Published in final edited form as:

Early Hum Dev. 2011 April ; 87(4): 247–252. doi:10.1016/j.earlhumdev.2011.01.023.

Behavior Problems of 9–16 Year Old Preterm Children: Biological, Sociodemographic, and Intellectual Contributions

Irene M. Loe, MD*, Eliana S. Lee, BS*, Beatriz Luna, PhD[#], and Heidi M. Feldman, MD PhD*

*Division of Neonatal and Developmental Medicine, Department of Pediatrics, Stanford University School of Medicine, Palo Alto, CA

[#]Department of Psychiatry and Psychology, Western Psychiatric Institute and Clinics, University of Pittsburgh, Pittsburgh, PA

Abstract

Background—Preterm children are at risk for behavior problems. Studies examining contributions of intellectual and environmental factors to behavior outcomes in preterm children are mixed.

Aims—(1) To identify the nature of maladaptive behaviors in preterm children age 9 to 16 years born across the spectrum of gestational age and birth weight (BW). (2) To examine contributions of BW as a biological factor, socioeconomic status as an environmental factor, and intelligence quotient (IQ) as indicative of intellectual ability to behavior outcomes.

Method—Using the Child Behavior Checklist, parent reports of behavior for 63 preterm children (gestational age 24 to < 36 weeks) were compared to 29 full term children of similar age, gender and socioeconomic status. Multiple regression models evaluated effects of prematurity, socioeconomic status, and intellectual ability on behavioral symptom scores.

Results—Preterm children had higher total and internalizing problem scores compared to full term children. They also had lower IQ. BW was a significant predictor of total and internalizing behavior problems. Among the syndrome scales, anxious/depressed and attention problems were elevated. Socioeconomic status did not contribute to behavior scores. IQ contributed to total, but not to internalizing or externalizing, scores. IQ contributed to attention problems, but not to anxious/depressed scores.

Conclusion—Preterm children had increased behavior problems, especially symptoms of inattention and anxiety. Lower BW predicted more behavior problems. IQ acted as a mediator between BW and attention scores, but not anxiety scores. These findings alert health care providers to assess anxiety in all preterm children regardless of intellectual ability and to assess attention in those with learning problems. Additional study on the influence of intellectual ability on behavioral outcomes in preterm children is needed.

Key terms

preterm birth; prematurity; behavior; anxiety; inattention; socioeconomic status; intellectual ability

Corresponding author: Irene M. Loe, MD, Stanford University, 750 Welch Road, Suite 315, Palo Alto, CA, 94304; Phone (650) 723-5711; Fax (650) 725-8351; iloe@stanford.edu.

Conflict of interest

The authors have no financial relationships or other conflict of interest relevant to this article to disclose.

1. Introduction

Behavior problems are sequelae of preterm birth and may be important contributors to poor academic achievement and educational outcomes. Behavior problems include internalizing symptoms (i.e., anxiety, depression), externalizing symptoms (i.e., oppositional behavior and conduct problems), and hyperactivity, impulsivity, and inattention (1, 2). Behavior problems have been documented in preterm children as early as the toddler years (3), through school age (4), and into adolescence and young adulthood (5–8). Preterm children also have a higher risk for Attention-Deficit/Hyperactivity (ADHD) and anxiety disorder (5, 9, 10).

Many studies that focus on differences in behavior between preterm and full term children have examined contributions of biomedical risk factors on outcomes, defining biomedical risk as the number or type of medical complications in the neonatal period. However, some studies have not shown that neonatal complications confer additional risk on outcomes above that attributable to prematurity as indexed by birth weight or gestational age (11, 12); one study showed that family factors were stronger predictors of school outcomes than perinatal complications (13). Many studies documenting adverse behavioral outcomes have focused exclusively on children born very preterm (≤ 32 weeks gestation)(14) or of very low (1000 g to < 1500 g) or extremely low (< 1000 g) birth weight (15). Recent studies of late preterm infants (i.e., 34 to 36-6/7 weeks gestation) have found increased risk of behavioral and academic difficulties compared to full-term peers, indicating that prematurity confers risk across the spectrum of gestational age (16, 17).

Sociodemographic factors, such as socioeconomic status (SES), may also contribute to behavioral outcomes. Low SES can be conceptualized as a marker for a large collection of adverse environmental factors, such as limited parental education and minimal fiscal resources, all of which may contribute to behavior problems as well as risk for premature birth. In term children, low SES is associated with increased rates of disruptive behavior problems, including ADHD (18). SES may have similar influence on outcomes in the preterm population. The high prevalence of prematurity among children of low SES makes it particularly important to evaluate any potential associations (19). As in the population of children born at term, other important sociodemographic variables may include age, as behavior problems may manifest at different ages (20), and gender, as males are more likely to have externalizing problems than females (18), and females may have higher rates of internalizing problems (20, 21).

