Secondhand Smoke Exposure and Neurobehavioral Disorders Among Children in the United States

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KEY WORDS
secondhand tobacco smoke, ADHD, learning disability, conduct disorder, NSCH

ABBREVIATIONS
SHS—secondhand smoke
ADHD—attention-deficit/hyperactivity disorder
ADD—attention-deficit disorder
OR—odds ratio
CI—confidence interval

All authors made substantial contributions to the article's conception and design, the acquisition of data or analysis and interpretation of data, drafting of the article and revising it critically for important intellectual content, and the final approval of the version to be published.

www.pediatrics.org/cgi/doi/10.1542/peds.2011-0023

doi:10.1542/peds.2011-0023

Accepted for publication Mar 29, 2011

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

WHAT'S KNOWN ON THIS SUBJECT: Physical health consequences of secondhand smoke exposure in children include respiratory diseases, sudden infant death syndrome, and asthma exacerbation. Approximately 5.5 million US children live in households in which someone smokes. Evidence is emerging of the etiologic contribution to childhood neurobehavioral disorders.

WHAT THIS STUDY ADDS: This is the first study to examine common child neurobehavioral disorders in relation to secondhand smoke exposure in the home. Odds of 2 or 3 parent-reported child neurobehavioral disorders increased by 50%, and need for treatment or counseling also increased.

abstract

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OBJECTIVES: The association between parent-reported postnatal secondhand tobacco smoke exposure in the home and neurobehavioral disorders (attention-deficit/hyperactivity disorder, learning disabilities, and conduct disorders) among children younger than 12 years in the United States was examined using the 2007 National Survey on Children's Health. Excess neurobehavioral disorders attributable to secondhand smoke (SHS) exposure in the home in 2007 were further investigated.

METHODS: The methods used in this study were multivariable logistic regression models that accounted for potential confounders and complex survey designs to evaluate associations.

RESULTS: A total of 6% of 55 358 children (aged $<$ 12 years), corresponding to a weighted total of 4.8 million children across the United States, were exposed to SHS in the home. The weighted prevalence and 95% confidence intervals of each of the children's neurobehavioral outcomes were 8.2% (7.5–8.8) with learning disabilities, 5.9% (5.5–6.4) with attention-deficit/hyperactivity disorder, and 3.6% (3.1–4.0) with behavioral and conduct disorders. Children exposed to SHS at home had a 50% increased odds of having $\geq$2 childhood neurobehavioral disorders compared with children who were not exposed to SHS. Boys had a significantly higher risk. Older children, especially those aged 9 to 11 years, and those living in households with the highest poverty levels were at greater risk. In absolute terms, 274 100 excess cases in total of these 3 disorders could have been prevented if children had not been exposed to SHS in their homes.

CONCLUSIONS: The findings of the study, which are associational and not necessarily causal, underscore the health burden of childhood neurobehavioral disorders that may be attributable to SHS exposure in homes in the United States. *Pediatrics* 2011;128:263–270

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Exposure to secondhand tobacco smoke (SHS) has been shown to have numerous physical health consequences for children,[1,2] including respiratory problems and an increased risk of sudden infant death syndrome, acute respiratory infections, ear problems, and more frequent and severe asthma attacks.[1,2] Yet, in 2007, 7.6% (or 5.5 million) of US children lived in households where someone smoked inside the home.[3] There is recent emerging evidence of the etiologic contribution of environmental factors, including tobacco smoke, to cognitive, behavioral, and developmental disorders of childhood, which are not explained on a solely genetic basis.[4,5,6,7]

