1.82) that increased with number of household smokers (data not shown).

The effects of ETS exposure on the risk of absences differed substantially by children's asthma and wheezing status (table 5). Children with physician-diagnosed asthma were susceptible to absences. Compared with unexposed children without asthma, unexposed children with asthma were at an increased risk of respiratory-illness-related school absences (RR = 1.48, 95 percent CI: 1.17, 1.87) that was significantly larger ($p < 0.05$) if they were exposed to one or more household smokers (RR = 2.55, 95 percent CI: 1.78, 3.65). The profile of increased risks for respiratory-illness-related absences was reflected in all illness-related absences. ETS exposure was not associated with non-illness-related absences among children with or without asthma.

The strength of the association between ETS and school absences increased as the number of household smokers increased for children with and without asthma. Compared with unexposed children without asthma, children with asthma who were exposed to one household smoker had an increased risk of respiratory-illness-related school absences (RR = 2.35, 95 percent CI: 1.49, 3.71) that was significantly larger ($p < 0.05$) if they were exposed to two or more household smokers (RR = 4.45, 95 percent CI: 2.80, 7.07). Moreover, children without asthma were also at an increased risk of respiratory-illness-related school absences if exposed to two or more smokers (RR = 1.44, 95 percent CI: 1.04, 2.00). A dose-response relation between number of smokers and non-illness-related absence was not apparent. The effects of wheezing symptoms on the relations between ETS exposure and the risk of absences generally followed the same patterns as those for children with asthma, but the magnitude of the risk estimates was smaller. In our analyses, we considered a number of additional covariates that could potentially modify the effects of ETS, including family history of asthma and allergy, sex, age, education, ethnicity, and health insurance, and we found no evidence for a statistically or biologically significant interaction.

TABLE 3. Association of sociodemographic factors with school absences, Air Pollution and Absence Study, southern California, January–June 1996*

	All absences		Non-illness-related absences		Illness-related absences		Respiratory-illness-related absences	
	RR†	95% CI†	RR	95% CI	RR	95% CI	RR	95% CI
Ethnicity								
White	1		1		1		1	
Asian	0.58	0.44, 0.77	0.25	0.09, 0.71	0.68	0.46, 1.0	0.79	0.51, 1.23
African American	0.87	0.70, 1.08	1.12	0.71, 1.78	0.70	0.49, 1.01	0.92	0.62, 1.37
Hispanic	1.03	0.93, 1.13	1.13	0.91, 1.40	0.98	0.84, 1.13	1.04	0.86, 1.25
Other	1.19	0.99, 1.43	1.74	1.20, 2.51	1.21	0.91, 1.61	1.21	0.84, 1.73
Age (years)‡								
≤9.5	1		1		1		1	
>9.5–10.5	0.83	0.75, 0.92	0.87	0.69, 1.10	0.91	0.77, 1.07	0.91	0.74, 1.12
>10.5	0.91	0.76, 1.09	1.22	0.83, 1.79	1.00	0.75, 1.32	1.18	0.85, 1.65
Sex								
Female	1		1		1		1	
Male	0.97	0.89, 1.05	1.06	0.88, 1.29	0.94	0.83, 1.07	0.94	0.80, 1.10
Asthma in either parent								
No	1		1		1		1	
Yes	1.20	1.09, 1.34	1.13	0.88, 1.45	1.21	1.03, 1.43	1.41	1.16, 1.71
Asthma in mother								
No	1		1		1		1	
Yes	1.22	1.07, 1.38	1.17	0.88, 1.56	1.19	0.98, 1.45	1.33	1.05, 1.68
Asthma in father								
No	1		1		1		1	
Yes	1.17	1.01, 1.35	0.95	0.65, 1.38	1.18	0.93, 1.48	1.42	1.08, 1.85
Education§								
<High school	1		1		1		1	
High school	0.93	0.80, 1.08	0.96	0.69, 1.33	1.15	0.91, 1.45	1.16	0.87, 1.56
Some college/technical school	0.90	0.79, 1.02	0.90	0.67, 1.21	1.06	0.85, 1.31	1.08	0.83, 1.42
College graduate	0.72	0.62, 0.84	0.68	0.48, 0.98	0.97	0.76, 1.24	0.98	0.72, 1.34
Postgraduate	0.91	0.73, 1.13	0.71	0.40, 1.25	0.92	0.63, 1.34	0.78	0.47, 1.29
Yearly income ($)¶								
<7,500	1		1		1		1	
7,500–14,999	1.17	1.01, 1.35	0.89	0.63, 1.27	1.31	1.03, 1.66	1.49	1.11, 2.01
15,000–29,999	0.91	0.79, 1.05	0.85	0.61, 1.18	1.04	0.82, 1.32	1.13	0.84, 1.53
30,000–49,999	0.93	0.81, 1.05	0.88	0.66, 1.18	1.18	0.95, 1.45	1.33	1.02, 1.72
50,000–99,999	0.90	0.79, 1.01	0.87	0.66, 1.13	1.23	1.02, 1.49	1.27	0.99, 1.62
≥100,000	0.81	0.65, 1.02	0.75	0.45, 1.24	0.83	0.58, 1.20	0.97	0.63, 1.50
Health insurance								
No	1		1		1		1	
Yes	1.10	0.97, 1.24	1.03	0.78, 1.35	1.20	0.98, 1.45	1.16	0.91, 1.48
Body mass index (kg/m^2)#								
≤15.8	1		1		1		1	
15.8–17.4	0.91	0.81, 1.03	0.69	0.53, 0.91	1.06	0.89, 1.27	0.93	0.74, 1.18
17.5–20.0	0.88	0.78, 0.99	0.79	0.61, 1.03	0.92	0.76, 1.11	0.90	0.72, 1.14
>20.0	1.06	0.95, 1.19	0.87	0.68, 1.13	1.18	0.99, 1.41	1.20	0.97, 1.49