In many studies, IQ differentiates preterm from term children matched for age, gender, and SES even though preterm children may have IQ scores within the average range. The magnitude of the difference between groups ranges from 0.5 to 1 SD (2, 9). In preterm (14) and full term children behavior problems are often associated with lower IQ or similar cognitive measures (22).

An important issue is how the biomedical and sociodemographic factors interact in relation to the development of behavior problems. A recent study by Conrad and colleagues examined both biological and environmental predictors of behavior symptoms in 7 to 16 year old preterm children with mean gestational age of 27.7 weeks and mean birth weight of 939g (23). Using a brief parent rating scale of behavior, they found that (1) preterm children had higher parental ratings of hyperactivity/inattention and depression/anxiety compared to full term children, (2) birth weight was a strong predictor of behavior problems, (3) SES made no significant contribution and (4) cognitive ability showed no significant relationship to behavior, contrary to expectations. In contrast, a study by Samara et al. of 6-year old children born at < 26 weeks gestation found that behavioral symptoms of hyperactivity and

impulsivity were accounted for by cognitive ability or intellectual deficits, but attention, peer, and emotional problems, such as worry and fear, were not associated with cognitive ability (28).

In this study, we sought to consider sources of variation in the nature of behavior problems in another sample of children age 9 to 16 years, using a broad standardized parent rating scale of behavior problems. We studied children born across the spectrum of birth weight (< 500 to 2500g) and gestational age (24 to < 36 weeks) to capture a wide range of biomedical risk. Our sample represented a spectrum of SES with many middle and upper SES families, a study feature that improves the chances of identifying significant associations between SES and behavior problems, if such associations exist. We used multiple regression models to evaluate effects of prematurity as a biological factor, SES as an environmental influence, and IQ on behavioral symptom scores. We hypothesized that (1) behavioral outcomes would be associated with the degree of prematurity and with SES and (2) IQ would influence behavior outcomes, acting as a mediator between prematurity and behavior. We were particularly interested in whether IQ would be associated with specific symptom domains associated with prematurity--inattention and anxiety.

2. Methods

2.1. Participants

Participants were part of a two-site study conducted in Pittsburgh, PA, and Palo Alto, CA. The larger study is a neuroimaging study of language, reading, and executive function skills. Study subjects, age 9 to 16 years, had a history of preterm (PT) birth (< 36 weeks gestation) and birth weight (BW) < 2500 g (n = 63). Controls were born full term (FT) ($\geq$ 37 weeks) and had BW $\geq$ 2400 g (n = 29). Exclusion criteria for all participants included severe neurological disorders; receptive vocabulary standard score < 70; sensory impairments; and non-English speaker. Medical complications at birth in the preterm group were as follows: 13 had abnormal findings on head ultrasounds or MRIs (at least grade 2 intraventricular hemorrhage, echodensities, or cystic lesions), 9 had mildly abnormal findings (defined as either grade 1 hemorrhage or choroid plexus cyst); 22 had respiratory distress syndrome and 7 developed chronic lung disease; and 4 were small for gestational age (defined as lying at or below the 3rd percentile in birth weight for gestational age). Controls were excluded for identified language, learning, or psychiatric disorder requiring medication, and retention in grade after age 7 years. The reason for these exclusion criteria was that the larger study included neuroimaging (i.e., functional MRI and diffusion tensor imaging), and the presence of other conditions could interfere with understanding the associations of brain injury and function in the preterm sample.

The study population consisted of a convenience sample of children born during the 1990s to 2001. Preterm subjects were recruited by flyers posted in early intervention newsletters distributed in Pittsburgh and surrounding areas and by letters sent to families of children who were evaluated at Infant Follow-up Services at Lucile Packard Children's Hospital in Palo Alto. Control children were recruited by local ads, school newsletters, and by word of mouth at both sites. Controls were group-matched to preterm children for age, gender, and race. (See Table 1) Maternal education (< 4-year college degree versus college degree or higher) was used as the measure of SES. There were no differences between sites of testing for age, gender or race. SES was higher at the Palo Alto site than the Pittsburgh site, $X^2(1) = 19.2$, $p < .001$.