Neurobehavioral diseases are associated with substantial morbidity and economic costs, affecting an estimated 3% to 8% of school-aged children each year and accounting for ~$9.2 billion in total annual costs.[8,9] Attention-deficit/hyperactivity disorder (ADHD), learning disabilities, and conduct disorders often are comorbid. ADHD typically begins at an early age, with developmentally inappropriate levels of inattention and hyperactivity, and symptoms often continue into adulthood and throughout the life span.[9] The percentage of children ages 4 to 17 years with parent-reported ever-diagnosis of ADHD increased from 7.8% to 9.5% during 2003–2007, representing a 21.8% increase in 4 years.[10,11] The annual medical costs associated with these disorders are substantial, at $14 576 per individual.[12] Learning disabilities are disorders that affect the brain's ability to receive, process, store, and respond to information among individuals of average intelligence. More than 6 million children in the United States ages 6 through 21 years are affected by learning disabilities, with a prevalence of 10.6% based on parent reports.[4] Behavioral and conduct disorders are characterized by persistent behavioral patterns in children and an increased risk for drug and alcohol abuse, antisocial personality disorder, and anxiety-related disorders.[9,13]

Significant associations often have been observed between prenatal tobacco smoke exposure and these neurobehavioral disorders among children,[14–21] whereas increased rates (eg, a twofold increased risk of ADHD and 60% increased odds of learning disabilities) also have been observed in association with postnatal SHS exposure.[22,23] Isolation of the independent effect of postnatal exposure to SHS on child neurodevelopment and behavior is challenging because of the correlation between prenatal and postnatal exposure. In addition, children's exposure to SHS is associated with other possible confounding factors that may adversely affect neurobehavioral outcomes, such as low maternal education and low socioeconomic status of the family. Findings from a recent study[24] also underscored the possibility of racial disparities in the effects of SHS on behavioral problems in children.

The aim of the present study is to assess the association between postnatal SHS exposure and these neurodevelopmental and behavioral disorders both individually and jointly among US children from birth through 11 years of age. The analysis adjusts for confounding by other potential risk factors and estimates the population-attributable fractions of these neurobehavioral disorders on the basis of the associations determined.

METHODS

The data for this study are from the 2007 National Survey of Children's Health. This survey was conducted by the US Centers for Disease Control and Prevention, National Center for Health Statistics, with funding and direction from the Health Resources and Services Administration's Maternal and Child Health Bureau. The purpose of the survey was to provide national and state-specific prevalence estimates for a range of children's health and well-being indicators. The survey also included an extensive array of questions pertaining to family environment, including parental health, family activities, and parental concerns regarding their children's physical and mental health.

Sampling Procedures

The 2007 National Survey of Children's Health was a telephone survey conducted between April 2007 and July 2008. It consisted of a total sample size of 91 642 children from birth through 17 years of age, with an average sample size of ~1800 children per state. A random-digit-dial sample of households with children younger than 18 years was selected from each of the 50 states and the District of Columbia. One child per household was selected as the subject if any were age eligible, with additional early and middle childhood and adolescent questions asked for children of respective age groups. The individual child living in households with a single child and 1 child selected at random in households with more than 1 child were identified as the subject of the interview. Analyses were conducted for the total 55 358 children from birth to 11 years of age. All such children had information reported regarding household smoking.

Interviews were conducted in English, Spanish, or an Asian language. The respondent was identified by the interviewer as the parent or guardian most knowledgeable about the child's health status and health care. The interview completion rate among known households with children was 66.0%. The National Center for Health Statistics Research ethics review board ap-

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proved data collection procedures, and verbal informed consent was obtained.

Primary Outcome and Exposure Variables

1. Four pediatric neurobehavioral outcomes were investigated: learning disability was derived from the question "Has a doctor, health care provider, teacher, or school official ever told you [sampling child] had a learning disability?"
2. Attention-deficit disorder (ADD) and ADHD was derived from the question "Has a doctor or other health care provider ever told you that [sampling child] had ADD/ADHD?"
3. Behavioral and conduct disorders were derived from the question "Has a doctor or other health care provider ever told you that [sampling child] had behavioral or conduct problems, such as oppositional defiant disorder or conduct disorder?"
4. Treatment or counseling was derived from the question "Does [sampling child] have any kind of emotional, developmental, or behavioral problem for which (he/she) needs treatment or counseling?"

