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The Limited Effects of Obstetrical and Neonatal Complications on Conduct and ADHD Symptoms in Middle Childhood

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Abstract

Objective—The purpose of this study was to examine the effects of a wide range of obstetrical and neonatal complications as well as socioeconomic variables on the behaviors characterized by attention deficit hyperactivity disorder (ADHD), conduct disorder (CD) and oppositional defiant disorder (ODD).

Method—Data were collected on 7–8 year old twins, using multiple instruments assessing many areas of individual and family functioning. The influence of several aspects of prenatal care, labor and delivery, and early life were considered as well as indicators of socioeconomic status such as family income and maternal education.

Results—The observed associations were stronger for ADHD than CD symptoms and stronger for females than males. Family income and gender significantly predicted both behavioral outcomes, while birthweight predicted ADHD symptoms only. However, the presence of ADHD and conduct symptom behaviors were not associated with an occurrence of more obstetrical or neonatal complications as indicated by hierarchical linear modeling (HLM) analyses.

Conclusions—By school age, behavioral problems related to inattention, impulsivity, hyperactivity, defiance, and conduct are relatively unaffected by general adversity in the neonatal and perinatal periods.

Keywords

neonatal; pregnancy; birth complications; twins; ADHD

Do pregnancy and birth complications have longer term behavioral consequences? As survival rates for complicated pregnancies and births improve, the question of longer term consequences must be continually reinvestigated. Maternal health during pregnancy can

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** Although low birthweight is considered to be a primary risk factor and is considered so in this study, higher than average birthweight is not necessarily protective. When we analyzed only the sample with above mean birthweight there was a significant correlation for heavier girls and ADHD symptoms ($r=.17$, $p=.03$). The correlation for heavier girls and conduct symptoms were nonsignificant. The same was true for male correlations for both outcome variables.

affect not only the quality of a fetus' gestational development but also the vigor of the neonate.¹ Although the longer term consequences of obstetrical complications are generally not well understood, there is the potential for long-lasting effects on the child's maturation, and specifically on behavior. Problematic childhood behaviors such as hyperactivity, irritability, impulsivity, and inattention as well as oppositionality and defiance may be susceptible to early developmental insults. Focusing on Attention Deficit Hyperactivity Disorder (ADHD) as the outcome, Linnet et al.² reviewed 39 studies of the effects of prenatal exposure to various substances and psychosocial stress. Many findings were contradictory but the cumulative evidence implicated maternal smoking during pregnancy as a risk for ADHD. Results for other exposures were inconclusive. In conclusion methodological shortcomings identified in previous studies include insufficient control of confounders, low statistical power, recall bias and inaccurate exposure assessments as possible contributors to inconclusive results. Therefore, the current study addresses all four of these shortcomings.

Other than an expectation that detrimental effects diminish over time, little consensus exists about general principles relating pregnancy and birth complications to later behavioral outcomes. Most commonly, pregnancy and birth complications have been indexed by the easily quantified variables of prematurity and low birthweight, rather than by more detailed measures. Although both prematurity and low birthweight are associated with multiple risks during the early months of life,³ their links with behavioral outcomes later in childhood are more ambiguous. For example, Nigg and Breslau⁴ found evidence indicating a relationship between low birthweight (< 2500g) and ADHD based on teacher report at ages 6 and 11 years, as well as a robust effect of maternal smoking on ODD and CD. Furthermore, Iannone et al.⁵ found more negative neuropsychological outcomes as determined by assessments of learning and language difficulties in low birthweight (< 2500g) infants. In contrast, Goodman and Stevenson⁶ did not find perinatal adversity, qualified by birthweight and birth order, associated with hyperactivity, and Miller et al.⁷ found no relationship between low birthweight (500–999g) and future behavioral difficulties at ages 5 and 8 years. Other studies have shown that infants without low birthweight but with other prenatal complications such as toxemia of pregnancy had problematic behavioral outcomes, at least in some contexts.⁸ The varying findings of these studies justify further investigation of long term effects of obstetrical complications on behavior.