The study was approved by the University of Pittsburgh and Stanford University institutional review boards. A parent or legal guardian provided informed consent and children provided assent. Participants were compensated for participation.

2.2. Measures and Variables

Participant characteristics—Gestational age (GA), BW, and medical complications were gathered from parent report and confirmed with medical records. Demographic information included race, ethnicity, and maternal education, and parent report of learning problems addressed with special education at school.

Child Behavior Check List for Ages 6–18 (CBCL)—Parents completed the CBCL, a well-validated, broadband behavior rating questionnaire (24). This standardized measure has 113 items rated on a 3-point Likert scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true) which are grouped into eight syndrome scales: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior. Rated symptoms can also be scored in terms of two broad groupings of syndromes, Internalizing (consists of anxious/depressed, withdrawn/depressed, and somatic complaints) and Externalizing (consists of rule-breaking and aggressive behavior). A Total Problems Score is also generated from the sum of scores for internalizing, externalizing, three other syndromes (i.e., social, thought, and attention problems), and other items not included in any of the syndromes. Note, attention is not included in the externalizing scale.

Scores for syndrome and broadband scales are reported as T-scores (mean of 50, standard deviation (SD) of 10). T-scores are normed for gender and two age categories: 6 to 11 years and 12 to 18 years. Higher T-scores indicate a higher level of behavior problems. For total, internalizing, and externalizing, scores above 63 (> 90th percentile) are considered in the clinical range. Scores of 60–63 (84th to 90th percentile) are considered in the borderline clinical range. For the syndrome scales, scores ≥ 70 are considered in the clinical range. Scores of 65–69 (93rd to 97th percentile) are considered in the borderline clinical range. A score of 60 is in the 85th percentile.

IQ—Full scale IQ was estimated using the four subtest format of the Wechsler Abbreviated Scale of Intelligence, a widely used, nationally standardized test of general intellectual ability that measures verbal and nonverbal cognitive ability (25). The four subtests include vocabulary, similarities, block design, and matrices.

2.3. Statistical Analyses

To compare demographic variables, behavior, and test scores between PT and FT groups, we used t-tests or analysis of covariance (ANCOVA; covariates of SES and IQ) for univariate analyses of continuous variables and Pearson chi-square for dichotomous outcomes. Even though the CBCL is normed for age and gender, we conducted analyses of age and gender on T-scores because the normative population did not focus on the preterm population. We ran correlations between age and T-scores and used gender as another between group variable to evaluate group by gender interactions in the ANCOVAs. We reasoned that if we confirmed that age and gender did not affect T-scores we would not include them in further regression analyses.

To investigate contributions of biological and environmental factors to behavioral outcomes, we used a similar mediation analysis method as Conrad et al. (23) and Baron et al. (26). Mediation analysis tests whether the effect of a given predictor variable on an outcome measure can be accounted for by its effect on an intermediate variable (mediator) which in turn affects the outcome measure. Mediation requires (1) a significant effect of the predictor (i.e., BW) on the outcome variable (behavior T-score), (2) a significant effect of the predictor (i.e., BW) on the mediator variable (i.e., IQ), (3) a significant effect of the mediator (i.e., IQ) on the outcome (behavior T-score) controlling for the predictor (BW),

and (4) a significant decrease in the effect of the predictor on the outcome when controlling for the mediator.

Due to our interest in IQ as a mediator, we examined the contributions of BW and SES to IQ using hierarchical multiple regression. Birth weight was entered in the first step, and SES was entered in the second step.

We then investigated IQ as a mediator between the predictors of BW and SES and outcomes of total, internalizing, and externalizing T-scores for the entire sample using hierarchical multiple regression. For each model, BW a continuous variable used as an indicator of prematurity was entered in the first step. SES was entered in the second step and IQ was entered in the third step. Analyses were repeated with GA; however, results using BW are shown given that BW and GA are highly correlated, $r = .9$, $p < .001$. The model allows for determination of contributions of BW and SES to behavior score. By adding IQ in the third step, any decrease in variance in behavior T-score due to BW after the addition of IQ suggests mediation.

For the CBCL syndrome scale scores, we first used Mann-Whitney U tests due to the nonparametric nature of the data to investigate group differences. Binary logistic regression was used to calculate odds ratios for elevated CBCL syndrome scale scores (T-scores > 60) for PT compared to FT children, examining group (PT vs. FT), SES and IQ. A cutoff T-score of > 60 , or a score greater than 1 SD above the mean, was chosen since a meta-analysis of behavior problems in PT children found combined effect sizes of 0.43 to 0.59 SD difference for attention problems in PT children compared to control children (1). Group (PT vs. FT) was entered in the first step of the model, followed by SES in the second step. In the third and final step, mediational effects of IQ were assessed.

