HHS Public Access

Author manuscript

J Dev Behav Pediatr. Author manuscript; available in PMC 2022 February 25.

Published in final edited form as:

J Dev Behav Pediatr. 2008 December ; 29(6): 450–457. doi:10.1097/dbp.0b013e31818d0c21.

Environmental Tobacco Smoke Exposure and Child Behaviors

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Abstract

Rationale: Emerging evidence suggests that exposure to environmental tobacco smoke (ETS) may be linked with behavior problems in childhood, but previous research has relied primarily on parent report of exposure, and results are inconclusive.

Objectives: To investigate the relationship between exposure to ETS and child behavior problems among children with asthma.

Methods: The sample included 220 children who were enrolled in an asthma intervention trial and regularly exposed to ETS at home. Serum cotinine was used to measure exposure to tobacco smoke, and behavior problems were assessed by parent report on the Behavior Assessment System for Children. Covariates in adjusted analyses included: sex, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, maternal depression, and Home Observation for Measurement of the Environment score.

Results: Child behavior problems increased with increasing exposure to ETS. A stratified analysis of boys and girls separately indicated higher exposure among girls, but behavior problems were statistically significantly associated with exposure only in boys. Increasing behavior problems included externalizing behavior problems ($\beta = 2.23$, $p = .02$) such as hyperactivity and aggression, internalizing behavior problems ($\beta = 2.19$, $p = .01$) such as depression, and behavior symptoms ($\beta = 2.55$, $p = .01$).

Conclusions: Among children with asthma, exposure to ETS is related to increased child behavior problems among boys.

Keywords

environmental tobacco smoke; behavior; children; exposure

There is considerable evidence implicating tobacco smoke exposure, both prenatally and postnatally, with numerous consequences to child health including prematurity,[1-3] low

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birth weight,[1,4-7] sudden infant death syndrome,[8-11] and asthma severity.[12-14] There have been several reports linking prenatal and postnatal tobacco smoke exposure with cognitive deficits in childhood.[15-20] However, the research linking environmental tobacco smoke (ETS) exposure with behavioral problems is not as widely recognized.[4,12,21-23] Research on the association between tobacco smoke and behavioral problems has yielded inconsistent results, but suggests that tobacco smoke is an exposure which may entail detrimental consequences for child behavior.[24] With the increasing prevalence of child behavior problems,[25] understanding yet another possible contributor to the rise is critical.

Exposure to tobacco smoke during gestation has been linked with behavior problems in childhood including increased prevalence of attention-deficit hyperactivity disorder (ADHD),[26-29] conduct disorder,[30,31] disruptive behaviors,[30] and externalizing behaviors.[32,33] However, these results are inconclusive due to limitations of previous research that failed to properly control for confounders such as postnatal ETS exposure and other known covariates of child behavior.[34,35] After conducting a thorough review of case-control and cohort studies of the relationship between prenatal tobacco smoke exposure and child behavior problems, Linnet et al[35] concluded that “there may be an association with exposure to tobacco smoke in utero (and ADHD),” but that studies effectively measuring the proper potential covariates of this relationship were “few and of poor quality.”

Although some questions remain about the relative contribution of prenatal tobacco smoke exposure to behavior problems in childhood, we have even more limited information about the impact of postnatal ETS exposure on child behavior. Few studies have specifically investigated the association between postnatal ETS exposure and child behavior, and these have reported inconsistent results. Fergusson et al[30] found no relation between childhood ETS exposure and attention, conduct, or disruptive behavior problems at ages 8 to 12 when controlling for maternal smoking during pregnancy. In contrast, Weitzman et al[36] reported a dose-response relationship for both internalizing and externalizing behavior problems among children whose mothers smoked at least a pack of cigarettes per day, even after controlling for a variety of potential covariates including maternal smoking during pregnancy. The combination of prenatal and postnatal exposure appeared to have the greatest negative influence on child behavior. Williams et al[33] found a similar relationship in which maternal smoking both early in pregnancy and concurrent with the assessment of the child’s behavior at age 5 had the strongest relationship with child externalizing behavior problems. More recent work by Braun et al suggests that ETS may be associated with increased risks for conduct disorder[36a] but not ADHD.[37]

One of the most significant limitations of previous studies on ETS exposure and child behavior is that they have relied primarily on parent report to estimate children’s exposure to tobacco. National data indicate that while 25% of parents report child exposure to cigarettes at home, over 50% of children are exposed to tobacco smoke according to biological markers.[38] This suggests that parent report may not be a sensitive or accurate way to measure children’s total exposure to ETS. Until researchers systematically measure child exposure to ETS as well as the potential covariates, the contribution of ETS exposure to behavior problems will be uncertain.