The current project investigates the relationship between risk factors arising during pregnancy, childbirth, and the neonatal period with behavioral problems during middle childhood. However, our study is distinctive in several ways. First, we study a large (N=750) statewide sample of twins which allows us to include a range of hospital birth practices in rural and urban areas throughout Wisconsin. While twin gestation is not representative of all pregnancies as twinning carries an increased medical risk and the nature of any associations found in this study should be informative for the larger population of singleton births.⁹ Furthermore, our study not only provides the power of a population-based sample but also assesses behavior during middle childhood, when diagnosable behavior problems are evident and interfering with social relationships in the home and school settings. Rather than concentrating on diagnosed psychopathology, which is relatively infrequent in early childhood, we quantify a broad range of symptoms that cause problems

for children with a multi-method approach.¹⁰ Recognizing that obstetrical risk factors are often associated with other non-health related variables, we also quantify the effects of socioeconomic status (SES) and gender. Finally, while many earlier studies focus on a few specific obstetrical risk factors, we employ three extensive scales assessing (1) maternal obstetrical complications, (2) fetal obstetrical complications, and (3) neonatal complications and morbidity as described below.

Prenatal, birth and neonatal complications can originate from two separate, however closely related sources-the maternal environment and the fetus itself. On the part of the mother, substance abuse, depression, and infection, as well as factors including maternal age, parity, and delivery type and duration may all affect subsequent fetal well-being.^{4,8,11} For example, corticosteroids, a standard treatment for preterm labor, have been shown to suppress the fetus' hypothalamus-pituitary-adrenal axis resulting in a reduction in the responsivity to environmental stressors thus affecting the infants' ability to regulate stress and adapt to change.¹²⁻¹⁴

The fetus brings its own risks to the pregnancy and can be directly challenged in unique ways by the obstetrical environment. Neonatal immaturity involving low birthweight and respiratory distress as a result of low gestational age, and neonatal asphyxia as caused by umbilical cord and placental complications are specific to the newborn but closely related to complications of the pregnancy and delivery. These complications, among others, can lead to life threatening complications including hypoxemia, intraventricular hemorrhage, and kericterus.¹⁵ While causes of risk factors such as low birthweight are associated with future development, low birthweight itself has also been linked to behavioral issues. Small infants (birthweight of 3.31 lbs or lower) are also considered to be more likely to have learning difficulties at school and a higher frequency of neurological and behavioral abnormalities.¹⁶

While all of these risk factors can occur in singleton and twin gestations, twins are subject to an increased presence of high risk complications.¹⁷ Several complications such as weight discordancy, certain placental abnormalities and resource competition can occur only in multiple gestation pregnancies. Studies have shown that one such complication, twin-to-twin transfusion syndrome (TTTS), a cause of both low birthweight and weight discordancy, can result in changes of neonatal temperament, and can leave the infants at risk for hyperactivity, high irritability, and temperament difficulties during their school age years.¹⁶

Family and Environmental Factors

Family level factors have been shown to influence aspects of both the prenatal and neonatal time period and later behavioral outcomes. For example, socioeconomic status (SES) can affect the quality of prenatal education and care and may affect complications during labor and delivery.¹⁸ Furthermore, Scahill et al.¹⁹ found that of several indicators of SES, low income was the best predictor of ADHD. Therefore, investigation of obstetrical and neonatal complications should be conducted in the context of these known family and environmental risk factors in order to establish their uniqueness. The present study considers total family income and maternal education level as indicators of SES.

An additional variable to consider is that of gender, which can be indicative of differences in rates of certain behaviors.²⁰ For example, males and females had significantly different rates of inattention and hyperactive and impulsive behaviors in that males had higher rates of CD, whereas females had higher rates of internalizing behaviors. Furthermore, in extremely low birth weight infants, differences were seen in ADHD scores between genders.²¹ This study will investigate the effects of gender on ADHD and CD symptoms.

The present study: hypotheses and research questions

With the goal of identifying prenatal and neonatal complications as risk factors for behavioral problems, this study collected data on specific behavioral attributes and symptoms of ADHD, CD, and ODD. Further, information on indicators of SES were also gathered. ADHD, CD and ODD have both genetic and environmental origin.²² Genetic factors for these disorders have been extensively investigated and are not treated in this paper.²³ Recent studies on ADHD have revealed evidence of a link between complications of pregnancy, birth and infancy, and the subsequent development of ADHD.⁴ Specific risk factors including maternal bleeding, smoking, and illicit drug use as well as preterm birth and low SES have been reported.²⁴