89 children had complete data; 3 had incomplete CBCL data. For analyses with missing data, degrees of freedom were adjusted accordingly. Significance level was set at $p < .05$.

3. Results

Participant Characteristics

By design, the PT and FT group differed in GA and BW but were well matched in SES. There were significant differences in IQ across groups (See Table 1). PT children had mean IQ scores in the normal range, but were approximately one SD lower than FT controls and showed greater variability in IQ scores.

CBCL Broadband Scales

The PT children had significantly higher scores on the total and internalizing scales compared to FT children, but not on the externalizing scale (Table 1). There were no significant correlations between age and CBCL T-scores, so age was not included as a covariate in any additional analyses. The group differences on the total, $F(1, 82) = 5.3$, $p = .024$, and internalizing, $F(1, 82) = 6.3$, $p = .014$, scales persisted after controlling for SES, gender, and IQ, using ANCOVA. There were no main effects of SES or gender and no group by gender interactions, all $p > .05$, for total, internalizing, and externalizing T-scores. Gender was therefore not considered in further analyses. In addition, IQ as a covariate in the ANCOVA had a significant main effect on total, $F(1, 82) = 7.6$, $p = .007$ and externalizing, $F(1, 82) = 4.1$, $p = .05$, but not on internalizing scores.

Effects of Biological and Environmental Factors on CBCL Broadband Scales

In examining the contributions of biological and environmental factors on behavior problems using hierarchical multiple regression, we first evaluated the contributions of BW and SES to IQ due to our interest in IQ as a mediator. The models were significant with BW contributing approximately 20.3% of the variance in the first step such that higher BW was associated with higher IQ. SES in the second step accounted for an additional approximately 6% of the variance in IQ scores, such that lower SES was associated with lower IQ. (Table 2)

We found that the overall models predicting total, $F(3, 84) = 9.1$, $p < .001$, and internalizing, $F(3, 84) = 5.4$, $p = .002$, were significant but the model predicting externalizing scores was not, $F(3, 84) = 2.4$, $p = .073$. For total and internalizing scores, BW remained a significant predictor even with addition of SES and IQ to the final models. For externalizing scores, BW was significant in the first and second steps, but did not remain significant with the addition of IQ in the final step. For total, internalizing, and externalizing scores, SES made no significant contribution to the variance in scores. The results confirm an inverse relationship between BW and behavior problems, indicating lower BW is predictive of more behavior problems. (Table 3)

The addition of IQ in the third and final step allowed investigation of the role of IQ as a potential mediator in the relationship between BW and total, internalizing, and externalizing scores. In the final models, IQ significantly predicted total, but not internalizing or externalizing scores, indicating IQ served as a mediator in the relationship between IQ and total behavior scores. Regression analyses using GA instead of BW showed similar results (data not shown).

CBCL Syndrome Scales

On univariate analysis, PT children had higher scores on 5 of 8 syndrome scales: anxious/depressed, withdrawn/depressed, social, thought, and attention problems. (Table 4) The regression models for the entire sample showed no significant effects of SES on any of the outcome variables. PT vs. FT group differences were significant for the outcomes of anxious/depressed and attention scores after adjusting for SES and IQ. Among the syndrome scales, IQ was a significant variable in addition to group, contributing only to the social and attention problems scales such that higher IQ scores were associated with fewer behavior problems.

4. Discussion

We found increased total and internalizing behavior problems in PT children born across the spectrum of GA and BW. On the syndrome scales the elevations were particularly high for the anxious/depressed and attention problems scales. The attention problems scale is not included in the externalizing score, but does contribute to the total score, suggesting that group differences in total scores in part reflects group differences in attention problems. Group differences remained after adjusting for SES and IQ, and there were no group by gender interactions.

Biological Factor

Multiple regression models showed significant contribution of BW to total and internalizing behavior scores, such that lower BW was predictive of more behavior problems. These findings are consistent with other studies showing a unique contribution of prematurity as a biological factor to behavioral outcome. BW or GA in our study was conceptualized as a summary measure of the biological issues experienced by preterm children. Children born at

early GA with low BW are at high risk for central nervous system involvement that could contribute to the association between behavior problems and prematurity. We are currently investigating associations between more specific biological measures of white matter microstructure from current scans that may be implicated in behavior outcomes in PT children.