* All analyses were adjusted for 12 communities.
† RR, relative risk; CI, confidence interval.
‡ Age at study entry.
§ Highest educational level of the parent/guardian.
¶ Family income self-reported by the parent.
# Calculated from height and weight measurement during pulmonary function tests conducted at the schools and categorized by quartiles.

TABLE 4. Effects of asthma, wheezing, and household ETS† exposure on risk of school absences,‡ Air Pollution and Absence Study, southern California, January–June 1996

	Non-illness-related absences		Illness-related absences		Respiratory-illness-related absences	
	RR†	95% CI†	RR	95% CI	RR	95% CI
			Asthma/wheezing			
Asthma						
No	1.00		1.00		1.00	
Yes	0.93	0.70, 1.23	1.42	1.20, 1.68	1.70	1.39, 2.08
Wheezing						
No	1.00		1.00		1.00	
Yes	1.26	1.02, 1.54	1.34	1.16, 1.54	1.63	1.38, 1.94
			Household ETS			
Any ETS exposure						
No	1.00		1.00		1.00	
Yes	1.29	1.02, 1.63	1.33	1.13, 1.57	1.27	1.04, 1.56
Current parental smoking						
None	1.00		1.00		1.00	
Only mother	1.19	0.91, 1.55	1.49	1.17, 1.90	1.44	1.06, 1.94
Only father	1.10	0.82, 1.49	1.06	0.79, 1.42	0.93	0.64, 1.35
Both	1.02	0.73, 1.44	1.74	1.34, 2.25	1.80	1.31, 2.46
No. of smokers						
0	1.00		1.00*		1.00*	
1	1.37	1.05, 1.80	1.25	1.03, 1.52	1.17	0.92, 1.49
≥2	1.34	0.94, 1.90	1.64	1.31, 2.06	1.75	1.33, 2.30

* p for trend = 0.01.

† ETS, environmental tobacco smoke; RR, relative risk; CI, confidence interval.