This study offers a multi-method assessment with a statewide sample of twins. This study should elucidate the relationships among fetal, maternal, and familial factors contributing to psychopathology, as well as the importance of different types of obstetrical risk factors. Specifically, we hypothesize that higher maternal and fetal obstetrical complications, higher neonatal complications and morbidity, lower gestational age, lower birthweight, lower maternal education, and lower family income will predict problem behaviors indicative of ADHD and CD in middle childhood. By studying a population of twins at higher risk for obstetrical complications, we should be able to find associations that might have been overlooked in studies involving singleton births. We expect to not only find relationships between birthweight, gestational age and ADHD and CD symptoms but we also hope to clarify the associations between the presence of obstetrical and neonatal complications and these adverse behaviors in childhood. Furthermore, because previous research investigating the links between SES, obstetrical complications and behavioral outcomes has been inconclusive, we aim to clarify these relationships.

METHODS

Overview

Participants were members of the birth-record based Wisconsin Twin Panel,²⁵ and 83.7% of the contacted eligible birth cohorts chose to join the panel. Twins in this panel were born between 1989 and 1998 (about 800 births per year). A screening interview for behavioral problems was administered via a phone call to parents of approximately 2500 twins, and selected families were asked to participate in a more extensive protocol that included questionnaires, interviews, and home-based assessments. An overview of the panel is provided by Goldsmith et al.²⁶ Prior to selection for the current study, the panel was screened for behavioral problems using the Health and Behavior Questionnaire (HBQ).²⁷ Children identified as at risk scored 1.5 standard deviations above the mean on any one of

the following internalizing and externalizing scales: depression, separation anxiety, overanxious disorder, oppositional defiant disorder (ODD), conduct disorder (CD), overt aggression, inattention, and impulsivity. Of the selected “at risk” children, 30.5% demonstrated internalizing behavior, 20.8% demonstrated externalizing behavior, 11.2% demonstrated ADHD symptoms and 37.5% were comorbid for at least two of these types of behavior problems; taking symptom overlap into account, a total of 37.1% of the children qualified in a very broad “risk” group. A control group consisted of unselected cotwins (34.1%) and children who scored below the mean on all subscales of behavior problems (28.8%). This panel supplies participants for multiple studies; below we describe the sample studied for the current analyses.

Participants

The sample for present study consisted of 750 twins (1) who participated in the behavioral assessments described above ($N = 796$), and (2) for whom medical records covering pregnancy and delivery could be obtained. Thus, the participation rate was 750/796 (94.2%); nonparticipation was due primarily to families refusing access to birth records and lack of response from hospitals. Children were 8.13 ($SD = .97$) years old at the time that symptoms were assessed with 50.8% female. Zygosity breakdown was 39.5% MZ, 34.3% same sex dizygotic (DZ) and 26.2% opposite sex DZ. Zygosity was identified through the Zygosity Questionnaire for Young Twins,²⁸ observation, medical records and DNA genotyping. The ethnic breakdown for twin mothers was 96.6% Non-Hispanic White, 1.1% Black, 1% Hispanic, and 1.3% American Indian, Asian or other. Mean age for fathers was 31.0 year and for mothers was 29.3 years. Average level of education for mothers was 14.4 years ($SD = 2.08$), and for fathers was 14.23 ($SD = 2.34$). Paternal education was not used as a predictor variable due to inconsistencies in documentation of this information and due to the greater power of maternal education as a predictor. Approximately 21% of families reported an annual of income of \$40,000 or below while 23.4% reported an income of \$70,000 or higher. Forty-four percent of families live in a rural setting, or communities with populations less than 10,000.

Assessment of Risk Factors

Obstetrical and Neonatal Assessments—Medical records concerning the mother’s prenatal care, labor and the twins’ birth were obtained from 113 different Wisconsin area hospitals. Both the mother’s obstetrical records and the twin’s birth and perinatal records were used to complete measures of obstetrical complications and neonatal risk factors. A coding manual specified how to translate raw data in records to the scales described below.* Two researchers independently completed codes for all scales to maximize the quality and accuracy of transcription. Discrepancies were rare and resolved by consensus.

