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Pre- and Postnatal Risk Factors for ADHD in a Nonclinical Pediatric Population

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Abstract

Objective—The authors characterized pre- and postnatal risk factors for ADHD among a population-based sample of 8-year-old children followed since birth ($N = 604$).

Method—Parents and teachers rated ADHD symptoms, including inattention and impulsivity/hyperactivity. The authors reviewed pediatric medical records for history of an ADHD diagnosis, and parents reported ADHD medication use. The authors analyzed risk factors in relationship to outcomes using multivariable regression models.

Results—Low paternal education, prenatal smoking, prenatal illicit drug use, maternal depression, and low Home Observation for Measurement of the Environment score were associated with greater risk for ADHD behaviors assessed via rating scale. Low income and being male were associated with ADHD diagnosis in medical records and ADHD medication use.

Conclusion—The authors found associations between socioeconomic, psychosocial, and prenatal exposures and ADHD-related behavior. Selection bias due to access to care and recall bias from inaccurate report of past exposures is minimized in this large, nonclinical, prospective cohort study.

Keywords

ADHD; cohort study; epidemiology; family risk factors

ADHD is the most common neurobehavioral disorder among school-aged children, affecting 5% to 10% of children worldwide (American Academy of Pediatrics, 2000; Faraone, Sergeant, Gillberg, & Biederman, 2003). Approximately 80% of children with ADHD have symptoms that persist into adolescence and adulthood (Faraone et al., 2003). Investigation of risk factors for ADHD is a public health priority given the substantial burden on the quality of life of affected children and their families, the large number of children treated with stimulant medication, and the strain on medical, educational, and social resources (Faraone et al., 2003; Pelham, Foster, & Robb, 2007).

The etiology of ADHD is multifactorial with a strong genetic component (Faraone & Doyle, 2001). Nongenetic risk factors are thought to play a role in the pre- and early postnatal periods, when the developing brain is particularly vulnerable to insult (Pasamanick, Rogers, & Lilienfeld, 1956). Identified risk factors for ADHD include prenatal maternal smoking, exposure to environmental toxins (e.g., lead), pregnancy complications, low socioeconomic status, and psychosocial adversity (Biederman, 2005; Millichap, 2008).

Previous studies examining ADHD-related risk factors have been predominantly retrospective in design, which makes assessment of prenatal and early life risk factors particularly challenging. Use of prospectively collected risk information allows assessment of a number of prenatal risk factors for ADHD, including prenatal smoking, alcohol consumption, and illicit drug use with less concern about biased recall. In addition, assessing risk factors in a nonclinical population provides the opportunity to study predictors of ADHD among the general population without limiting participants to those that seek or have access to care.

The purpose of this study is to characterize risk factors for ADHD and associated behaviors in a population-based sample of 8-year-old children enrolled in the New Bedford Cohort Study, a longitudinal birth cohort of early life contaminant exposure and child development.

Method

Study Population

The New Bedford Cohort study was designed to investigate the association between polychlorinated biphenyls (PCBs)—persistent organic pollutants that were discharged into the New Bedford harbor for decades prior to their ban in the United States in the 1970s—and neurodevelopment. Although associations between PCBs and ADHD-like behaviors in infancy and at school age have been documented in New Bedford (Sagiv et al., 2008, 2010), cord serum PCB levels were low compared with other PCB-exposed populations (Korrick et al., 2000; Longnecker et al., 2003). The New Bedford Cohort is comprised of 788 mother–infant pairs recruited at the time of the infant's birth between 1993 and 1998 at the main obstetrical hospital serving the Greater New Bedford area. Eligible mothers were aged 18 and older, resided in towns adjacent to the PCB-contaminated harbor during pregnancy, and spoke English or Portuguese. Infants unable to undergo neonatal examination or born by cesarean section were ineligible for the main study. Neurobehavioral assessments were performed at the 8-year follow-up visit on 607 children (77% of the main cohort of 788), including 3 children born in twin gestations. The analysis was restricted to 604 singleton births.

Outcome Assessment

Conners' Rating Scales (CRS)—The CRS are standardized questionnaires administered to teachers and parents to assess problem behaviors in children, including ADHD-related behavior. The CRS were designed for clinical diagnosis, screening, monitoring treatment, and as a research tool, and a large normative database supports the instrument's reliability and validity (Conners, 1997). For this study, we used the CRS for teachers and the CRS for parents, which contain 59 and 80 items, respectively, that cluster into 13 subscales, each of which is composed of nonmutually exclusive questions that are summed and converted to age- and sex-adjusted *T*-scores. We considered 4 subscales to be measures of behaviors associated with ADHD: (a) Conners' ADHD Index, (b) *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994) Inattentive, (c) *DSM-IV* Hyperactive-Impulsive, and (d) *DSM-IV* Total. The Conners' ADHD Index contains items that best distinguish children with ADHD from children without ADHD

(Conners, 1997). The three *DSM-IV* subscales link directly to the ADHD symptom domains in the ADHD diagnostic criteria as defined by the *DSM-IV*. Higher CRS scores are associated with greater frequency of problem behaviors.

ADHD Diagnosis—Pediatric medical records were reviewed at the time of the child's 8-year exam to determine whether the child ever had a diagnosis of ADHD. Parents were also asked to report whether the child was regularly taking ADHD medications, including dextroamphetamine/amphetamines (e.g., Adderall), methylphenidate hydrochloride (Ritalin, Concerta, Metadate), and dextmethylphenidate hydrochloride (Focalin) on the 8-year questionnaire.