Asthma is often associated with an increased prevalence of behavior problems in children. Reports occasionally include elevated externalizing behaviors such as ADHD,[39] and oppositional or negative behaviors[40,41] but more often indicate more frequent internalizing behaviors such as anxiety and depressive symptoms in children with asthma.[39-45] Behavioral symptoms in children with asthma increase in conjunction with increasing asthma severity,[39,46] and Alati et al[47] reports that internalizing behaviors detected at age 5 remain problematic into adolescence. To our knowledge, the specific association between ETS exposure and increases in behavior problems among children with asthma has not been carefully examined.

The objective of this study was to investigate the relationship between ETS exposure and child behavior problems among a group of children with asthma. We used a biomarker of tobacco exposure, serum cotinine, to objectively quantify exposure from all sources. We hypothesized that children with asthma who are exposed to higher levels of ETS exhibit more behavior problems, as reported by parents, than children with lower levels of exposure to ETS.

METHODS

This study utilized the Cincinnati Asthma Prevention (CAP) Study, a double-blind, placebo controlled intervention trial designed to test the efficacy of reducing environmental tobacco smoke (ETS) exposure among children with asthma using high-efficient particulate air cleaners fitted with carbon-permanganate-zeolite filters. Outcome measures of the CAP study were focused on asthma symptoms, health care utilization, and pulmonary function. For the current study, baseline measures of exposure were used in addition to concurrent measures to assess child behavior and potential covariates.

Children with asthma between 6 and 12 years of age were initially identified for participation in the CAP Study (n = 2240). Letters were mailed to parents introducing the study and providing a postcard that could be returned if they were not interested in being contacted for participation. Among those who did not return the postcard and were able to be reached by telephone, a screening survey with the child's primary caregiver determined eligibility and interest in study participation (n = 1678). Eligibility criteria for the 6- to 12-year-old children were doctor diagnosed asthma that was treated within the previous 12 months in a pediatric hospital or participating private practice clinic, exposure to ETS from at least 5 cigarettes per day at home, and no plans to move within the 12-month period of the planned intervention trial. Children were excluded if they had other respiratory diseases (n = 646), heart disease (n = 34), were mentally retarded (n = 23), or had other serious conditions barring participation in the study (n = 31). Since the intervention for the parent study required use of an electrical device, children were also excluded if the family did not have working electricity at the time of the screening survey (n = 14). Of the 348 eligible participants, 232 enrolled and completed the study (67% participation rate).

Twelve participants were later excluded from the current analysis plan due to: ineligibility according to initial enrollment criteria and inadvertent enrollment (n = 7), missing baseline cotinine sample (n = 3), target child was an active smoker by survey (n = 1), and cotinine

level (112 ng/mL) indicative of active smoking (n = 1). The final sample for this analysis included 220 children. Protocols were approved by the institutional review board.

ETS exposure was measured through analysis of serum cotinine samples that were obtained at the baseline home visit for all 220 children included in this study. Cotinine, a metabolite of nicotine, is currently considered the most reliable biomarker of exposure to tobacco smoke.[48] Serum levels provide a short-term view of exposure over the previous 48 to 72 hours. Cotinine detection in serum was performed by the Centers for Disease Control using published methods involving high-performance liquid chromatography linked to atmospheric-pressure chemical ionization tandem mass spectrometry.[49]

The Behavior Assessment System for Children (BASC)[50] was used to measure child behavior problems within the past 2 weeks as reported by the primary caregiver at the baseline home visit. The BASC yields age and sex standardized *T*-scores for 4 composite clinical scales (externalizing problems, internalizing problems, behavioral symptoms index, adaptive skills) as well as scores on 12 clinical subscales (anxiety, attention problems, atypicality, conduct problems, depression, hyperactivity, somatization, withdrawal, adaptability, leadership, social skills). This instrument is used in clinical and research settings to provide a broad description of child behaviors that may be problematic or adaptive. Internal consistency reliabilities of composite scores are in the middle .80s to low .90s, and test-retest correlations are in the low .90s for the age group of interest. Correlations with the Child Behavior Checklist,[51] a conceptually similar measure, range from .65 to .84 for the Internalizing and Externalizing composites. Ostrander et al[52] determined that the BASC was a more parsimonious and accurate measure for distinguishing students with and without attention-deficit hyperactivity disorder (ADHD) than the Child Behavior Checklist. To maintain uniformity, this measure was administered as an interview in which caregiver responses were coded by a trained research assistant.