The main exposure variable was childhood SHS exposure in the home, which was derived from the question asked of parents "Does anyone smoke inside child's home?"

Covariates

In addition to state of residence, potential covariates considered were household member smoking status, child's age group (birth to 2, 3–5, 6–8, and 9–11 years), gender, race/ethnicity (white only, black only, multiracial, or other only), household composition (2-parent biological or step families, single mother, or other), residence (metropolitan or nonmetropolitan), primary language spoken (English or other language), household poverty status measured as a ratio of family income to federal poverty level (<100%, 100%–199%, 200%–399%, and 400%), mothers' education (less than a high school graduate, high school graduate, beyond high school), foreign status of mother (yes or no), legal marital status of mother (married, separated, divorced, widowed, or never married), total number of children in the household, total number of adults in the household, and low birth weight (<2500 g).

Statistical Analyses

Unadjusted and multivariate-adjusted estimates of the percentage of SHS-exposed and SHS-nonexposed children younger than 12 years were computed for each of the 4 childhood neurobehavioral outcomes investigated. In addition, estimates of percentages of exposed and nonexposed children younger than 12 years were computed for a 3-level pediatric neurobehavioral disorder outcome category (none, at least 1, and ≥2 conditions).

The 2007 National Survey of Children's Health data were obtained through a complex sample design involving unequal probabilities of selection of children within households and stratification of households within states. Sampling weights were used for both national and state-level representative analyses. Sampling weights are adjusted for potential nonresponse biases and also accounted for noncoverage of nontelephone households. Estimates are generalizable only to the population of US noninstitutionalized children ages birth through 12 years at the time of the interview. Weighted estimates of the population prevalence of learning disabilities, ADHD and ADD, and conduct disorders were computed with 95% confidence intervals (CIs). Unadjusted and adjusted weighted estimates accounted for a clustering effect within the 50 states.

Multivariable logistic regression modeling with a stepwise selection procedure was used to derive the odds ratios (ORs) and covariate-adjusted prevalence of exposure for each of the childhood neurobehavioral outcomes. Statistically significant covariates at P values of <.05 are presented for each of the outcomes, in addition to adjusted ORs and 95% CIs. The OR is a good approximation to the relative risk ratio, where the rare disease assumption (<0.10%) holds as in the present context. Interaction terms between SHS exposure and selected covariates (age, gender, poverty status, foreign status, state of residence, total number of children, and race) were examined for each of the 4 outcomes. Multicollinearity between SHS exposure in the home and household member smoking status was assessed by the variance inflation factor and tolerance.

The population-attributable risk percentage was computed for each of the child neurobehavioral outcomes investigated following the conventional formula[25]: population-attributable risk percentage $= [P_{exp}(RR - 1)/P_{exp}(RR - 1) + 1] \times 100$, where P_{exp} represents SHS exposure in the home of children younger than 12 years and RR represents the relative risk ratio. All analyses were conducted by using SAS 9.1.3 (SAS Institute, Inc; Cary, NC).

RESULTS

A total of 6% (SE: 0.22) of 55 358 children younger than 12 years, corresponding to a weighted total of 4.8 million children across the United States, were exposed to SHS in the home in 2007. The weighted prevalence rates and 95% CIs of each of the childhood neurobehavioral outcomes were 8.2% (7.5–8.8) with learning disabilities, 5.9% (5.5–6.4) with ADD or ADHD, and 3.6% (3.1–4.0) with conduct disorders.