Risk Factor Assessment

Data on potential risk factors for ADHD came from multiple sources: Maternal age at infant's birth, and infant's sex, race, and gestational age came from the maternal and infant medical records, reviewed by study personnel at time of birth; maternal prenatal smoking, alcohol consumption, and illicit drug use came from a questionnaire administered 2 weeks after birth; maternal and paternal education, household income, maternal marital status, type of school the child attends (public vs. private/parochial), and number of siblings living in the house came from a questionnaire administered at the child's 8-year exam; data on breast feeding, including duration, came from the 2-week and 8-year questionnaire; maternal intelligence (IQ) was assessed at the child's 8-year exam with the Kaufman Brief Intelligence Test; maternal depression symptoms were assessed at the child's 8-year exam with the Beck Depression Inventory; and a Home Observation for Measurement of the Environment (HOME) assessment, which measures quality and quantity of stimulation and support available to a child in the home environment, was performed as part of the child's 8-year exam (Caldwell & Bradley, 1984). Several variables were collected via questionnaire both at 2 weeks after the birth and during the 8-year exam, for example, parental education, household income, marital status. Data for these two time points were highly correlated, and associations with ADHD outcomes were very similar (data not shown); we therefore chose the time point that minimized missing data.

Statistical Analysis

All statistical analyses were generated using SAS software, Version 9.1.3 of the SAS System for Unix (SAS Institute Inc., 2002-2003). All statistical tests used an alpha of .05. Continuous CRS *T*-scores were log-transformed to better satisfy model assumptions (i.e., homoscedasticity) and were treated as repeated measures (2 CRS outcomes per child: one from the teacher and one from the parent) using generalized estimating equations (Zeger & Liang, 1986); outcome correlations were modeled as exchangeable. Log-transformed scores were back-transformed to the natural scale to yield geometric means across levels of predictors. We used log risk models to estimate associations between predictors and ADHD reported on the pediatric medical record, and parent-reported ADHD medication use. Adjusted estimates, 95% confidence intervals and *p* values, were generated for each predictor using multivariable regression models, adjusting for all other predictors. We based our conclusions about whether or not a variable was an important predictor of our outcome on the magnitude of the effect and the precision of the confidence interval. Participants with missing data on any of the predictors were excluded from the adjusted analyses.

The study protocol was reviewed and approved by the Human Subjects Committees of Harvard School of Public Health and Brigham and Women's Hospital, Boston, Massachusetts, and of Southcoast Hospitals Group, New Bedford, Massachusetts. Written informed consent was obtained from all participating families before study evaluation.

Results

Baseline characteristics for the 604 children and their parents (Table 1) show this to be a diverse population sociodemographically, with almost a quarter of fathers without a high school degree, 21% of households earning less than US\$20,000 per year, 42% of mothers unmarried at the child's 8-year exam, and 31% of children of non-White race (including Cape Verdeans). A sizable number of children had potentially adverse prenatal exposures, including tobacco smoke (30%) and alcohol (11%); 14% of mothers used illicit drugs in the year prior to their child's birth.

T-score statistics for the CRS teacher and parent assessments are provided in Table 1 and were moderately correlated with Pearson correlation coefficients ranging between .42 and .48 for the four CRS outcomes. The proportions of children with an ADHD diagnosis reported in the pediatric medical record and with parent-reported ADHD medication use were 12.5% and 7.6%, respectively. Comparing rating scale scores with clinical outcomes, CRS *T*-scores were significantly higher (indicating more abnormal behavior) among children with an ADHD diagnosis reported in the pediatric medical record or parent report of ADHD medication use compared with children without these outcomes. For example, the mean teacher's CRS *DSM-IV* Total *T*-score was 60 and 58, respectively, among children with an ADHD diagnosis reported in the pediatric medical record and parent report of ADHD medication use, compared with 52 among children with neither of these outcomes.

Of the 604 children included in the analysis, 463 had data on all of the predictors of interest. Children with missing data tended to be from families with less sociodemographic advantage compared with the total sample (mothers were younger, less educated, more likely to be unmarried, were less likely to breast feed and had lower IQ; household income and HOME scores were lower). Unadjusted associations between predictors and ADHD-related behavior and diagnosis for the subset of participants with nonmissing data were not meaningfully different than those found for the complete cohort (results not shown).

Unadjusted and adjusted associations between predictors and all four CRS outcomes were very similar; thus, Table 2 presents geometric mean scores for only the *DSM-IV* Total outcome. Predictors associated with higher unadjusted scores (more ADHD-like behavior) included young maternal age at the time of the child's birth, maternal prenatal smoking and illicit drug use, non-White race (child), never breastfed or discontinued before the infant was 1 month old, and, at the time of the child's 8-year exam, low maternal and paternal education, low household income, having an unmarried mother, lower maternal IQ, more maternal depression symptoms, lower HOME score, older age of the child, attending public school, and having no siblings living in the house at the time of the 8-year exam.

In analyses adjusting for all Table 2 predictors in the model ($n = 455$ and 463 children with data on all covariates had CRS teacher and parent scores, respectively), all associations were attenuated. Predictors that remained associated in adjusted models were paternal education (CRS *T*-score 3.4 points higher for children with fathers who did not complete high school compared with those who did), prenatal smoking (1.5 and 2.3 points higher for children whose mothers smoked 1-10 and >10 cigarettes per day, respectively, compared with nonsmoking mothers; p for trend = .02), maternal illicit drug use prior to birth (2.9 points higher), maternal depression symptoms (3.7 and 4.7 points higher for children of mothers with mild to moderate and severe depression symptoms, respectively, compared with minimal symptoms; p for trend < .0001), and HOME score (1.0 and 2.7 points higher for children with medium and low HOME scores, respectively compared with high HOME score; p for trend = .006). Suggestive associations were also found for maternal age (1.5 points lower for mothers 35+ years of age; $p = .08$) and child's sex (1.1 points higher for

males vs. females; $p = .06$). Results for separate analyses using the CRS teachers' and parents' ratings were similar to those of the repeated measures analysis.