Asthma severity, as perceived by the parent, was reported as mild, moderate, severe or very severe. Parent report of asthma symptoms is an effective means for characterizing child asthma and is not enhanced by asthma diaries or pulmonary function testing.[53] Parents additionally reported asthma medication use by the child in the form of short-acting bronchodilators, long-acting inhaled steroids, and oral steroids used for acute exacerbations. To account for the well-established association between maternal depression and child behavior,[54,55] we used the Beck Depression Inventory, Second Edition[56] to measure maternal depression during the baseline home visit. To account for quality of the home environment, a known contributor to child behavioral outcomes,[54,57,58] the Home Observation for Measurement of the Environment (HOME) instrument for elementary school aged children[59] was administered at the 12-month follow-up visit. The HOME is primarily an observational tool that assesses the quality of the home environment, including physical characteristics, variety of stimulation, and nurturing behavior from the parent.

A log base 2 transformation was used for analysis of serum cotinine because of the skewed distribution of the raw data. This not only allowed use of parametric methods but provided for a simpler interpretation of the beta coefficients from the regression analyses. Use of the log base 2 transformation means that for each doubling of the cotinine level, there is

an increase in the behavior outcome scale equal to the beta coefficient for log (cotinine). Univariate analysis involved estimation of frequencies and means with the associated standard deviation, serum cotinine is reported as a geometric mean and 95% confidence interval, and household income is reported as median and 25th and 75th percentiles. The initial step involved simple regression analysis of log serum cotinine on the behavior outcome scales. Full models were explored including all the potential covariates and confounders: age, race, gender and asthma severity of the child, education and depression (Beck Depression Inventory-II) of the mother, HOME score and prenatal tobacco exposure. The most parsimonious model was created for each of the behavioral outcomes, and the final models included covariates and confounders that were appropriate for any of the outcomes based on $p < .05$ and change in the independent variable of interest by 10%. This was done so that interpretation of the effect of ETS exposure would be based on the same measures of adjustment for each outcome. Further analysis of the relationship between serum cotinine and child behavior was done using tertiles of serum cotinine to provide another illustration of the relationship. The same approach was used for modeling as described above. SAS® version 9.1[60] was used for all analyses.

RESULTS

The mean age of the subjects at the baseline visit was 9.4 years. Sixty one percent of the children were boys and 56% were reported to be African-American. The majority of parents reported a high school education or less (65%), and 42% were single and never married with a median household income of $25,000 per year. The majority of children (77%) had moderate to severe asthma (Table 1).

By report, 66% of mothers smoked sometime during pregnancy with the index child resulting in both prenatal and postnatal tobacco smoke exposure. Children in the sample were exposed to a median of 13 cigarettes each day at baseline as reported by parents. There was no difference in median reported cigarette exposure for girls and boys. The geometric mean serum cotinine level for the full sample was 1.18 ng/mL, a value indicative of passive exposure. Girls had significantly higher serum cotinine levels than boys (girls = 1.50 ng/mL; boys = 1.01 ng/mL, $p = .02$). The correlation between serum cotinine and reported exposure (number of cigarettes/day) was 0.39 ($p < .0001$) for the full sample.

The incidence of behavior problems, as reported by parents on the Behavior Assessment System for Children (BASC), was relatively high among children in this sample. Children scored in a range considered to be clinically relevant (standard T score ≥70) at rates of 19% for externalizing problems, 27% for internalizing problems, and 21% for behavior symptoms. Bivariate analyses of the associations between the log of serum cotinine and child behaviors was significant for all 4 BASC composite scales. Externalizing problems ($\beta = 2.71$, $p < .0001$), Internalizing problems ($\beta = 1.75$, $p = .002$), and Behavior symptoms ($\beta = 2.55$, $p < .0001$) scores increased with increasing cotinine levels, and Adaptive skills ($\beta = -1.27$, $p = .003$) decreased with increasing cotinine levels.