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TABLE 1 Observed (Weighted) and Adjusted Prevalence of Pediatric Behavioral Disorders According to SHS Exposure Status at Home in Children Aged 0 to 11 Years in the United States, 2007

Disorders	SHS Exposure			
	Yes, %		No, %	
	Crude (95% CI)[a]	Adjusted (95% CI)[b]	Crude (95% CI)[a]	Adjusted (95% CI)[b]
Learning disabilities	14.1 (11.4–16.8)	15.1 (14.2–16.1)	7.7 (7.1–8.4)	7.2 (6.9–7.4)
ADHD or ADD	14.2 (11.4–16.9)	13.0 (11.9–14.2)	5.4 (4.9–5.8)	5.5 (5.3–5.6)
Conduct or behavioral disorders	9.7 (7.1–12.2)	8.7 (7.9–9.5)	3.1 (2.7–3.5)	2.8 (2.7–2.9)
Treatment or counselling	13.0 (10.6–15.5)	11.7 (10.8–12.5)	5.5 (5.0–6.0)	5.3 (5.1–5.4)

[a] Adjusted for clustering effect within states of residence.
[b] Adjusted by multivariable logistic regression for age of child, gender, poverty status of the household, state of residence, metropolitan status, mothers' level of education, mothers' foreign status, race, family structure, marital status, total number of children in households, total number of adults in households, primary language, and birth weight.

More than twofold-increased rates were observed in parent-reported childhood neurobehavioral disorders in children exposed to SHS at home compared with children who were not exposed to SHS (Table 1). Also, children with parent-reported need of treatment or counseling for emotional, developmental, or behavioral problems were proportionately higher in children exposed to SHS at home compared with children not exposed to SHS (Table 1).

Children exposed to SHS at home had a 50% increased odds of having 2 or more parent-reported child neurobehavioral disorders (Table 2). Likewise, children exposed to SHS at home had a 51% increased odds of having at least 1 of these child neurobehavioral disorders (Table 2).

The results of multivariable covariate–adjusted analyses for each of the 4 outcomes are shown in Table 3. In general, children exposed to SHS at home had a 50% or more increased odds of neurobehavioral disorders relative to children who were not exposed. With household member smoking status included in the analyses, the adjusted OR for children exposed to SHS at home are increased 10% to 39%. Variance inflaction factor was less than 10 and tolerance was more than 0.1, indicating no multicollinearity between SHS exposure in the home and household member smoking status. Boys had a significantly higher risk of each of the disorders investigated. Older children, especially those aged 9 to 11 years, and those living in households with the highest poverty levels were at greater risk for the neurobehavioral disorders investigated. Children living with 2 biological parents, those living in English-speaking households, or those with mothers' with more education had reduced odds of having 1 of these disorders. Children born with low birth weight had a twofold-increased risk of having learning disabilities, ADHD or ADD, and conduct disorders.

The only effect modification observed was poverty on the effect of SHS exposure levels on learning disabilities. For children living in households with the highest poverty levels and who were exposed to SHS, the risk of developing learning disabilities was significantly higher by 22%. On the contrary, children living in households with the lowest poverty levels and who were also exposed to SHS had an 11% lower risk of developing learning disabilities.

The population-attributable risk percentage of each of the child neurobehavioral disorders investigated are shown in Table 4. A total of 3.9 million cases of learning disabilities, 2.8 cases of ADHD or ADD, and 1.7 million cases of conduct disorders among children younger than 12 years were reported. Of these, 3.2%, 2.6%, and 4.5% of cases of learning disabilities, ADD or ADHD, and conduct disorders, respectively, were attributable to SHS exposure at home. In absolute terms, 274 100 excess cases in total of these 3 disorders could have been prevented had the children been not exposed to SHS in their homes.