Obstetrical Complications Scale: The Obstetrical Complications Scale (OCS)²⁹ includes an extensive range of items about prenatal and maternal history and the occurrence of mother specific and child specific complicating variables during pregnancy and birth. Mother variables such as maternal parity and gravidity, blood pressure and post-birth

* All obstetrical and neonatal coding and scoring forms are available from the authors.

hemoglobin level, pre-term labor, labor and delivery chronology and medications and placental information are all rated as being at risk (score of one) or of no risk (score of zero). Several variables such as fetal position at birth and type of feeding were weighted based on multiple levels of possible risk status. Furthermore, presence or absence at each trimester is noted for the following: drug use and prescribed medications, infections, chronic maternal disease, pre-eclampsia, and bleeding. The recording of trimester-specific data was an addition to the original scoring sheet made by the Wisconsin Twin Project. Specific values for several of these factors are also recorded. Child specific variables were recorded for each individual and include fetal heart rate, fetal presentation, type of delivery, state of amniotic fluid and umbilical cord insertion and condition. Variables that were present for longer periods during pregnancy or presented more risk to the child than their counterparts were weighted on a four point scale. For example, a breech presentation of the fetus at delivery was weighted more heavily than a compound or transverse presentation due to an increase in potential risk. In total, 43 maternal (mother obstetrical complications) and 12 fetal (twin obstetrical complications) variables were considered for each twin. The maximum possible score was 85.

Neonatal Complications Scale: This scale, also developed by Littman and Parmalee (NCS),²⁹ was designed to collect further information on the state of the infants within the first 24 hours of life. Variables such as gestational age, size and weight, admission to the neonatal intensive care unit, type and length of resuscitation and birth order are all indicated. Also, factors such as heart rate, respiratory rate, Apgar scores, temperature disturbance are determined to be either within or outside of normal ranges. Finally, information on days spent in the hospital, infection or noninfectious illnesses and circumcision are also collected. Several of these variables were also weighted based on increasing risk or the severity of the complication. For example, if the infant received only gavage feedings a lower score was given than if the infant received IV or both gavage and IV feedings because the latter is more indicative of more serious complications. A total of 20 variables were considered and the maximum possible score was 25.

Neonatal Morbidity Scale: The Neonatal Morbidity Scale (NMS)³⁰ taps common neonatal health complications. These include bradycardia, tachypnea, and whether the infant was prohibited from feeding. Presence, length and type of treatment administered was also recorded for apnea, respiratory distress syndrome and hyperbilirubinemia. Scores were weighted depending on type of treatment for these problems as treatment type is indicative of the severity of the complication. Thus, the maximum possible score was 15 for this seven item scale.

Behavioral Outcome Assessments—Behavioral outcomes were derived from three instruments. As part of a more extensive protocol, parents reported on children's behavior via telephone, mailed questionnaires, and during an in person diagnostic interview.

Children Behavior Questionnaire: The Children Behavior Questionnaire (CBQ)³¹ consists of 15 scales (180 items) that assess temperament and emotional reactivity in a series of everyday situations. Parents rate their child's behavior within the past six months on a 7-

point Likert scale with 1 being “extremely untrue” and 7 being “extremely true”. This instrument was administered to mothers and fathers as separate written questionnaires.

Health and Behavior Questionnaire: The HBQ²⁷ provided eight scales of behavior problem symptoms (84 items). Parents rate their twins’ behavior within the past six months on a 3-point Likert scale ranging from 0 = rarely applies to 2 = certainly applies or almost always. This instrument was administered to mothers and fathers during separate telephone interviews.

Diagnostic Interview Schedule for Children: This computer based assessment, Version IV (DISC-IV),³² was administered to the primary caregiver (97.6% mother) during the home-based assessment. This assessment comprised 19 scales. Data were collected from the Disruptive Behaviors module, which covered three disruptive behaviors: attention deficit and hyperactivity, oppositional defiance and conduct. The DISC-IV has strong interrater reliability ($r = .93$) and test-retest reliability ($r = .64$) of the past year diagnoses.^{33–35} Furthermore, the DISC showed moderate validity when compared to diagnoses generated from symptom ratings after a clinical-style interview ($K = .52$). The symptom scales were used instead of the diagnoses to obtain a continuous measure.

Socioeconomic Status—Indicators of SES were obtained by parental report. Variables including mother education level and family income at time of follow-up were obtained in a demographic form during the telephone interview. Annual income was reported in \$10,000 increments with the lowest level being \$20,000 or less, and the highest being over \$200,000.

Formation of Composite Scores

Scores from each of the obstetrical and neonatal scales were totaled to obtain four separate sums for each participant: mother obstetrical complications, twin obstetrical complications, neonatal complications and neonatal morbidity. Variables of gestational age and birth weight were removed from the NCS for use as individual predictor variables.