In multivariable analyses including potential contributors to child behaviors, we found that higher levels of environmental tobacco smoke (ETS) exposure were significantly

associated with higher scores on the BASC Internalizing Problems and Behavior Symptoms composites. The relationship approached significance for the Externalizing Problems composite, but was not significant for the Adaptive Skills composite (Table 2).

To better describe the relationships between ETS exposure and child behavior, we examined the relationship of serum cotinine to the BASC subscales that make up the externalizing and internalizing composites while controlling for the covariates identified previously (Table 2). For the externalizing composite, log serum cotinine was significantly related to higher scores on the hyperactivity subscale. For the BASC internalizing composite, log serum cotinine was significantly related to higher scores on the depression subscale and approached significance for the somatization subscale.

Significant relationships between our measured covariates and child behaviors were found as follows: poorer home quality (Home Observation for Measurement of the Environment [HOME] Score) was related to higher externalizing composite, hyperactivity, aggression, and conduct problems; increasing child age was related to lower hyperactivity and aggression scores; and maternal depression was related to higher internalizing and behavioral symptoms index composites, anxiety, and depression. Greater asthma severity was related to higher internalizing composite and somatization scores, and asthma medication use (short-acting inhaled bronchodilators and oral steroids) was related to higher externalizing composite including 3 subscales, higher internalizing composite and depression, higher behavior symptoms, reduced adaptive skills including social skills and leadership, and higher attention and somatization scores.

Although no clear difference by sex was evident in the effect of serum cotinine on behavior in the main models, and a statistically significant sex interaction was not found (sex × log cotinine interaction p values ranging from .22 to .96), the significantly higher exposure that girls had in relation to boys prompted us to examine the association between child behavior and ETS exposure for girls and boys separately. (Table 2) For boys, significant relationships were found between serum cotinine and higher scores on externalizing behaviors, including subscales of hyperactivity, and aggression; internalizing behaviors including depression; and behavior symptoms. Significant covariates of behavior among boys were asthma severity (internalizing, behavior symptoms, somatization), asthma medications (internalizing, behavior symptoms, adaptive skills, depression, attention problems, social skills, leadership), maternal depression (anxiety, depression), and black race (depression). For girls, no statistically significant relationships were found between serum cotinine and behavior. Significant covariates of behavior were maternal education (externalizing, behavior symptoms, adaptive skills, aggression, conduct), HOME score (externalizing, adaptive skills, aggression, conduct), maternal depression (externalizing, internalizing, adaptive skills, hyperactivity, anxiety, depression), asthma severity (anxiety, somatization), and asthma medications (depression, social skills).

We then divided the sample into tertiles based on serum cotinine levels; low (n = 73); middle (n = 74); high (n = 73). In unadjusted and adjusted analyses, a potential dose-response relationship was found in which more children in the middle and high cotinine tertiles had

higher behavior problem scores (BASC) when compared with children in the lowest tertile (Table 3 and Fig. 1).

Results for the secondary analysis of behavior problems by serum cotinine tertile for the full sample and divided by sex are shown (Table 4). The lowest tertile of ETS exposure was used as the reference in all analyses, so betas and associated standard errors are given for tertiles 2 and 3 only. The results mirror those found in the previous analysis using the log serum cotinine as a continuous variable. However, a potential leveling in the effect at or near the second tertile is indicated as evidenced by a plateau in the beta values. This may also be seen by examination of the means by tertile presented in Table 3 and Figure 1. The same covariates were used for these adjusted analyses as were used for the previous adjusted analyses (Table 3).

DISCUSSION

Consistent with previous research studies,[33,36] we found that children's exposure to environmental tobacco smoke (ETS), as measured by serum cotinine, is associated with increased behavior problems of both externalizing and internalizing types among boys. Our findings of increased externalizing behavior problems, in particular hyperactivity and aggression, are consistent with previous reports linking pre and postnatal tobacco smoke exposure with externalizing behavior problems.[30,33,36] We also found relationships between ETS exposure and the specific internalizing type behaviors of somatization and depression. Reports of internalizing behaviors in relation to ETS exposure are less common, but Weitzman et al[36] reported increased behavior problems related to socialization, anxiety and depression, and immaturity among children who were exposed to higher levels of tobacco smoke.