ADHD diagnosis reported in the pediatric medical record showed similar unadjusted results to the CRS with notable associations for nearly all risk factors (Table 3). In adjusted analyses ($n = 461$ children had data on all covariates), only household income and child's sex remained associated with ADHD diagnosis reported in the pediatric medical record, though suggestive associations were also found for low maternal education, prenatal smoking, and maternal depression symptoms, and protective associations for older maternal age at birth. Similar results were found for parent-reported ADHD medication use, with suggestive adjusted positive associations remaining between medication use and low household income, male sex, low maternal education, prenatal smoking, maternal depression symptoms, and no siblings living in the house, and protective associations for older maternal age at birth and higher maternal IQ.

Discussion

We investigated risk factors for ADHD and associated behaviors among a population-based sample of school-aged children. Although the study population was socioeconomically diverse, most study children were full-term, generally healthy neonates. In this context of relatively low perinatal risk, we report moderate unadjusted associations between ADHD behaviors and socioeconomic indicators, such as maternal age at the child's birth, income, parental education, marital status, HOME score, and other predictors such as prenatal smoking, maternal illicit drug use prior to birth, and maternal depression symptoms. However, many of these associations were no longer present in adjusted models, and the predictors that did remain varied somewhat between the CRS and ADHD diagnosis reported in the pediatric medical record. Lower paternal education, prenatal smoking, maternal illicit drug use prior to birth, maternal depression symptoms, and lower HOME score were predictors of ADHD-like behavior for the CRS, with suggestive associations for being male and protective associations for older maternal age at birth. For ADHD diagnosis reported in the pediatric medical record, low household income and being male remained risk factors, with suggestive associations also found for prenatal maternal smoking, maternal depression symptoms, low maternal education, and potentially protective effects of older maternal age at birth.

ADHD has been shown to be more common in males versus females in clinical and epidemiologic studies (Cantwell, 1996), a difference attributable, in part, to under-diagnosis in girls (Biederman, 2005). Risk for ADHD diagnosis reported in the pediatric medical record and parent-reported ADHD medication use was at least 2 times higher for males versus females in this cohort. Surprisingly, adjusted CRS scores were also higher for males versus females, despite the use of T -scores that were sex and age standardized, suggesting that perhaps sex effects found in this cohort were stronger than the population to which these scores were standardized.

Our finding that indicators of socioeconomic status (i.e., education and income) are associated with ADHD-like behaviors and diagnosis, even after adjustment for other risk factors, is supported by previous studies that report associations of ADHD with low income, education, social class, and poverty to income ratio (Froehlich et al., 2007; Langley, Holmans, van den Bree, & Thapar, 2007; Scahill et al., 1999; St. Sauver et al., 2004). It is unclear why, in adjusted models, paternal education remained associated with the behavioral rating scale measures, whereas household income and maternal education were associated with ADHD diagnosis reported in the pediatric medical record, though these correlates of socioeconomic status are certainly related (e.g., the proportion of fathers with at least a high

school diploma with children living in households with income <US\$20,000 and US \$40,000+ was 59% and 86%, respectively) and are likely markers for other factors that are related to ADHD, such as psychosocial adversity in the home, prenatal cigarette smoke or illicit drug exposure (Banerjee, Middleton, & Faraone, 2007; Rowland, Lesesne, & Abramowitz, 2002), and maternal mental health (Lesesne, Visser, & White, 2003).

Prenatal toxicants such as tobacco, alcohol, and illicit drugs have been linked with ADHD in previous studies (Banerjee et al., 2007; DiFranza, Aligne, & Weitzman, 2004; Elgen, Bruaroy, & Laegreid, 2007; Eskenazi & Castorina, 1999; Williams & Ross, 2007). Whether prenatal smoking is the causal agent or a marker for other factors remains a subject of controversy (Gilman, Gardener, & Buka, 2008). For example, a population-based study of prenatal smoking found that associations with externalizing behaviors (attention problems and aggressive behavior) were attenuated after controlling for socioeconomic status and parental psychopathology (Roza et al., 2009). The association between prenatal smoking and ADHD-related behavior and diagnosis was also attenuated in the current study after controlling for numerous other factors, though all outcome measures retained at least suggestive associations with prenatal smoking. Maternal illicit drug use prior to birth was associated with the CRS though not associated with ADHD diagnosis reported in the pediatric medical record. Maternal alcohol consumption during pregnancy was not a predictor of the CRS; however, for ADHD diagnosis reported in the pediatric medical record, only the middle category (1-2 servings per month) was associated with elevated risk. Given the stigma associated with drinking during pregnancy, self-report of prenatal alcohol consumption likely involves some reporting bias (e.g., heavier drinkers may have underreported their intake), which could explain this nonlinear pattern.

Inverse associations between maternal age and ADHD-related behavior and diagnosis, though attenuated, persisted after controlling for variables thought to explain this association, such as socioeconomic indicators (education and income), psychosocial adversity (marital status), and prenatal exposure indicators (prenatal exposure to tobacco, alcohol, and illicit drugs). Absent a biologic explanation for this association, residual confounding due to factors that were poorly measured or unmeasured could account for this association.