Sociodemographic

Contrary to our hypothesis and similar to some studies of PT children(23), SES as an environmental influence did not influence behavioral outcomes. Our study sample had the advantage of a higher proportion of high SES than many studies. However, the lack of effect of SES may be due to use of a single dichotomized measure (maternal education) which may not capture more specific SES information that influences behavioral outcome. In some studies, the influence of SES may be absorbed by PT status as these variables are highly correlated. Other studies have found that low SES as measured by parent occupation level (14) and family adversity (27) was related to behavior problems in preterm children.

IQ

There was a significant mediational effect of IQ for total, but not internalizing or externalizing, scores. This finding is due to the effects of IQ on attention because the attention scale score contributes to total, but not externalizing, scores. IQ was not related to internalizing or anxious/depressed syndrome scale scores, lending support to an association between IQ and inattention but not anxiety.

Prior studies examining intellectual contributions to behavior symptoms have shown variable results. Our findings are different from those of Conrad and colleagues (23) in that we found IQ mediated inattention, but not internalizing or externalizing symptoms. This difference may relate to differences in study sample and their use of a shortened behavior rating scale. Our findings are similar to those of Samara et al. in that they found hyperactivity and impulsivity were accounted for by intellectual deficits. However, in contrast to our findings, attention problems were not mediated by intellectual ability (28). The Samara study used measures that differentiated hyperactivity, overactive/impulsive problems, and attention; these tools may have led to better ability to differentiate the impact of intellectual ability on specific symptom domains. In addition, the study focused on 6-year old children with GA < 26 weeks, which may also contribute to differences in findings. The finding that intellectual status did not mediate emotional problems (i.e., worrying, being unhappy or fearful) in the Samara study was similar to our findings.

PT children in our study had mean IQ scores in the average range, and parents reported that 30% of PT children received special education, indicating functional academic difficulty. This finding is consistent with studies of children with ADHD who have IQ in the average range, but lower mean scores than children without ADHD, and higher rates of special education (29). The association of IQ with inattention symptoms in our study highlights the importance of assessing for both attention and learning problems in PT children.

Limitations

The relationship between cognitive status and behavior symptoms is complex, and these results should be explored in future work. We could not fully evaluate differences between elevations in anxiety and attention in our sample due to high correlations between these scales and the small sample size. We did not conduct diagnostic interview to confirm behavior disorders or collect child/youth self-report or teacher report of behavior symptoms. Given that parents often underreport children's internalizing symptoms, our findings of

elevated anxious/depressed symptoms from parents are notable. The sample was a relatively small convenience sample that may not be representative of all PT children.

Conclusions

Data from this population of PT children confirm increased behavior problems, especially inattention and anxiety, indicating that these problems are not limited to the lowest BW or earliest GA children. These findings alert health care providers to assess anxiety in all preterm children regardless of intellectual ability and to assess attention in those with learning problems. Currently there is no systematic follow-up of the school age and adolescent PT population that is at high risk for behavioral problems and related disorders. The results of our study also highlight the need for additional research on understanding the neurobiological basis of behavioral outcomes in PT children. We are using neuroimaging to evaluate the contributions of neural injury to behavior problems.

Abbreviations

BW	birth weight
GA	gestational age
SES	socioeconomic status
PT	preterm
FT	full term
CBCL	Child Behavior Checklist
IQ	intelligence quotient
ADHD	attention-deficit/hyperactivity disorder
ANCOVA	analysis of covariance
OR	odds ratio

Acknowledgments

This study was supported by grant RO1-HD46500 from the National Institutes of Health (Dr. Heidi M. Feldman, principal investigator), NIH Pediatric Research Loan Repayment Program Award to the first author, and also supported in part by the Clinical and Translational Science Award 1UL1 RR025744 for the Stanford Center for Clinical and Translational Education and Research (Spectrum) from the National Center for Research Resources, National Institutes of Health.