Two composite measures were created from variables from the HBQ, CBQ and DISC. The first composite score, “*Conduct Symptoms*,” was a measure of negative behavior such as aggression, disruptive outbursts, rule violations and hostility. Conduct Symptoms was calculated as a mean of eight scores, six of which were obtained from three scales completed by both mother and father; and two of which were completed by the primary caregiver. Scales included in this composite score were: the Conduct Disorders (mother $\alpha = .83$, father $\alpha = .80$) and the Oppositional Defiant Disorder (mother $\alpha = .87$, father $\alpha = .83$) scales from the HBQ, the Anger/Frustration scale (mother $\alpha = .83$, father $\alpha = .81$) from the CBQ and the Conduct Disorder and Oppositional Defiant Disorder Symptom scales from the DISC. The second composite score, “*ADHD Symptoms*,” was a measure of behaviors related to activity level, impulsivity, hyperactivity, restlessness, and problems sustaining attention. ADHD Symptoms was calculated as a mean of 13 scores, 12 of which were obtained from six scales completed by both mother and father; and one of which was completed by the primary caregiver. Scales included in this composite score were: the Impulsivity and Inattention scales from the HBQ, and the Attentional Focusing (reversed), the Activity Level, the

Impulsivity and the Inhibitory Control scales (reversed) from the CBQ and the ADHD Symptom scales from the DISC. Previous studies have successfully validated the use of these questionnaires for the investigation of ADHD and conduct problems.^{37–40} All scales were standardized using Z score transformation and weighted before computing the mean outcome scores.

Hierarchical Linear Modeling

Hierarchical linear modeling (HLM) was used to examine the predictive power of the obstetrical, neonatal and SES risk factors for the behavioral outcomes.⁴¹ Risk factor variables were divided into two levels to adjust for the dependency of twins being in the same family. Level 1, the “individual” level, included 750 twins and level 2 the “family” level, included 375 pairs. Level 1 consisted of individual data including twin obstetrical and neonatal complications, neonatal morbidity, gender, birthweight and the behavioral outcome variables, while level 2 consisted of pair data for which twins in the same family necessarily had the same value. Level 2 data included mother obstetrical complications, gestational age and SES. All data were analyzed using an HLM program.⁴²

RESULTS

Descriptive Statistics

The mean length of maternal education was 14.4 years (SD=2.08). The average gestational age and birthweight were 36.16 weeks (SD=2.50) and 5.53 lbs (SD=1.23) respectively. Approximately 21% of families reported an annual income of less than \$40,000 while 23.4% reported an income of greater than \$70,000. Median income was the \$30,000–\$40,000 income bracket. To help frame the risk status in later analyses, a frequency distribution of OCS mom and twin, NCS and NMS scores was analyzed. Approximately 3–14% of obstetrical and neonatal assessment scores fell in the high-end extreme.

Correlations among Risk Factors

Given gender differences in Table 1, correlations were computed separately by gender for all predictors, see Table 2. The patterns of correlations were similar for males and females with one exception. The absolute value of correlations of maternal obstetrical complications with other neonatal variables was descriptively greater for females (first column Table 2) than for males (first row Table 2). However, these differences were only significant for neonatal complications ($z = 2.3, p < .05$) and gestational age ($z = 2.6, p < .01$).

We tested for gender differences in mean levels of four obstetrical and neonatal predictors using a series of generalized linear models that controlled for the paired nature of the data. For the mother obstetrical complications, both members of the pair have the same score. This analysis was conducted with only same sex pairs to examine if male pregnancies were significantly different in risk from female pregnancies and the difference between males and females was not significant. For the other three obstetrical and neonatal predictors, each child could have a different score but the scores might not be independent within pairs; thus, pair membership was accounted for in the test of gender differences. For twin obstetrical complications and neonatal morbidity, differences between males and females were not

significant. For neonatal complications, males had significantly greater complications than females, $F(1, 372)=4.53$, $p=.03$.

Correlations Between Risk Factors and Behavior Outcomes

Table 3 shows the correlations between predictor variables and ADHD and Conduct Symptoms. There were three notable findings. Pregnancy and birth complication indices were not related to later symptoms in males but significant correlations emerged for females. Gestational age and birthweight predicted ADHD Symptoms only, for both genders and family income predicted both ADHD and Conduct Symptoms for both genders.