Inconsistencies found between the CRS and ADHD diagnosis reported in the pediatric medical record in this study may be explained by the different nature of these outcomes. Rating scales, though useful for diagnosing ADHD in conjunction with other guidelines and for characterizing the functional consequences of its symptoms (inattention, hyperactivity, impulsivity; American Academy of Pediatrics, 2000), do not represent an ADHD diagnosis but rather ADHD-like behavior on a continuous scale. Although there is an algorithm for determining a *DSM-IV* diagnosis for inattentive and hyperactive-impulsive ADHD subtypes using CRS symptoms subscales, the number of participants who met this criterion was too small to obtain reliable estimates, particularly in adjusted models: $n = 25$ (5.5%) inattentive and $n = 6$ (1.3%) hyperactive-impulsive for teachers and $n = 6$ (1.3%) inattentive and $n = 6$ (1.3%) hyperactive-impulsive for parents. We therefore presented results for the continuous CRS outcomes, which has the advantage of increasing study power and minimizing the potential bias of outcome misclassification that may arise from using a dichotomous cut point (Bellinger, 2004). The CRS may also be useful for detecting early-stage or mild symptoms of ADHD, which a clinical diagnosis could miss, and is less influenced by parents' access to or propensity to seek care. This may explain why our results show more detectable associations with the CRS compared with ADHD diagnosis reported in the pediatric medical record.

Almost a quarter of children had missing data on at least one risk factor of interest. Prenatal alcohol consumption and illicit drug use had the most missing data (89 and 91 observations, respectively). Although children with missing data were different than those without missing data (younger, less educated mothers, lower income households), the unadjusted predictor-outcome associations for those with nonmissing data were comparable with the complete cohort, indicating that, aside from reduced precision, excluding participants with missing data may not have impacted our results.

Several risk factors, including maternal depression symptoms and the HOME score, were evaluated at the time of the child's 8-year exam and are thus cross-sectional with respect to ADHD-related behavior and diagnosis. The temporality of some of these associations is therefore less clear than risk factors assessed at the 2-week exam.

We estimated risk for ADHD-related behavior across a large number of risk factors; however, there were several factors that were not addressed in this study due to low prevalence of the risk factor in the study or because we did not collect data on that risk factor. Perinatal risk factors, including medical conditions and complications, such as diabetes or hypertension were rare (<2%) in this cohort, and we were therefore underpowered to look at these risk factors in our multivariable analysis. A previous study identified family dysfunction as a risk factor for ADHD (Scahill, 1999); however, we did not assess family dysfunction directly in our study. Finally, we have not conducted genetic testing for this cohort and were therefore unable to evaluate genetic risk factors for ADHD-related behaviors.

There are several strengths of this study. First, we investigated multiple measures of ADHD-related behavior and diagnosis, which allowed us to explore the consistency of risk factors across these different assessment methods. Second, the New Bedford Cohort Study is a well-characterized longitudinal birth cohort with rich covariate data, allowing us to examine a number of predictors for ADHD and to adjust for them to arrive at less confounded estimates of the independent effect of each risk factor. Third, because this was a prospective cohort study, we were able to assess the effect of prenatal exposures, such as cigarette smoking, alcohol consumption, and illicit drug use without the limitation of retrospective recall.

Conclusion

Understanding modifiable correlates that predict ADHD is a priority for reducing its incidence. We found that indicators of socioeconomic status (parental education and household income), family function (HOME score and maternal depression symptoms), adverse prenatal exposures (illicit drugs and smoking), being male, and maternal age were associated with rating scales and/or ADHD diagnosis reported in the pediatric medical record.

This is the first study of its kind to investigate risk factors for ADHD using a large, nonclinical population with prospectively collected data on prenatal exposures. Results from this population-based study sample are less vulnerable to selection bias than are clinic-based studies that are affected by access to care. In addition, prospective assessment of risk factors, such as prenatal maternal smoking, makes these findings more robust to inaccurate recall, a notable source of bias in cross-sectional and retrospective study designs. In summary, we identify a number of independent risk factors for ADHD-related behavior, essential for targeting screening and intervention efforts.

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Biographies

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David C. Bellinger is a Professor of Neurology at Children's Hospital Boston and Professor of Environmental Health at Harvard School of Public Health. His research focuses on two types of early insults to the developing nervous system—those of chemical exposures, (e.g., lead, methylmercury, and persistent organic pollutants)—and those related to serious medical conditions (e.g., congenital heart lesions).

Susan A. Korrick is an Assistant Professor of Medicine at Harvard Medical School and an Assistant Professor of Environmental Health at Harvard School of Public Health. Her research activities are focused in three areas: 1) the developmental and reproductive toxicities of polychlorinated biphenyls (PCBs) and chlorinated pesticides; 2) chronic lead toxicities in middle-aged and elderly adults; and 3) the relationship of perimenopausal alterations in bone metabolism with changes in kinetics, distribution, and toxicities of lead.

Table 1
Distribution of Predictors and Behavioral Outcomes for 8-Year-Old Children (*n* = 604)
Born in New Bedford, 1993-1998

	No.	%	<i>M</i> (<i>SD</i>)	Range
Parental characteristics				
Maternal age at child's birth (years)			26.7 (5.4)	18.0-41.3
<20	79	13.1		
20-29	317	52.5		
30-34	131	21.7		
35+	77	12.8		
Maternal education at child's school age (6 missing)				
<12th grade	65	10.9		
HS graduate	193	32.3		
Some college	340	56.9		
Paternal education at child's school age (29 missing)				
<12th grade	140	24.4		
HS graduate	247	43.0		
Some college	188	32.7		
Annual household income at child's school age (8 missing)				
<US\$20,000	124	20.8		
US\$20,000-US\$39,999	165	27.7		
US\$40,000	307	51.5		
Maternal marital status at child's school age				
Married	353	58.4		
Never married/separated/divorced	251	41.6		
Maternal smoking during pregnancy (44 missing)				
Nonsmoker	394	70.4		
1-10 cigarettes/day	122	21.8		
>10 cigarettes/day	44	7.9		
Maternal alcohol consumption during pregnancy (89 missing)				
<1 servings/month	461	89.5		
1-2 servings/month	14	2.7		
>2 servings/month	40	7.8		
Maternal illicit drug use in year prior to birth (91 missing)				
No	439	85.6		
Yes	74	14.4		
Maternal IQ ^a (4 missing)			97.9 (10.4)	57.0-126.0
Below average (<90)	111	18.5		
Average (90-109)	428	71.3		
Above average (110+)	61	10.2		
Maternal depression symptoms ^a (3 missing)			8.3 (8.8)	0.0-49.0
Minimal (<14)	485	80.7		