References

1. Aarnoudse-Moens CSH, Weisglas-Kuperus N, van Goudoever JB, Oosterlaan J. Meta-Analysis of Neurobehavioral Outcomes in Very Preterm and/or Very Low Birth Weight Children. *Pediatrics*. 2009 August 1; 124(2):717–728. [PubMed: 19651588]
2. Bhutta AT, Cleves MA, Casey PH, Cradock MM, Anand KJS. Cognitive and Behavioral Outcomes of School-Aged Children Who Were Born Preterm: A Meta-analysis. *JAMA*. 2002 August 14; 288(6):728–737. [PubMed: 12169077]
3. Spittle AJ, Treyvaud K, Doyle LW, Roberts G, Lee KJ, Inder TE, et al. Early emergence of behavior and social-emotional problems in very preterm infants. *Journal of the American Academy of Child & Adolescent Psychiatry*. 2009; 48(9):909–918. [PubMed: 19633579]
4. Farooqi A, Hagglof B, Sedin G, Gothefors L, Serenius F. Mental health and social competencies of 10- to 12-year-old children born at 23 to 25 weeks of gestation in the 1990s: a Swedish national prospective follow-up study. *Pediatrics*. 2007 Jul; 120(1):118–133. [PubMed: 17606569]

5. Indredavik MS, Vik T, Heyerdahl S, Kulseng S, Brubakk AM. Psychiatric symptoms in low birth weight adolescents, assessed by screening questionnaires. *Eur Child Adolesc Psychiatry*. 2005 Jul; 14(4):226–236. [PubMed: 15981134]
6. Indredavik MS, Vik T, Heyerdahl S, Kulseng S, Fayers P, Brubakk AM. Psychiatric symptoms and disorders in adolescents with low birth weight. *Arch Dis Child Fetal Neonatal Ed*. 2004 Sep; 89(5):F445–F450. [PubMed: 15321968]
7. Dahl LB, Kaaresen PI, Tunby J, Handegard BH, Kvernmo S, Ronning JA. Emotional, Behavioral, Social, and Academic Outcomes in Adolescents Born With Very Low Birth Weight. *Pediatrics*. 2006 Aug; 118(2):e449–e459. [PubMed: 16882786]
8. Hack M, Youngstrom EA, Cartar L, Schluchter M, Taylor HG, Flannery D, et al. Behavioral Outcomes and Evidence of Psychopathology Among Very Low Birth Weight Infants at Age 20 Years. *Pediatrics*. 2004 Oct; 114(4):932–940. [PubMed: 15466087]
9. Aylward GP. Neurodevelopmental Outcomes of Infants Born Prematurely. *Journal of Developmental & Behavioral Pediatrics* December. 2005; 26(6):427–440.
10. Botting N, Powls A, Cooke RW, Marlow N. Attention deficit hyperactivity disorders and other psychiatric outcomes in very low birthweight children at 12 years. *J Child Psychol Psychiatry*. 1997 Nov; 38(8):931–941. [PubMed: 9413793]
11. Wagner AI, Schmidt NL, Lemery-Chalfant K, Leavitt LA, Goldsmith HH. The limited effects of obstetrical and neonatal complications on conduct and attention-deficit hyperactivity disorder symptoms in middle childhood. *J Dev Behav Pediatr*. 2009 Jun; 30(3):217–225. [PubMed: 19433988]
12. Landry SH, Denson SE, Swank PR. Effects of medical risk and socioeconomic status on the rate of change in cognitive and social development for low birth weight children. *J Clin Exp Neuropsychol*. 1997 Apr; 19(2):261–274. [PubMed: 9240485]
13. Gross SJ, Mettelman BB, Dye TD, Slagle TA. Impact of family structure and stability on academic outcome in preterm children at 10 years of age. *J Pediatr*. 2001 Feb; 138(2):169–175. [PubMed: 11174612]
14. Delobel-Ayoub M, Arnaud C, White-Koning M, Casper C, Pierrat V, Garel M, et al. Behavioral problems and cognitive performance at 5 years of age after very preterm birth: the EPIPAGE Study. *Pediatrics*. 2009 Jun; 123(6):1485–1492. [PubMed: 19482758]
15. Taylor HG, Klein N, Drotar D, Schluchter M, Hack M. Consequences and risks of <1000-g birth weight for neuropsychological skills, achievement, and adaptive functioning. *J Dev Behav Pediatr*. 2006 Dec; 27(6):459–469. [PubMed: 17164618]
16. Morse SB, Zheng H, Tang Y, Roth J, Morse SB, Zheng H, et al. Early school-age outcomes of late preterm infants. *Pediatrics*. 2009 Apr; 123(4):e622–e629. [PubMed: 19336353]
17. Chyi LJ, Lee HC, Hintz SR, Gould JB, Sutcliffe TL. School outcomes of late preterm infants: special needs and challenges for infants born at 32 to 36 weeks gestation. *J Pediatr*. 2008 Jul; 153(1):25–31. [PubMed: 18571530]
18. Scahill L, Schwab-Stone M, Merikangas KR, Leckman JF, Zhang H, Kasl S, et al. Psychosocial and clinical correlates of ADHD in a community sample of school-age children. *Journal of the American Academy of Child & Adolescent Psychiatry*. 1999 Aug; 38(8):976–984. [PubMed: 10434489]
19. Kramer MS, Goulet L, Lydon J, Seguin L, McNamara H, Dassa C, et al. Socio-economic disparities in preterm birth: causal pathways and mechanisms. *Paediatr Perinat Epidemiol*. 2001 Jul.15 Suppl 2:104–123. [PubMed: 11520404]
20. Schmidt LA, Miskovic V, Boyle M, Saigal S. Frontal electroencephalogram asymmetry, salivary cortisol, and internalizing behavior problems in young adults who were born at extremely low birth weight. *Child Development*. 2010 Jan–Feb; 81(1):183–199. [PubMed: 20331661]
21. Saigal S, Pinelli J, Hoult L, Kim MM, Boyle M. Psychopathology and social competencies of adolescents who were extremely low birth weight. *Pediatrics*. 2003 May; 111(5 Pt 1):969–975. [PubMed: 12728073]
22. Loe I, Balestrino M, Phelps R, Kurs-Lasky M, Chaves-Gnecco D, Paradise J, et al. Early Childhood Histories of Children with Attention-Deficit/Hyperactivity Disorder (ADHD). *Child Development*. 2008 November–December; 79(6):1853–1868. [PubMed: 19037954]