‡ All analyses were adjusted for 12 communities, ethnicity, sex, age, educational level of the parent/guardian who completed the questionnaire, health insurance, family income, body mass index, and number of hours of outdoor activity.

DISCUSSION

A substantial literature documents the effects of ETS on childhood respiratory morbidity, yet few studies have examined associations between ETS and respiratory-related school absences, a common and potentially important indicator of childhood lung morbidity (16–20). We found that household ETS exposure among fourth-grade students was associated with increased rates of illness-related, especially respiratory-illness-related, absences. A dose-response relation was evident in that the risk of respiratory-related school absence increased as the number of household smokers increased. Our findings are consistent with the substantial body of evidence showing that exposure to ETS increases the risk of respiratory infections, visits to physicians and emergency rooms, and hospital admissions (1–3, 19). The evidence supporting adverse effects of ETS exposure is stronger among children less than school age than among school-age children. The present study shows that ETS exposure has important adverse effects among older children aged 8–12 years who spend a substantial amount of time each week away from home. Thus, although ETS exposure among school-aged children is likely to be substantially lower than that among preschool children, the adverse effects appear to be substantial.

Our results provide additional support for and extend the conclusion of numerous studies that children with asthma are more susceptible than children without asthma to the effects of ETS (2, 3). The 4.5-fold increased risk of respiratory-illness-related absences among asthmatic children who were exposed to two or more household smokers shows that the effects of ETS may extend beyond increased symptoms or medication use to adversely impact a child's education and family functioning. In this study, the data were insufficient to assess the effects of medication use on absences among children with asthma.

Children without asthma who reported exposure to two or more household smokers also had an increased risk of respiratory-illness-related absence. Although the magnitude of the ETS risk was greater for the 15 percent of children with asthma, all school-age children may be at increased risk of respiratory-illness-related absences when exposed to ETS. Our results suggest that the social and economic burden from the morbidity associated with ETS exposure among children may have been underestimated.

TABLE 5. Relative risks and 95% confidence intervals of the joint effects of ETS* and asthma and of ETS and wheeze on school absences, Air Pollution and Absence Study, southern California, January–June 1996†

	No. of children	Non-illness-related absences		Illness-related absences		Respiratory-illness-related absences	
		RR*	95% CI*	RR	95% CI	RR	95% CI
ETS and asthma‡							
No ETS and no asthma	1,264	1.00		1.00		1.00	
No ETS and asthma	217	0.82	0.58, 1.16	1.30	1.06, 1.59	1.48	1.17, 1.87
ETS and no asthma	303	1.23	0.96, 1.59	1.25	1.04, 1.50	1.14	0.91, 1.44
ETS and asthma	48	1.21	0.69, 2.14	2.19	1.59, 3.01	2.55	1.78, 3.65
No. of smokers and asthma‡							
No smokers and no asthma	1,294	1.00		1.00		1.00	
No smokers and asthma	226	0.91	0.66, 1.26	1.27	1.04, 1.55	1.45	1.15, 1.83
1 smoker and no asthma	209	1.40	1.05, 1.87	1.18	0.95, 1.47	1.05	0.79, 1.39
1 smoker and asthma	30	1.26	0.63, 2.53	2.02	1.35, 3.00	2.35	1.49, 3.71
≥2 smokers and no asthma	98	1.31	0.90, 1.92	1.46	1.12, 1.89	1.44	1.04, 2.00
≥2 smokers and asthma	17	1.51	0.64, 3.59	3.29	2.16, 5.03	4.45	2.80, 7.07
ETS and wheeze‡							
No ETS and no wheeze	968	1.00		1.00		1.00	
No ETS and wheeze	467	1.28	1.01, 1.61	1.26	1.08, 1.47	1.45	1.20, 1.75
ETS and no wheeze	218	1.27	0.94, 1.73	1.14	0.92, 1.42	0.93	0.69, 1.25
ETS and wheeze	124	1.59	1.11, 2.26	1.90	1.50, 2.39	2.29	1.75, 3.00
No. of smokers and wheeze‡							
No smokers and no wheeze	992	1.00		1.00		1.00	
No smokers and wheeze	480	1.32	1.05, 1.66	1.25	1.07, 1.47	1.43	1.18, 1.73
1 smoker and no wheeze	159	1.46	1.04, 2.05	1.08	0.83, 1.41	0.89	0.62, 1.27
1 smoker and wheeze	75	1.71	1.11, 2.62	1.81	1.36, 2.41	2.13	1.53, 2.97
≥2 smokers and no wheeze	61	1.49	0.93, 2.39	1.43	1.03, 2.00	1.20	0.76, 1.88
≥2 smokers and wheeze	51	1.49	0.88, 2.50	2.21	1.62, 3.02	2.97	2.09, 4.23