We additionally found differences between boys and girls in the relationships between ETS exposure and behaviors as well as the influence of covariates. For boys, ETS exposure was associated with increased externalizing behaviors, including hyperactivity, aggression, and conduct problems; internalizing behaviors including depression; and overall behavior symptoms. Although girls were exposed to a greater number of cigarettes by parent report, had higher serum cotinine levels, and were more likely to be in the higher tertiles of serum cotinine, there was no evidence of a relationship between this exposure and behavior problems. Although sex differences in smoking habits, nicotine metabolism, and nicotine effects have been reported among adult smokers, and animal studies reveal sex differences in behavioral and physiological responses to nicotine,[61] to our knowledge, sex differences in metabolism and effects of ETS on children have not been thoroughly studied. In contrast to our findings, Braun et al[37] suggested that girls may actually be at greater risk of attention-deficit hyperactivity disorder (ADHD) when exposed to tobacco smoke prenatally although there was no statistical significance in the sex differences discussed. A potential sex difference in metabolism and susceptibility to effects of tobacco smoke should be further explored to help explain differences between boys and girls in the relationship between exposure and behaviors.

Covariates that significantly affected the relationships between ETS exposure and behavior also varied by sex. Statistically significant covariates of behavior among boys included asthma severity (internalizing, behavior symptoms, somatization), maternal depression (anxiety, depression), and black race (depression). For girls, significant covariates of behavior included maternal education (externalizing, behavior symptoms, adaptive skills, aggression, conduct), Home Observation for Measurement of the Environment (HOME) score (externalizing, adaptive skills, aggression, conduct), maternal depression (externalizing, internalizing, adaptive skills, hyperactivity, anxiety, depression), and asthma severity (anxiety, somatization).

Maternal depression was an important covariate for both boys and girls but was related primarily to internalizing symptoms in boys and both internalizing and externalizing symptoms in girls. In general, childhood depression is more common among children of depressed parents.[62] In addition, girls are generally recognized as having higher rates of depression than boys.[62-64] Maternal depression is associated with increased disruptive behaviors, anxiety, and depression in children at rates as high as 2 to 3 times children with nondepressed mothers.[55,65]

The relationship between asthma severity and child behaviors is not surprising. Previous research has consistently shown a relationship between asthma and increased level of anxious behaviors in children but not depression.[43,46,66-68] In addition, disruptive behaviors have been reported rarely and at a lower prevalence among children with asthma.[66] In fact, Katon et al[68] speculated that up to one third of children with asthma may experience anxiety, and Bussing et al reported that children with severe asthma had nearly 3 times the odds of having severe behavior problems.[69]

This study is not without limitations. No information was gathered about maternal drug or alcohol use during pregnancy, so we are unable to adjust for these potentially important contributors to later child behavior. We additionally had no birth outcome information such as birth weight or gestational age which can be related to child behavior. All enrolled children had asthma so the results may not be generalizable to populations of children without asthma. Still, these results may be reflective of risks from ETS exposure for the 7 to 10% of children in the US today who have been diagnosed with asthma.[70] It is important to reiterate that research on children with asthma generally reveals a tendency toward increased internalizing behavior problems[43,46,66-68] whereas prior research on prenatal and postnatal tobacco smoke exposure has primarily yielded associations with externalizing behavior problems.[26-33,36] Among children with asthma, reported behavior problems tend to be more frequent than among the general population and may include both internalizing[46,47,71] and to a lesser extent externalizing behaviors.[72-78] Children with asthma are often more sensitive to the respiratory effects of ETS,[14,79] but we are unaware of published studies exploring their susceptibility to the potential behavioral consequences of ETS exposure.

All children in this study were exposed to ETS so we may not be able to generalize our findings to unexposed children. There was, however, a reasonable amount of variability in ETS exposure and asthma severity among the sample allowing for exploration of a potential dose-response relationship between ETS exposure and child behaviors. Additionally,

National data suggest that that the majority of children are exposed to ETS at some level.[38] Furthermore, our findings of increased behavior problems among those children most heavily exposed suggest a dose-response relationship. In addition, this study suggests that even among families with smokers, variations in child behaviors are observed, diminishing the concern that families of smokers may interpret children's behaviors differently.