	No.	%	<i>M</i> (<i>SD</i>)	Range
Mild to moderate (14-28)	90	15.0		
Severe (>28)	26	4.3		
HOME score (14 missing)			45.6 (5.4)	28.0-57.0
Lowest tertile (<44)	194	32.9		
Middle tertile (44-48)	212	35.9		
Highest tertile (>49)	184	31.2		
Child's characteristics				
Age at exam (years)	604		8.2 (0.6)	6.8-11.0
Gestational age (weeks; 2 missing)	602		39.7 (1.3)	33.0-42.5
Sex				
Male	308	51.0		
Female	296	49.0		
Race/ethnicity (11 missing)				
White	411	69.3		
Black	37	6.2		
Hispanic	58	9.8		
Cape Verdean	63	10.6		
Other	24	4.1		
Breast feeding (2 missing)				
<1 month or never	381	63.3		
1-<6 months	124	20.6		
6+ months	97	16.1		
Type of school				
Public	548	90.7		
Private or parochial	56	9.3		
Number of siblings living in house				
None	91	15.1		
One	282	46.7		
Two or more	231	38.3		
Behavioral outcomes				
Conners' Rating Scale-teachers (14 missing)	590			
Conners' ADHD Index			53.2 (11.0)	41.0-90.0
DSM-IV Inattentive			53.5 (10.7)	40.0-90.0
DSM-IV Impulsive/Hyperactive			51.7 (10.1)	42.0-90.0
DSM-IV Total			53.0 (10.1)	41.0-90.0
Conners' Rating Scale-parents (1 missing)	603			
Conners' ADHD index			53.0 (10.2)	40.0-87.0
DSM-IV inattentive			52.4 (10.3)	40.0-90.0
DSM-IV Impulsive/Hyperactive			55.1 (10.3)	41.0-90.0
DSM-IV Total			53.8 (10.2)	40.0-90.0
ADHD diagnosis reported in pediatric medical record (3 missing)				
Yes	75	12.5		

	No.	%	<i>M (SD)</i>	Range
No	526	87.5		
Parent report of ADHD medication use (1 missing)				
Yes	46	7.6		
No	557	92.4		

Note: HS = high school; HOME = Home Observation for Measurement of the Environment; *DSM-IV*= *Diagnostic and Statistical Manual of Mental Disorder* (4th ed.).

^aMaternal IQ was measured with the Kaufman Brief Intelligence Test, and maternal depression symptoms were measured with the Beck Depression Inventory.

Table 2
Unadjusted and Adjusted Conners' Rating Scale (Teachers and Parents Combined) Geometric Mean Scores, Percentage Change, and Difference in T-score Across Predictors for 8-Year-Old Children Born in New Bedford, 1993-1998

		Conners' Rating Scale-DSM-IV Total					
		Unadjusted			Adjusted ^a		
		GM score [95% CI]	% Change in GM ^b [95% CI]	p value	GM score [95% CI]	% Change in GM ^b [95% CI]	Difference in T-score
Parental characteristics							
Maternal age at child's birth (years)							
<20	57.6 [55.5, 59.8]	8.5 [4.2, 13.0]	<.01	50.8 [47.7, 54.1]	2.9 [-1.8, 7.8]	.23	1.4
20-29	53.1 [52.2, 54.0]	Reference		49.4 [47.0, 51.9]	Reference		
30-34	50.0 [49.0, 51.0]	-5.9 [-8.3, -3.4]	<.01	48.7 [46.3, 51.1]	-1.4 [-4.2, 1.3]	.30	-0.7
35+	49.8 [48.4, 51.2]	-6.3 [-9.4, -3.1]	<.01	47.8 [45.2, 50.6]	-3.1 [-6.5, 0.3]	.07	-1.6
Maternal education at child's school age							
<12th grade	55.6 [53.5, 57.8]	5.1 [0.6, 9.8]	.03	48.3 [45.2, 51.7]	-2.1 [-7.2, 3.4]	.44	-1.0
HS graduate	52.9 [51.8, 54.1]	Reference		49.4 [47.0, 51.9]	Reference		
Some college	51.7 [50.9, 52.5]	-2.3 [-4.9, 0.3]	.08	49.7 [47.4, 52.2]	0.7 [-2.2, 3.7]	.62	0.4
Paternal education at child's school age							
<12th grade	56.2 [54.7, 57.7]	8.1 [4.7, 11.6]	<.01	52.7 [49.9, 55.7]	6.8 [3.2, 10.5]	<.01	3.3
HS graduate	51.9 [51.0, 52.9]	Reference		49.4 [47.0, 51.9]	Reference		
Some college	50.0 [49.1, 50.9]	-3.7 [-6.2, -1.2]	<.01	49.3 [46.9, 51.8]	-0.2 [-2.9, 2.6]	.90	-0.1
Annual household income at child's school age							
< US\$20,000	55.7 [54.2, 57.3]	10.5 [7.1, 14.1]	<.01	48.2 [45.0, 51.6]	-2.4 [-7.0, 2.3]	.31	-1.2
US\$20,000-US\$39,999	54.4 [53.0, 55.7]	7.8 [4.8, 11.0]	<.01	49.7 [46.9, 52.6]	0.6 [-2.8, 4.2]	.72	0.3
US\$40,000	50.4 [49.7, 51.1]	Reference		49.4 [47.0, 51.9]	Reference		
Maternal marital status at child's school age							
Married	50.9 [50.2, 51.7]	Reference		49.4 [47.0, 51.9]	Reference		
Never married/separated/divorced	54.9 [53.9, 56.0]	7.9 [5.3, 10.5]	<.01	49.8 [47.1, 52.7]	0.9 [-2.4, 4.3]	.59	0.5
Maternal smoking during pregnancy							
Nonsmoker	50.9 [50.2, 51.6]	Reference		49.4 [47.0, 51.9]	Reference		
1-10 cigarettes/day	54.9 [53.4, 56.5]	7.9 [4.6, 11.4]	<.01	50.9 [48.2, 53.6]	3.0 [-0.2, 6.4]	.06	1.5