DISCUSSION

In the present study, 6% of 55 358 children younger than 12 years, corresponding to a weighted total of 4.8 million children across the United States, were found to have been exposed to SHS in the home in 2007. This figure is slightly lower than a recent estimate of 7.6% that included all children younger

TABLE 2 Observed (Weighted) and Adjusted Prevalence of Pediatric Behavioral Disorders (Learning Disabilities/ADHD/Conduct) With and Without Combinations According to SHS Exposure Status at Home in Children Aged 0 to 11 Years in the United States, 2007

No. of Disorders	SHS Exposure			
	Yes, %		No, %	
	Crude (95% CI)[a]	Adjusted (95% CI)[b]	Crude (95% CI)[a]	Adjusted (95% CI)[b]
At least 1	20.4 (17.4–23.4)	19.3 (17.8–20.7)	8.6 (8.0–9.1)	8.2 (7.9–8.4)
Adjusted OR (95% CI)[b]		1.51 (1.30–1.74)		
At least 2	9.4 (7.0–11.7)	9.0 (8.0–9.9)	3.2 (2.9–3.6)	3.1 (2.9–3.2)
Adjusted OR (95% CI)[b]		1.50 (1.23–1.84)		
All 3	3.5 (2.1–4.9)	3.9 (3.3–4.5)	0.9 (0.7–1.1)	0.76 (0.7–0.8)
Adjusted OR (95% CI)[b]		2.17 (1.55–3.05)		

[a] Adjusted for clustering effect within states of residence.
[b] Adjusted by multivariable logistic regression for age of child, gender, poverty status of the household, state of residence, metropolitan status, mothers' level of education, mothers' foreign status, race, family structure, marital status, total number of children in households, total number of adults in households, primary language, and birth weight.

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TABLE 3 Weighted SHS Prevalence and Adjusted ORs of Pediatric Behavioral Disorders According to SHS Exposure Status at Home and Across Significant Covariates in Children Aged 0 to 11 Years ($N = 55\,358$) in the United States, 2007