CONCLUSION

Among children with asthma, especially boys, exposure to environmental tobacco smoke (ETS) is related to increased behavior problems, including externalizing problems such as hyperactivity, aggression, and conduct problems, internalizing problems such as depression, and behavior symptoms. The results of this study provide further evidence that even low levels of environmental tobacco smoke may contribute to behavior problems in children and should encourage us to make stronger efforts to prevent childhood exposure to tobacco smoke especially among higher risk populations such as children with asthma.

ACKNOWLEDGMENTS

We thank the staff and participating families of the Cincinnati Asthma Prevention Study for their contribution to this research.

This project was supported by Grants from the National Institutes of Health: NIEHS R21 ES12952-01 and NHLBI R01 HL65731.

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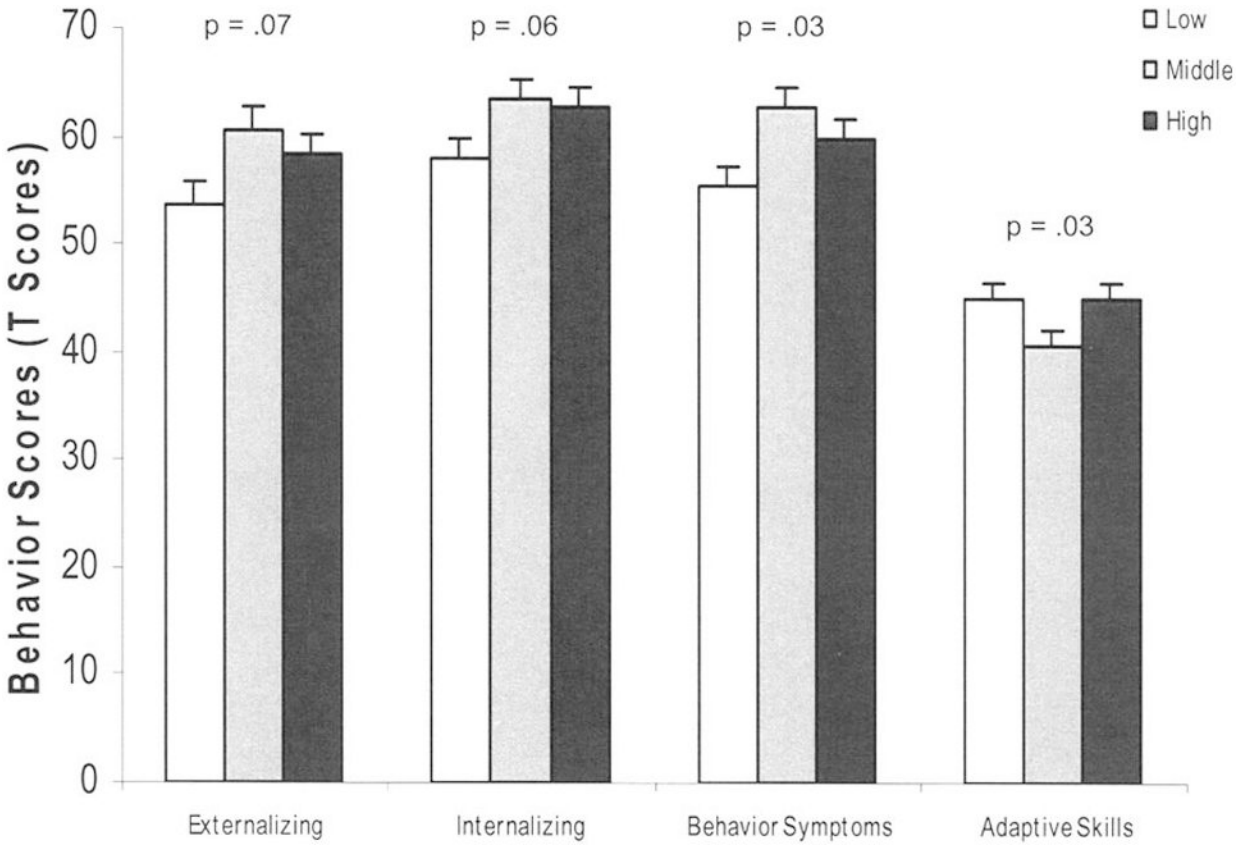

Figure 1.