Conners' Rating Scale-DSM-IV Total							
	Unadjusted				Adjusted ^a		
	GM score [95% CI]	% Change in GM ^b [95% CI]	p value	GM score [95% CI]	% Change in GM ^b [95% CI]	p value	Difference in T-score
>10 cigarettes/day	57.4 [54.8, 60.2]	12.8 [7.5, 18.5]	<.01	51.7 [48.4, 55.3]	4.8 [-0.2, 10.0]	.06	2.4
Maternal alcohol consumption during pregnancy							
<1 servings/month	52.3 [51.6, 53.0]	Reference		49.4 [47.0, 51.9]	Reference		
1-2 servings/month	52.4 [47.9, 57.2]	0.2 [-8.4, 9.5]	.97	49.3 [44.7, 54.3]	-0.1 [-8.5, 8.9]	.97	-0.1
>2 servings/month	52.6 [50.2, 55.2]	0.6 [-4.2, 5.8]	.80	50.1 [47.1, 53.4]	1.6 [-2.4, 5.7]	.45	0.8
Maternal illicit drug use in year prior to birth							
No	51.6 [50.9, 52.2]	Reference		49.4 [47.0, 51.9]	Reference		
Yes	57.1 [55.0, 59.3]	10.7 [6.4, 15.2]	<.01	52.2 [48.8, 55.9]	5.8 [1.3, 10.5]	.01	2.8
Maternal IQ ^c							
Below average (<90)	55.7 [54.2, 57.3]	7.0 [3.7, 10.5]	<.01	50.7 [47.5, 54.0]	2.6 [-1.6, 7.0]	.23	1.3
Average (90-109)	52.1 [51.3, 52.8]	Reference		49.4 [47.0, 51.9]	Reference		
Above average (110+)	50.3 [48.5, 52.2]	-3.4 [-7.1, 0.4]	<.01	49.7 [46.9, 52.6]	0.6 [-2.7, 4.0]	.73	0.3
Maternal depression symptoms ^c							
Minimal (<14)	51.5 [50.8, 52.1]	Reference		49.4 [47.0, 51.9]	Reference		
Mild to moderate (14-28)	56.7 [55.0, 58.5]	10.2 [6.7, 13.9]	<.01	53.1 [49.8, 56.5]	7.5 [3.5, 11.6]	<.01	3.7
Severe (>28)	59.1 [55.4, 63.1]	14.8 [7.4, 22.8]	<.01	54.0 [50.0, 58.3]	9.3 [2.5, 16.6]	<.01	4.6
HOME score							
Lowest tertile (<44)	55.8 [54.6, 57.1]	13.2 [10.1, 16.5]	<.01	52.0 [49.3, 54.9]	5.3 [1.5, 9.3]	<.01	2.6
Middle tertile (44-48)	52.6 [51.5, 53.6]	6.7 [3.9, 9.5]	<.01	50.4 [48.0, 52.9]	2.0 [-0.9, 4.9]	.17	1.0
Highest tertile (>49)	49.3 [48.5, 50.1]	Reference		49.4 [47.0, 51.9]	Reference		
Child's characteristics							
Age at exam (years)	54.0 [52.6, 55.4]	2.7 [0.5, 4.9]	.02	49.1 [46.3, 52.0]	-0.6 [-2.9, 1.7]	.59	-0.01
Gestational age (weeks)	52.9 [52.1, 53.7]	0.6 [-0.2, 1.5]	.16	49.6 [47.2, 52.2]	0.5 [-0.4, 1.3]	.27	0.00
Sex							
Male	53.1 [52.2, 54.1]	2.0 [-0.4, 4.6]	.10	49.4 [47.0, 51.9]	2.2 [-0.1, 4.6]	.06	1.1
Female	52.0 [51.2, 52.9]	Reference		48.3 [45.8, 50.9]	Reference		
Race/ethnicity							