* ETS, environmental tobacco smoke; RR, relative risk; CI, confidence interval.

† All analyses were adjusted for 12 communities, ethnicity, sex, age, education of the parent/guardian who completed the questionnaire, health insurance, family income, body mass index, and number of hours of outdoor activity.

‡ Interactions were significant ($p < 0.05$) for illness-related absences and respiratory-illness-related absences.

We did not directly study the mechanisms by which ETS exposure affects absenteeism. ETS is a complex mixture of respiratory toxins that adversely affect immune function, airway function, and the respiratory epithelium broadly through several pathophysiologic pathways. It is likely that ETS exposure increases the risk of an absence by increasing the risk and severity of respiratory infections, severity of asthma airflow obstruction, and inflammation and symptoms. The higher risk from ETS exposure among children with asthma is consistent with increased respiratory infections that are the primary pathway for asthma exacerbations. Further research is needed to define the mechanism for ETS effects because such knowledge will be essential to developing interventions to protect children whose parents continue to expose them to ETS.

Although school absenteeism data have been used for a limited number of health studies, absences have been considered too nonspecific to be a broadly useful source of information for studies of children's health. Consideration of the epidemiology of absenteeism suggests that such data offer opportunities for both research and public health surveillance. A number of population-based studies have documented the descriptive epidemiology of school absences. Reports based on the National Health Interview Survey and other surveys show that absence rates vary by school, age, grade, and gender and are likely to be affected by family structure, function, and other social factors (21, 22). Because a number of non-health-related factors influence absenteeism, it has not been widely used as a measure of the adverse effects of ETS or other exposures; however, the majority of school absences are illness related and are attributable to illnesses and respiratory infections (5, 21). Our findings support the use of carefully collected school absenteeism data for a broad range of public health purposes.

Our study enrolled more than 2,000 fourth-grade schoolchildren and their families. The active surveillance system and modeling strategy did, however, have some limitations. Although the restriction of absences to those reported within

1 month of occurrence and the incomplete ascertainment of type of absence may have introduced bias into our study, this method was adopted to minimize any recall bias of absence events by parents. On the basis of distributions of the study population in the full and restricted sample of absence days, we found little evidence of any selection bias from the restriction. To account for the effects of incomplete ascertainment, the denominator of the rates and the offset in the Poisson models were adjusted for the proportion of absences that included information on absence type. Our study also had limited information on ETS exposure assessment and asthma phenotype. Exposure to tobacco smoke was assessed retrospectively by using questionnaire responses and was not validated by objective measurements. However, exposure estimates based on questionnaire responses have been validated (23–25). Asthma status was assigned by using parental reports of a physician diagnosis of asthma. Parental reports have been shown to reflect physician diagnoses; however, the diagnosis of asthma by a physician depends on access and use of medical care and on physician diagnostic practices (26, 27). However, the ETS effects were also observed in children with wheezing, indicating that a diagnostic bias was unlikely to explain our results.

In conclusion, household ETS exposure was associated with increases in respiratory-illness-related school absences in children aged 8–12 years. Because exposure to ETS is common, the substantial increased risk of school absenteeism from respiratory illnesses documents an important adverse impact of ETS on children's health and well-being. The social and economic burden resulting from children's exposure to ETS may be broader and larger than previously appreciated.

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