Adjusted (covariates in all models: gender, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, Home Observation for Measurement of the Environment (HOME) Score, and maternal depression) effect of serum cotinine on child behavior among 6 to 12 year olds with asthma.

* Covariates in all models: gender, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, HOME Score, and maternal depression

Table 1.

Sample Characteristics at Study Enrollment (N = 220)

Characteristic	
Age (yr)	
Mean	9.40
SD	1.83
Male	135 (61.4%)
Race	
African-American	123 (55.9%)
Caucasian	92 (41.8%)
Other	5 (2.3%)
Parent education	
High school graduate or less	143 (65.0%)
Some college	51 (23.2%)
College graduate	26 (11.8%)
Parent marital status	
Married/living with someone	91 (41.4%)
Divorced/separated	34 (15.5%)
Single—never married	92 (41.8%)
Widowed	3 (1.4%)
Household income[a]	$25,000 ($15,000, $45,000)
Asthma severity	
Mild	51 (23.2%)
Moderate	106 (48.2%)
Severe/very severe	63 (28.6%)
Maternal smoking during pregnancy	
None	74 (33.6%)
Until pregnancy recognition	32 (14.6%)
Throughout pregnancy	114 (51.8%)
Cigarettes smoked in the home daily (at screening)[a]	20 (14,40)
Cigarettes smoked in the home daily (at baseline home visit)[a]	13 (9.5, 20)
Serum cotinine (ng/mL)[b]	1.18 (0.10, 13.37)
HOME scores	
Mean	46.74
SD	8.08
Maternal depression (BDI)	
Mean	11.12
SD	9.66
BASC (within clinical range ≥70)	
Externalizing	41 (18.8%)
Internalizing	58 (26.6%)

Characteristic	
Behavior symptoms	46 (21.1%)

Data presented as N (%), mean ± standard deviation. HOME, Home Observation for Measurement of the Environment.

[a] Median (interquartile range).

[b] Geometric mean (95% confidence interval).

Table 2.

ETS Measured by Log Serum Cotinine and Child Behavior (Adjusted[a], N = 220)

Behavior Subscale	Full Sample			Males			Females		
	β	**SE *β***	***p***	***β***	**SE *β***	***p***	***β***	**SE *β***	***p***
Externalizing	1.16	0.69	.09	2.23	0.92	.02	−0.91	1.27	.48
Hyperactivity	1.54	0.63	.02	2.14	0.88	.02	0.74	1.09	.50
Aggression	1.18	0.68	.09	1.99	0.87	.02	−0.39	1.38	.78
Conduct	0.60	0.64	.35	1.59	0.82	.06	−1.51	1.24	.23
Internalizing	1.31	0.61	.03	2.19	0.87	.01	−0.03	1.02	.98
Somatization	1.13	0.61	.07	1.53	0.82	.06	−0.07	1.17	.95
Anxiety	0.73	0.53	.17	1.39	0.77	.07	0.22	0.87	.80
Depression	1.21	0.61	.05	2.19	0.88	.01	−0.16	0.98	.87
Behavior Symptoms	1.39	0.66	.04	2.55	0.94	.01	−0.05	1.08	.96
Adaptive Skills	−0.40	0.47	.40	−0.96	0.62	.13	−0.07	0.84	.94

[a]Covariates in all models include: sex, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, maternal depression, HOME score.

Table 3.

Unadjusted and Adjusted *T* Scores on BASC by Serum Cotinine Tertiles (Mean [Standard Deviation], N = 220)