Conners' Rating Scale-DSM-IV Total							
	Unadjusted			Adjusted ^a			
	GM score [95% CI]	% Change in GM ^b [95% CI]	p value	GM score [95% CI]	% Change in GM ^b [95% CI]	p value	Difference in T-score
White	51.7 [51.0, 52.4]	Reference		49.4 [47.0, 51.9]	Reference		
Black	54.1 [51.6, 56.6]	4.6 [-0.3, 9.7]	.07	49.5 [46.1, 53.1]	0.3 [-4.8, 5.6]	.93	0.1
Hispanic	54.9 [52.8, 57.2]	6.3 [1.9, 10.9]	<.01	49.5 [46.0, 53.3]	0.3 [-4.9, 5.8]	.91	0.1
Cape Verdean	53.2 [51.3, 55.1]	2.9 [-1.0, 7.0]	.15	49.4 [46.3, 52.7]	0.1 [-3.7, 4.1]	.95	0.1
Other	55.6 [51.8, 59.7]	7.6 [0.0, 15.7]	.05	51.7 [47.2, 56.6]	4.7 [-2.8, 12.6]	.23	2.3
Breast feeding							
<1 month or never	53.4 [52.6, 54.2]	Reference		49.4 [47.0, 51.9]	Reference		
1-<6 months	51.5 [50.1, 52.8]	-3.6 [-6.5, -0.7]	.02	48.8 [46.3, 51.4]	-1.1 [-3.9, 1.7]	.43	-0.6
6+ months	50.3 [49.0, 51.5]	-5.9 [-8.6, -3.1]	<.01	49.0 [46.3, 51.9]	-0.7 [-3.8, 2.5]	.66	-0.3
Type of school							
Public	52.8 [52.2, 53.5]	Reference		49.4 [47.0, 51.9]	Reference		
Private or parochial	49.8 [48.2, 51.6]	-5.7-9.1, -2.2]	<.01	49.5 [46.5, 52.7]	0.3 [-3.6, 4.4]	.88	0.2
Number of siblings living in house							
None	54.4 [52.8, 56.2]	Reference		49.4 [47.0, 51.9]	Reference		
One	51.9 [51.0, 52.8]	-4.7 [-8.0, -1.2]	<.01	48.9 [47.0, 50.9]	-0.9 [-4.6, 3.0]	.65	-0.4
Two or more	52.7 [51.6, 53.7]	-3.3 [-6.8, 0.3]	.07	48.6 [46.5, 50.7]	-1.6 [-5.4, 2.2]	.40	-0.8

Note: *DSM-IV* = *Diagnostic and Statistical Manual of Mental Disorder* (4th ed.); GM = geometric mean; HOME = Home Observation for Measurement of the Environment; CI = confidence interval; HS = high school.

^a Adjusted for all other predictors in the table.

^b % change in geometric mean was computed by exponentiating the regression coefficient in a log-transformed CRS model.

^c Maternal IQ was measured with the Kaufman Brief Intelligence Test, and depression symptoms were measured with the Beck Depression Inventory.

Table 3
Unadjusted and Adjusted Risk Ratios and 95% Confidence Intervals for ADHD Diagnosis Reported in the Pediatric Medical Record and Parent Report of ADHD Medication Use Across Predictors for 8-Year-Old Children Born in New Bedford, 1993-1998

	Pediatric medical record				Parent-reported ADHD medication use			
	Unadjusted (n = 601)		Adjusted ^a (n = 461)		Unadjusted (n = 603)		Adjusted ^a (n = 462)	
	RR [95% CI]	p value	RR [95% CI]	p value	RR [95% CI]	p value	RR [95% CI]	p value
Parental characteristics								
Maternal age at child's birth (years)								
<20	1.2 [0.7, 2.0]	.59	0.9 [0.4, 2.0]	.72	1.3 [0.6, 2.6]	.52	1.3 [0.5, 3.5]	.56
20-29	Reference		Reference		Reference		Reference	
30-34	0.5 [0.3, 1.0]	.04	0.7 [0.3, 1.6]	.40	0.6 [0.3, 1.3]	.19	0.5 [0.2, 1.7]	.28
35+	0.3 [0.1, 0.8]	.02	0.5 [0.2, 1.9]	.32	0.1 [0.0, 1.0]	.05	0.2 [0.0, 1.3]	.09
Maternal education at child's school age								
<12th grade	2.0 [1.1, 3.6]	.02	1.7 [0.6, 4.5]	.28	2.1 [1.0, 4.5]	.05	2.1 [0.6, 7.5]	.26
HS graduate	Reference		Reference		Reference		Reference	
Some college	0.9 [0.6, 1.6]	.83	1.2 [0.6, 2.4]	.66	0.9 [0.5, 1.7]	.72	1.1 [0.4, 2.8]	.82
Paternal education at child's school age								
<12th grade	1.5 [0.9, 2.4]	.10	1.1 [0.6, 1.9]	.74	0.9 [0.5, 1.8]	.82	0.5 [0.2, 1.2]	.14
HS graduate	Reference		Reference		Reference		Reference	
Some college	0.5 [0.3, 1.0]	.04	0.5 [0.2, 1.4]	.21	0.5 [0.2, 1.0]	.05	0.8 [0.3, 2.1]	.58
Annual household income at child's school age								
<US\$20,000	4.3 [2.4, 7.5]	<.01	3.3 [1.3, 8.2]	.01	3.5 [1.7, 6.8]	<.01	3.4 [0.9, 12.7]	.06
US\$20,000-US\$39,999	3.1 [1.8, 5.5]	<.01	2.1 [0.9, 4.8]	.09	2.1 [1.0, 4.4]	.04	1.5 [0.5, 4.2]	.49
US\$40,000	Reference		Reference		Reference		Reference	
Maternal marital status at child's school age								
Married	Reference		Reference		Reference		Reference	
Never married/separated/divorced	2.2 [1.5, 3.5]	<.01	1.0 [0.5, 1.9]	.98	1.8 [1.0, 3.2]	.03	0.6 [0.2, 1.4]	.23
Maternal smoking during pregnancy								
Nonsmoker	Reference		Reference		Reference		Reference	
1-10 cigarettes/day	1.4 [0.8, 2.4]	.28	0.9 [0.4, 1.8]	.68	0.9 [0.4, 2.1]	.88	0.6 [0.2, 1.6]	.35
>10 cigarettes/day	2.7 [1.5, 5.0]	<.01	1.6 [0.8, 3.2]	.20	2.6 [1.2, 5.7]	.02	2.0 [0.7, 5.5]	.18