Significant Covariates	SHS, Weighted	Adjusted OR (95% CI)[a]			
	n (%)	ADHD/ADD	Learning Disabilities	Conduct Disorders	Treatment or Counseling
SHS					
No	Reference	Reference	Reference	Reference	
Yes	6.0 (5.6–6.5)	1.44 (1.21–1.72)	1.54 (1.27–1.85)[b]	1.78 (1.44–2.21)	1.50 (1.27–1.79)
Gender					
Female	26 733 (6.0)	Reference	Reference	Reference	Reference
Male	28 566 (6.0)	2.52 (2.24–2.83)	1.80 (1.61–2.00)	2.73 (2.31–3.24)	1.96 (1.76–2.18)
Child's age					
0–2 y	13 600 (4.0)	Reference		Reference	Reference
3–5 y	13 966 (5.6)	3.99 (1.94–8.22)	Reference	3.47 (1.81–6.66)	3.77 (2.91–4.89)
6–8 y	13 592 (7.0)	10.40 (4.77–22.9)	1.31 (0.96–1.78)	4.30 (2.10–8.81)	3.82 (2.77–5.28)
9–11 y	14 200 (7.6)	18.20 (8.34–39.9)	2.16 (1.59–2.91)	4.73 (2.31–9.67)	4.19 (3.04–5.77)
Race/ethnicity					
White only	40 236 (5.6)	Reference			Reference
Black only	5513 (12.0)	0.75 (0.63–0.90)			0.62 (0.52–0.75)
Multiracial	3203 (7.9)	1.08 (0.85–1.36)			1.20 (0.98–1.48)
Other only	2936 (2.4)	0.93 (0.67–1.29)			1.00 (0.77–1.31)
Household composition					
2-Parent biological	41 185 (3.6)	Reference	Reference	Reference	Reference
2-Parent stepfamily	2551 (13.0)	1.94 (1.63–2.30)	1.63 (1.37–1.94)	2.74 (2.17–3.46)	2.17 (1.81–2.60)
Single mother	8305 (11.8)	1.82 (1.58–2.10)	1.41 (1.23–1.62)	2.34 (1.94–2.83)	2.26 (1.79–2.88)
Other family type	2994 (13.8)	2.74 (1.54–4.88)	2.03 (1.11–3.72)	8.26 (4.63–14.7)	5.54 (3.48–8.82)
Primary language spoken at home					
English	50 537 (6.9)	Reference		Reference	Reference
Any other language	4784 (11.8)	0.58 (0.38–0.88)		0.64 (0.45–0.92)	0.59 (0.45–0.77)
Mothers' level of education					
Less than high school	4249 (9.8)	Reference	Reference	Reference	
High school graduate	9551 (10.3)	0.83 (0.67–1.02)	0.94 (0.77–1.14)	0.88 (0.68–1.14)	
More than high school	37 975 (3.2)	0.67 (0.55–0.82)	0.71 (0.58–0.86)	0.63 (0.48–0.81)	
Household poverty status					
<100%	6366 (11.7)	1.89 (1.55–2.31)	2.42 (2.00–2.92)	3.07 (2.34–4.03)	2.19 (1.83–2.62)
100%–199%	8967 (9.2)	1.46 (1.24–1.73)	1.66 (1.40–1.95)	1.98 (1.54–2.54)	1.49 (1.27–1.75)
200%–399%	17 164 (5.1)	1.17 (1.02–1.35)	1.33 (1.16–1.53)	1.42 (1.13–1.79)	1.07 (0.93–1.23)
≥400%	18 208 (1.4)	Reference	Reference	Reference	Reference
Foreign status of mother					
Yes	7324 (1.1)	1.84 (1.37–2.48)	1.33 (1.10–1.61)		
No	44 578 (6.9)	Reference	Reference		
Place of residence					
Metropolitan	30 308 (5.4)		1.24 (1.08–1.43)	1.22 (1.01–1.47)	1.23 (1.07–1.42)
Nonmetropolitan	8122 (10.8)		Reference	Reference	Reference
Legal marital status of parents					
Married	41 225 (3.5)				Reference
Separated	1311 (12.9)				1.19 (0.86–1.65)
Divorced	2911 (11.3)				0.91 (0.68–1.20)
Widowed	316 (12.0)				1.75 (1.10–2.76)
Never married	7769 (11.8)				0.86 (0.70–1.07)
Low birth weight, <2500 g					
No	24 511 (4.6)	Reference	Reference	Reference	Reference
Yes	30 847 (7.2)	2.12 (1.36–3.31)	1.97 (1.42–2.73)	2.06 (1.35–3.14)	2.31 (1.79–3.00)

[a] Stepwise elimination multivariable logistic regression analyses.

[b] A significant interaction (SHS × poverty) term was included in the model.

than 17 years.[3] The overall weighted prevalence rates of the 3 childhood neurobehavioral disorders investigated also were consistent with recent estimates in the United States (8.2%, 5.9%, and 3.6%, respectively).[4,10,11,13] In general, children exposed to SHS at home had a 50% or more increased odds of developing neurobehavioral health outcomes compared with children not exposed to SHS at home. The moderated odds, with the inclusion of household member smoking status, may be attributable to the exposure of children to SHS at home from household members smoking in their presence (eg, in cars or elsewhere outside of the home). Such adjusted ORs are in agreement with similar associations found in studies conducted in the United States and elsewhere.[4,6,7,13,26] Population-

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TABLE 4 Population-Attributable Risk Percentage for Pediatric Behavioral Disorders According to SHS Exposure Status at Home in Children Aged 0 to 11 Years ($N = 48.4$ million) in the United States, 2007

Disorders	Weighted Prevalence, % (95% CI)[a]	Adjusted OR (95% CI)[b]	Population-Attributable Risk, % (95% CI)[c]	Total Cases, Millions[d]	Excess Cases (95% CI)
Learning disabilities	8.2 (7.5–8.8)	1.54 (1.27–1.85)	3.2 (1.6–4.9)	3.9	124 800 (62 400–191 100)
ADHD or ADD	5.9 (5.5–6.4)	1.44 (1.21–1.72)	2.6 (1.3–4.2)	2.8	72 800 (36 400–117 600)
Conductor behavioral disorders	3.6 (3.1–4.0)	1.78 (1.44–2.21)	4.5 (2.5–6.8)	1.7	76 500 (42 500–115 600)
Total					274 100 (141 300–424 300)