	Low (0.05–0796 ng/mL)		Middle (0.819–2.16 ng/mL)		High (2.23–19.6 ng/mL)	
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Externalizing	51.7 (13.1)	53.8 (16.6)	60.2 (16.8)	60.6 (17.6)	62.5 (20.3)	58.3 (17.4)
Hyperactivity	52.0 (12.9)	53.8 (15.3)	58.6 (14.6)	59.3 (16.0)	62.5 (18.2)	58.6 (15.5)
Aggression	51.5 (13.0)	53.5 (16.3)	59.4 (17.0)	60.5 (17.1)	60.8 (18.4)	57.0 (17.2)
Conduct	50.8 (11.6)	53.5 (15.6)	58.3 (17.4)	57.9 (16.2)	59.8 (19.8)	55.3 (16.1)
Internalizing	57.3 (11.8)	58.1 (15.3)	62.0 (14.9)	63.6 (15.4)	63.9 (16.1)	62.7 (15.4)
Somatization	61.3 (12.9)	61.7 (14.7)	64.2 (13.4)	65.4 (15.5)	66.5 (17.8)	65.5 (15.4)
Anxiety	53.3 (11.5)	53.3 (12.8)	54.8 (12.5)	55.9 (13.4)	55.8 (12.6)	56.4 (13.4)
Depression	52.1 (11.7)	53.6 (14.6)	58.5 (15.8)	60.0 (15.3)	59.8 (16.1)	57.4 (15.2)
Behavior symptoms	53.6 (13.2)	55.5 (15.9)	61.3 (16.1)	62.6 (16.6)	63.0 (17.4)	59.8 (16.6)
Adaptive skills	46.6 (10.7)	45.1 (11.1)	41.5 (11.2)	40.5 (11.6)	42.8 (11.1)	44.9 (11.5)

[a]Covariates in all models include: sex, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, maternal depression, HOME score.

Table 4.

ETS Measured by Log Serum Cotinine Split into Tertiles[a] and Related to Child Behavior for the Entire Sample and by Sex (Adjusted[b], N = 220)

Behavior Subscale	Overall				Males				Females			
	Tertile 2		Tertile 3		Tertile 2		Tertile 3		Tertile 2		Tertile 3	
	β (SD)	*p*	β (SD)	*p*	β (SD)	*p*	β (SD)	*p*	β (SD)	*p*	β (SD)	*p*
Externalizing	6.50 (2.78)	.02	3.61 (2.96)	.22	8.82 (3.26)	.01	8.63 (3.79)	.02	−2.03 (5.49)	.71	−6.10 (5.49)	.27
Hyperactivity	5.51 (2.26)	.03	4.84 (2.72)	.08	6.30 (3.18)	.05	7.63 (3.71)	.04	2.27 (4.77)	.64	1.78 (4.78)	.71
Aggression	7.01 (2.74)	.01	3.59 (2.92)	.22	9.20 (3.06)	.01	8.16 (3.56)	.02	−0.51 (5.84)	.93	−5.39 (5.93)	.37
Conduct	4.42 (2.60)	.09	1.83 (2.76)	.51	7.28 (2.92)	.01	6.47 (3.41)	.06	−5.46 (5.39)	.32	−7.94 (5.40)	.15
Internalizing	5.53 (2.46)	.03	4.60 (2.62)	.08	5.67 (3.14)	.07	8.83 (3.66)	.02	3.39 (4.39)	.44	−1.40 (4.40)	.75
Somatization	3.67 (2.47)	.14	3.82 (2.62)	.15	5.52 (2.91)	.06	7.04 (3.39)	.04	−2.17 (5.08)	.67	−2.29 (5.08)	.65
Anxiety	2.59 (2.15)	.23	3.05 (2.29)	.18	1.08 (2.78)	.70	5.78 (3.24)	.08	5.41 (3.72)	.15	0.98 (3.72)	.79
Depression	6.43 (2.44)	.01	3.84 (2.60)	.14	6.51 (3.16)	.04	7.77 (3.68)	.04	4.28 (4.17)	.31	−2.00 (4.17)	.63
Behavior symptoms	7.12 (2.66)	.01	4.28 (2.83)	.13	8.24 (3.36)	.02	9.81 (3.91)	.01	2.72 (4.64)	.56	−3.10 (4.64)	.51
Adaptive skills	−4.52 (1.86)	.02	−0.17 (1.98)	.93	−3.97 (2.22)	.08	−2.72 (2.58)	.29	−6.31 (3.33)	.06	0.79 (3.34)	.81

[a]The lowest tertile of ETS exposure was used as the reference in all analyses, so betas and associated standard errors are given for tertiles 2 and 3 only.

[b]Covariates in all models: gender, age, race, asthma severity, asthma medication, maternal education, prenatal tobacco exposure, HOME Score, maternal depression.