Hierarchical Linear Modeling

The preceding analyses did not take into account the paired nature of twin data nor did they consider the multivariate nature of the predictors. Thus, we used HLM for a more comprehensive statistical approach. Analyses of Conduct Symptoms revealed family income as a significant independent predictor at the pair level and revealed both birthweight and gender as significant individual level predictors, see Table 4. Analyses of ADHD Symptoms revealed gestational age and family income as significant independent predictors at the pair level and revealed both birthweight and gender as significant individual level predictors. Two-way interactions were computed for the correlations between behavioral outcomes and predictors that were significant for girls only as seen in Table 3. Additional analyses revealed no interaction between gender and mother obstetrical complications, neonatal complications or neonatal morbidity.

DISCUSSION

Our goal was to assess the effects of obstetrical and neonatal complications on behaviors associated with ADHD and conduct problems by middle childhood. Because previous research has indicated mixed behavioral outcomes of complications such as low birthweight,^{4,7} a comprehensive analysis of the issue was needed. Because SES is a risk factor for the development of behavioral and emotional problems and might also be associated with pregnancy or birth-related complications,⁴³ it was considered as well.

The major conclusion was that no strong or even moderate predictions for both boys and girls were significant from the obstetrical and neonatal complication indexes to the behavioral outcomes in the early school years. It is unlikely that our null results were due to insufficient power; for instance, even our sample sizes separated by gender had 99% power to detect a population correlation of .20 as significant at $p = .05$. However, the two most common measures of neonatal risk, lower birthweight and shorter gestational age, were predictive of later behavioral problems. Also, as expected, lower SES was generally indicative of higher levels of ADHD and conduct symptoms. Lower birthweight and shorter gestational age remained significant when SES was controlled in hierarchical linear regressions. Furthermore, boys were more likely than girls to show conduct and ADHD symptoms. Due to many differences between genders, this variable was also controlled for in the regression analyses.

As the gender-specific correlations in Table 3 illustrate, in 11 of 12 cases, the correlation of a pregnancy or birth-related predictor with later conduct or ADHD problems was stronger—often only slightly so—in females than males. In the case of maternal education, the correlations were equal. For example, mother-specific obstetric complications, which included all prenatal information, were associated specifically with girls' conduct scores. However, none of these gender differences survived a more rigorous statistical test of a “gender by pregnancy or birth-related predictor” interaction in an HLM analysis, when all of the main effects were simultaneously considered. Thus, we conclude that the pregnancy or birth-related predictors were not significantly different for boys and girls.

One limitation of the study is its generalizability due to differences between twin and singleton pregnancies. We argued earlier that the higher risks for twin pregnancies would be an advantage for the current analyses, but direct generalization to singleton pregnancies must still be cautious due to unique features of twin pregnancies. Higher rates of pre-eclampsia, low birthweight and preterm delivery occur in twin gestations as compared with singleton pregnancies.^{44,45} However, as Table 1 shows, the incidence of severe complications in our sample was not great and therefore generalizability to very high risk pregnancies and newborns suffering from many complications is also unwarranted. It is also important to note that the SES for the sample in this study is only modestly higher than for Wisconsin as a whole.²⁶ Clearly a degree of family stability was a requirement for full participation. Therefore, the results should not be generalized to populations with divergent demographic characteristics.

It should also be emphasized that we analyzed “typical” pregnancy and birth records, gathered retrospectively. While we view this as a great improvement over retrospective maternal report, a prospective study in which hospital personnel were trained to collect specific types of pregnancy and birth information very systematically could conceivably uncover relations with later behavior that our analyses missed.

A final limitation relates to the behavioral outcomes. Although our multi-source assessment of ADHD and CD symptoms is an improvement over the brief behavioral checklists sometimes used in follow-up research of this type, it does not go beyond caregiver report and thus does not include behaviors seen in the school setting. Therefore, including teacher ratings would be appropriate in future studies. Furthermore, our behavioral outcomes do not exhaust the domain of school-age behavior problems. The behavioral outcome domain we studied is the one most frequently implicated by prior studies and was thus a proper focus, in our opinion. On the other hand, rarer behavioral problems might be related to pregnancy and birth insults. Moreover, our behavioral outcome was at age 7–8 years. Earlier symptoms related to obstetrical complications might have resolved before this age. Less plausibly, behaviors related to the obstetrical complications might develop later in adolescence. If so, this study would not have captured the information needed to assess these associations.