[a] Adjusted for clustering effect of state-wide variations.
[b] Adjusted by multivariable logistic regression for age of child, gender, poverty status of the household, state of residence, metropolitan status, mothers' level of education, mothers' foreign status, race, family structure, marital status, total number of children in households, total number of adults in households, primary language, and birth weight.
[c] Population-attributable risk percentage $= (P_{exp}\,[RR - 1]/P_{exp}\,[RR - 1] + 1) \times 100$, where $P_{exp} = 6.04\%$ (SE: 0.22).
[d] Population-weighted estimates from the 2007 National Survey of Children's Health (0–11 years of age).

attributable estimates differ from earlier estimates on the basis of different child age distributions.[4,27] Assuming a causal relationship, 274 100 excess cases of these 3 disorders could have been prevented had the children been not exposed to SHS in their homes.

Because of the fact that the analyses were restricted to children younger than 12 years to minimize any effect of current smoking among children, the present risk estimates could be attributable to both prenatal and postnatal SHS exposure. It is interesting to note that similar estimates reported from previous studies[4,6,7,13,26] were mainly related to prenatal childhood SHS exposure. The present study also finds, for the first time, a 50% increased odds of having 2 or 3 of the parent-reported child neurobehavioral disorders investigated jointly. Also, this is the first study to determine that children with a parent-reported need for treatment or counseling for emotional, developmental, or behavioral problems were proportionately higher among those exposed to SHS at home. This is particularly significant with regard to the potential burden of pediatric mental health care on an overextended health care system, a problem that could be dramatically reduced if voluntary smoke-free home policies were widely adopted. A 2005 econometric study reported a conservative estimate of the annual societal cost of illness for ADHD in children and adolescents in the United States at $42.5 billion, based on a prevalence of 5%.[12] Public expenditures related to general and mental health care, school services, and juvenile justice for children with conduct disorders exceed $10 000 per child per year.[28]

A recent pediatric health review suggested that childhood postnatal SHS exposure levels in their homes can by reduced by 20% to 50% if smoke-free home policies are strongly encouraged and widely adopted.[29] Public health law researchers recently recommended the use of federal regulatory or contractual mechanisms to ensure that public housing authorities implement no-smoking policies for the protection of children and other people[30] after strong encouragement of such policies by the US Department of Housing and Urban Development.[31]

Boys in general were observed to be at higher risk of the neurobehavioral disorders, a finding that also is consistent with a recent study[27] based on the National Health and Nutrition Examination Survey 1999–2002 examining ADHD in relation to childhood SHS exposure. Although the National Health and Nutrition Examination Survey also uses a parent-reported ADHD question, that study found nonstatistically significant effect modification by gender, with girls twice as likely to have ADHD when exposed prenatally.[27]

The mechanistic pathways of ADHD are gradually being understood, although the pathogenesis of learning disabilities and conduct disorders are less clear. Other risk factors for ADHD have not been thoroughly investigated, although evidence exists for prenatal maternal alcohol use, smoking, and low birth weight.[22] Genetic predisposition or a family history of ADHD has been noted, and environmental lead exposure also has recently been reported to be associated with ADHD.[7] SHS-associated child neurobehavioral disorders are likely to mediate through fetal growth restriction.[22] Some evidence indicates that complications during labor and delivery, low socioeconomic status, and relatively low maternal education levels are associated with learning disabilities.[4] Yet, these factors provide little insight regarding the specific causes. Consistent with other evidence,[3] the present study reported a twofold-increased odds of childhood neurobehavioral disorders in low birth weight infants, while adjusting for postnatal childhood SHS exposure.