23. Conrad AL, Richman L, Lindgren S, Nopoulos P. Biological and Environmental Predictors of Behavioral Sequelae in Children Born Preterm. *Pediatrics*. 2010 Jan; 125(1):e83–e89. [PubMed: 20008432]
24. Achenbach, TM.; Rescorla, LA. Manual for the ASEBA School-Age Forms and Profiles. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families; 2001.
25. Wechsler. Wechsler Abbreviated Scale of Intelligence (WASI) Manual. San Antonio, TX: Harcourt Assessment, Inc.; 1999.
26. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*. 1986; 51(6) pp.
27. Nadeau L, Boivin M, Tessier R, Lefebvre F, Robaey P. Mediators of behavioral problems in 7-year-old children born after 24 to 28 weeks of gestation. *J Dev Behav Pediatr*. 2001 Feb; 22(1):1–10. [PubMed: 11265917]
28. Samara M, Marlow N, Wolke D. for the EPICure Study Group. Pervasive Behavior Problems at 6 Years of Age in a Total-Population Sample of Children Born at ≤ 25 Weeks of Gestation. *Pediatrics*. 2008 Sep; 122(3):562–573. [PubMed: 18762527]
29. Loe IM, Feldman HM. Academic and educational outcomes of children with ADHD. *Ambul Pediatr*. 2007 Jan–Feb. 7 1 Suppl:82–90. [PubMed: 17261487]

Table 1

Participant Characteristics and Broadband CBCL scores

	Preterm (n = 63)		Full Term (n = 29)		P
	Mean (SD)	Range	Mean (SD)	Range	
Age (years) ^a	12.2 (1.8)	9.2–16.1	12.9 (1.9)	9.6–16.3	.109
Perinatal Data					
GA (weeks)	28.7 (2.8)	24–35.5	39.7 (1)	37–42	<.001*
Birthweight (grams)	1188 (460)	482–2495	3469 (526)	2438–4423	<.001*
Academic Scores					
IQ	101.9 (16.4)	67–136	116.5 (14)	86–142	<.001*
Demographics ^b					
Race, n (%)					.381
White	45 (71)		24 (83)		
Nonwhite	18 (29)		5 (17)		
Gender					.953
Male	33 (52)		15 (52)		
Female	30 (48)		14 (48)		
Maternal Education, n (%)					.354
< college degree	21 (33)		13 (45)		
≥ college degree	42 (67)		16 (55)		
CBCL Broadband Scores ^a					
	Preterm (n = 61)		Full Term (n = 28)		P
Total	53.5 (11.3)		44.1 (9.9)		<.001*
Internalizing	55.2 (11.5)		46.7 (9.5)		.001*
Externalizing	49.3 (11.1)		45.8 (8.2)		.144

^aData analyzed by t-test^bData analyzed by chi-square (asymptotic or exact significance: 2-sided)

Table 2

Hierarchical Multiple Regression Models of the Contribution of Birth Weight (BW) and Socioeconomic Status (SES) to IQ

Outcome	Predictors	R ²	p (model)	B	SE B	β	p (predictor)
IQ		.203	<.001*				
	BW			.007	.001	.450	<.001*
IQ ^a		.265	<.001*				
	BW			.007	.001	.479	<.001*
	SES			-8.85	3.27	-.250	.008*

B indicates unstandardized coefficient; SE B, standard error of B; β, standardized coefficient.