Given our findings, it is apparent that future studies that attempt to demonstrate a link between obstetrical complications and children's behavioral symptoms several years later will need to take into account the confounding variable of socioeconomic class and

potentially moderating variable of gender. Moreover, such future studies should focus on even higher risk pregnancies or neonates with defined susceptibilities.

The primary implication of the results is optimistic: By school age, behavioral problems related to inattention, impulsivity, hyperactivity, defiance, and conduct are relatively unaffected by general adversity in the neonatal and perinatal periods. However, as previous research has suggested, preterm birth and low birthweight are modest predictors of future behavioral problems,^{4,5,16} even when an array of possibly confounding variables are controlled in a systematically ascertained sample.

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Table 1

Descriptive Statistics for Predictor and Behavior Outcome Measures

<i>Predictor Measures</i>	Males (N=368)		Females (N=380)	
	M	SD	M	SD
Mother Obstetrical Complications	9.77	4.20	9.87	4.41
Twin Obstetrical Complications	1.79	1.35	1.66	1.33
Neonatal Complications	4.78	2.85	4.05	2.81
Neonatal Morbidity	1.52	2.53	1.46	2.36
<i>Behavior Outcomes</i>				
Conduct Symptoms	1.46	5.88	−1.33	5.63
ADHD Symptoms	3.77	11.56	−3.44	10.06

Table 2

Correlations Among Risk Factors Separated by Gender

	Mother Obstetrical Complications	Twin Obstetrical Complications	Neonatal Complications	Neonatal Morbidity	Gestational Age	Birthweight	Mother Education	Family Income
Mother Obstetrical Complications	-----	.04	.15**	.11*	-.16**	-.20**	-.07	.09
Twin Obstetrical Complications	-.06	-----	.11*	.05	.01	-.01	.05	-.03
Neonatal Complications	.31**	.10	-----	.75**	-.70**	-.65**	-.08	-.07
Neonatal Morbidity	.22**	.04	.70**	-----	-.71**	-.60**	-.07	-.09
Gestational Age	-.34**	.04	-.70**	-.73**	-----	.75**	-.07	.06
Birthweight	-.26**	-.06	-.69**	-.60**	.72**	-----	.10	.13*
Mother Education	.01	.02	-.03	.04	-.01	-.02	-----	.44**
Family Income	-.07	-.01	-.04	-.01	-.03	.11	.38**	-----

Note. Males' scores are reported above the diagonal.

* $p < .05$.

** $p < .01$.

Table 3

Correlational Associations Between Behavior Outcomes and Predictors by Gender

Predictors	Behavior Outcomes			
	Males N= 368		Females N= 380	
	Conduct Symptoms	ADHD Symptoms	Conduct Symptoms	ADHD Symptoms
Mother Obstetrical Complications	.02	-.01	.11 *	.10
Twin Obstetrical Complications	-.04	.01	.07	.03
Neonatal Complications	-.09	.06	.10	.15 **
Neonatal Morbidity	-.07	.04	.07	.13 *
Gestational Age	.00	-.12 *	-.08	-.13 *
Birthweight	.01	-.15 **	-.10	-.17 **
Mother Education	-.00	-.13 *	-.08	-.13 *
Family Income	-.18 **	-.17 **	-.21 **	-.24 **

Note.

*
 $p < .05$.**
 $p < .01$.

Table 4
 Hierarchical Linear Modeling Estimation of Fixed Effects of Predictor Variables on Behavior Outcome Scores

Predictors	Conduct Symptoms			ADHD Symptoms		
	Coefficient	S.E.	p	Coefficient	S.E.	p
Pair Level Predictors						
Mother Obstetrical Complications	0.008	0.012	0.54	-0.005	0.010	0.64
Gestational Age	0.001	0.023	0.95	-0.044	0.014	0.03
Mother Education	0.037	0.028	0.19	-0.040	0.020	0.05
Family Income	-0.082	0.023	<0.01	-0.037	0.016	0.02
Individual Level Predictors						
Twin Obstetrical Complications	-0.041	0.039	0.30	-0.030	0.045	0.51
Neonatal Complications	0.035	0.052	0.51	-0.060	0.072	0.41
Neonatal Morbidity	-0.026	0.040	0.52	-0.003	0.052	0.96
Birthweight	0.117	0.066	0.08	-0.266	0.093	0.01
Gender	0.130	0.044	<0.01	0.302	0.043	<0.01

Note. Results reported with robust standard errors.