	Pediatric medical record				Parent-reported ADHD medication use			
	Unadjusted (<i>n</i> = 601)		Adjusted ^a (<i>n</i> = 461)		Unadjusted (<i>n</i> = 603)		Adjusted ^a (<i>n</i> = 462)	
	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value
Maternal alcohol consumption during pregnancy								
<1 servings/month	Reference		Reference		Reference		Reference	
1-2 servings/month	2.9 [1.2, 7.0]	.02	2.5 [0.8, 7.2]	.10	2.1 [0.6, 8.0]	.27	3.4 [0.7, 17.5]	.14
>2 servings/month	0.8 [0.2, 2.3]	.64	0.8 [0.3, 2.1]	.71	0.4 [0.1, 2.6]	.32	0.6 [0.1, 3.9]	.56
Maternal illicit drug use in year prior to birth								
No	Reference		Reference		Reference		Reference	
Yes	2.2 [1.3, 3.9]	<.01	1.3 [0.6, 2.4]	.49	1.5 [0.7, 3.4]	.29	0.7 [0.3, 1.7]	.41
Maternal IQ ^b								
Below average (<90)	1.3 [0.8, 2.2]	.26	1.0 [0.5, 2.3]	.91	1.8 [1.0, 3.3]	.05	1.3 [0.5, 3.2]	.55
Average (90-109)	Reference		Reference		Reference		Reference	
Above average (110+)	0.5 [0.2, 1.4]	.21	0.9 [0.3, 3.1]	.90	0.2 [0.0, 1.7]	.15	0.2 [0.1, 1.0]	.05
Maternal depression symptoms ^b								
Minimal (<14)	Reference		Reference		Reference		Reference	
Mild to moderate (14-28)	2.2 [1.4, 3.5]	<.01	1.6 [0.9, 3.0]	.11	2.6 [1.4, 4.8]	<.01	1.8 [0.7, 4.6]	.23
Severe (>28)	2.3 [1.1, 4.8]	.03	2.0 [0.8, 4.9]	.15	4.1 [1.9, 9.1]	<.01	1.8 [0.6, 5.4]	.28
HOME score								
Lowest tertile (<44)	2.4 [1.3, 4.6]	<.01	1.0 [0.4, 2.5]	.95	2.5 [1.1, 5.5]	.02	1.2 [0.4, 3.9]	.71
Middle tertile (44-48)	2.2 [1.2, 4.2]	.01	1.3 [0.5, 3.8]	.58	1.7 [0.8, 4.0]	.19	1.3 [0.4, 4.3]	.61
Highest tertile (49+)	Reference		Reference		Reference		Reference	
Child's characteristics								
Age at exam (years)	1.1 [0.8, 1.4]	.46	0.7 [0.4, 1.2]	.20	1.2 [0.9, 1.7]	.31	0.8 [0.4, 1.7]	.64
Gestational age (weeks)	1.0 [0.8, 1.2]	.89	1.0 [0.8, 1.2]	.66	0.9 [0.8, 1.1]	.49	0.9 [0.7, 1.2]	.52
Sex								
Male	2.0 [1.3, 3.2]	<.01	2.5 [1.3, 4.6]	<.01	2.0 [1.1, 3.6]	.02	2.0 [0.9, 4.4]	.08
Female	Reference		Reference		Reference		Reference	
Race/ethnicity								
White	Reference		Reference		Reference		Reference	
Black	1.1 [0.4, 2.8]	.88	0.7 [0.3, 1.7]	.46	0.4 [0.1, 2.9]	.37	0.3 [0.1, 1.7]	.18

	Pediatric medical record				Parent-reported ADHD medication use			
	Unadjusted (<i>n</i> = 601)		Adjusted ^a (<i>n</i> = 461)		Unadjusted (<i>n</i> = 603)		Adjusted ^a (<i>n</i> = 462)	
	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value	RR [95% CI]	<i>p</i> value
Hispanic	2.3 [1.3, 4.0]	<.01	0.7 [0.3, 2.0]	.50	1.3 [0.5, 3.3]	.56	0.3 [0.1, 1.6]	.17
Cape Verdean	1.4 [0.7, 2.8]	.30	0.8 [0.3, 1.7]	.50	2.2 [1.1, 4.4]	.03	1.1 [0.4, 3.0]	.85
Other	2.1 [0.9, 4.8]	.08	0.6 [0.2, 1.9]	.42	1.3 [0.3, 5.0]	.74	1.0 [0.2, 5.8]	.99
Breast feeding								
<1 month or never	Reference		Reference		Reference		Reference	
1-<6 months	0.5 [0.3, 1.0]	.06	0.7 [0.3, 1.6]	.42	0.9 [0.4, 1.8]	.75	1.1 [0.5, 2.5]	.82
6+ months	0.5 [0.2, 1.0]	.06	0.9 [0.4, 2.2]	.82	0.6 [0.3, 1.6]	.33	1.5 [0.6, 4.0]	.31
Type of school								
Public	Reference		Reference		Reference		Reference	
Private or parochial	0.3 [0.1, 1.1]	.06	0.9 [0.2, 3.9]	.88	0.2 [0.0, 1.5]	.13	0.5 [0.1, 3.9]	.49
Number of siblings living in house								
None	Reference		Reference		Reference		Reference	
One	0.5 [0.3, 1.0]	.04	0.7 [0.4, 1.3]	.22	0.5 [0.2, 1.0]	.06	0.4 [0.2, 0.9]	.03
Two or more	0.9 [0.5, 1.6]	.71	0.7 [0.3, 1.4]	.28	0.8 [0.4, 1.7]	.61	0.3 [0.1, 1.0]	.04

Note: CI = confidence interval; HS = high school; HOME = Home Observation for Measurement of the Environment; RR = risk ratio.

^a Adjusted for all other predictors in the table.

^b Maternal IQ was measured with the Kaufman Brief Intelligence Test, and depression symptoms were measured with the Beck Depression Inventory.