Socioeconomic indicators, such as parental education, 2-parent biological parents, household poverty status, and foreign status of mothers, all proved to be significant predictors of childhood neurobehavioral disorders in the present study. Poor families often live in multiunit housing, where the risk of SHS exposure originating from

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neighboring units can be significant even where smoking may not be occurring their own home.[32] It is important to note that households under the federal poverty level were twofold or more at increased risk of childhood neurobehavioral disorders. Such findings signal the underlying health inequalities in SHS-associated childhood neurobehavioral disorders and the need for tobacco-control strategies for subgroups that are most vulnerable. A recent study[24] underscored the possibility of racial disparities in the effects of SHS on behavioral problems in children. However, no such racial modifications were observed in the associations investigated.

This study has limitations. Because of the cross-sectional design, the findings are associational and causal relationships cannot be inferred. Self-reported SHS exposure and parent-reported physician diagnoses may introduce misclassification and recall biases. Although several potential confounders for the associations were investigated, residual confounding cannot be ruled out. Maternal smoking rates during pregnancy, other prenatal exposures, and the child's current smoking status were not available in these data. However, analyses were restricted to children younger than 12 years to remove any effect of a child's current smoking status. Other unmeasured potential confounders, such as lead exposure, cannot be ruled out, although lead also is among the numerous toxic constituents of SHS.[33]

Additional strengths of the study include a nationally representative sample for the findings' generalizability to US children younger than 12 years. Many potential confounders were accounted for, and the estimates obtained are consistent with previous research.[4,6,7,13,26] Finally, this is the first study to examine the 3 most common childhood neurobehavioral disorders individually and in combination in relation to postnatal childhood SHS exposure in United States.

CONCLUSIONS

A total of 4.8 million US children younger than 12 years are exposed to SHS in their homes, and 3% to 8% suffer from 1 or more neurobehavioral disorders costing billions to the state health exchequer. In absolute terms, 274 100 excess cases of these disorders could have been prevented had children not been exposed to SHS in their homes. These health and economic burdens might be reduced significantly if voluntary smoke-free home policies are vigorously encouraged. Nevertheless, additional evidence is warranted in additional population settings for entirely evidence-based health policy decision making.

ACKNOWLEDGMENT

This research was supported by the Flight Attendants Medical Research Institute (Clinical Innovator Award 072085).

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BALLET: *Last fall I visited my sister in California. When I asked if she wanted to go for a bike ride, she replied that she sold her beloved mountain bike to pay for ballet classes. I was stunned. My sister spent most of her adult life living in the shadow of Mt. Tamalpais and knew every biking and hiking trail on the mountain by heart. Moreover, my 50-year-old sister is almost six–feet-tall and does not look like the prototypic ballerina seen in movies or television. I thought that her interest in ballet had waned by age 8, similar to many little girls. However, just the other day she mentioned how much fun she and her friends were having in their twice weekly ballet sessions. Evidently ballet is no longer just for young girls or true dance enthusiasts. As reported in* The New York Times *(Fashion & Style: May 11, 2011), ballet-based exercise has become quite popular among women of all ages and not just because of the movie "Black Swan." In large cities such as New York, numerous ballet-based workout studios have sprung up and across the country, gyms have added ballet or barre-centered classes (a barre is the handrail used during ballet exercises). The exercises focus on the arms, abdomen, gluteal muscles, and thighs and usually consist of specific, small movements to increase tone but not mass. Even experienced dancers are impressed at how challenging and tiresome the exercises can be. Women, including my sister, report that not only are the exercises great for their bodies and core strength, but the sessions are both calming and a great opportunity to connect with friends. While I don't expect my sister to be wearing a tutu anytime soon and no plans for a recital, I am thrilled that she has continued to exercise and is having so much fun doing so.*

Noted by WVR, MD

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