^aFinal model. Step 1, BW; step 2, SES. For BW, higher BW was associated with higher IQ. For SES, maternal education level of college graduate was coded as 0 and less than college graduate was coded as 1; therefore, lower SES was associated with lower IQ.

Table 3

Hierarchical Multiple Regression Models of Possible Mediation of CBCL Broadband Total, Internalizing, and Externalizing T-scores by IQ

Outcome	Predictors	R ²	p (model)	B	SE B	β	p (predictor)
Total ^a		.184	<.001*				
	BW			-.004	.001	-.429	<.001*
Total ^b		.194	<.001*				
	BW			-.004	.001	-.440	<.001*
	SES			2.50	2.39	.102	.299
Total ^c		.245	<.001*				
	BW			-.003	.001	-.312	.006*
	SES			.884	2.42	.036	.716
	IQ			-.178	.075	-.263	.021*
Internalizing ^d		.129	.001*				
	BW			-.004	.001	-.360	.001*
Internalizing ^e		.147	.001*				
	BW			-.003	.001	-.373	<.001*
	SES			3.18	2.41	.133	.191
Internalizing ^f		.161	.002*				
	BW			-.003	.001	-.306	.010*
	SES			2.34	2.51	.098	.353
	IQ			-.092	.078	-.139	.240
Externalizing ^g		.05	.037*				
	BW			-.002	.001	-.223	.037*
Externalizing ^h		.051	.107				
	BW			-.002	.001	-.227	.036*
	SES			.905	2.31	.042	.696

Outcome	Predictors	R ²	p (model)	B	SE B	β	p (predictor)
Externalizing ^c		.079	.073				
	BW			-.001	.001	-.132	.279
	SES			-.164	2.38	-.008	.945
	IQ			-.118	.074	-.196	.115

Outcomes are T-scores for Total, Internalizing, and Externalizing scales. Higher T-scores indicate more behavior problems. B indicates unstandardized coefficient; SE B, standard error of B; β, standardized coefficient.

^aFirst Model. Step 1, BW (birth weight). For BW, lower BW was associated with higher behavior problems.

^bSecond Model. Step 1, BW; step 2, SES. For SES, no significant associations with behavior problems.

^cFinal model. Step 1, BW; step 2, SES; and step 3, IQ. For IQ, lower IQ was associated with higher behavior problems. When IQ is in the model, BW is no longer a significant contributor to Externalizing problems.

Table 4**Child Behavior Check List Syndrome Scale Scores**

	Preterm (n = 61)	Full Term (n = 28)	p	
	Mean T-scores(SD)	Mean T-scores(SD)		
Syndrome Scales^a				
Anxious/Depressed	58 (7.7)	52 (3.9)	<.001*	
Withdrawn/Depressed	58 (8.7)	54 (5.6)	.035*	
Somatic Complaints	56 (7.1)	54 (4.4)	.186	
Social Problems	57 (7.7)	52 (4.7)	.001*	
Thought Problems	56 (6.5)	52 (3.4)	.006*	
Attention Problems	59 (9.0)	52 (3.2)	<.001*	
Rule-Breaking Behavior	54 (6.1)	52 (2.7)	.067	
Aggressive Behavior	55 (7.3)	52 (3.7)	.283	
	Preterm (n = 61)	Full Term (n = 28)	OR (95% CI)[^]	p
	Number (%) with T-score > 60	Number (%) with T-score > 60		
Syndrome Scales^b				
Anxious/Depressed	21 (34)	1 (4)	10 (.01–.84)	.034*
Withdrawn/Depressed	20 (33)	3 (11)	3.1 (.08–1.3)	.114
Somatic Complaints	15 (25)	2 (7)	3.8 (.05–1.4)	.112
Social Problems	19 (31)	2 (7)	3.5 (.06–1.5)	.135
Thought Problems	13 (21)	1 (4)	4.0 (.03–2.3)	.219
Attention Problems	24 (39)	1 (4)	10.2 (.01–.83)	.033*
Rule-Breaking Behavior	7 (12)	0	--	--
Aggressive Behavior	10 (16)	2 (7)	2.1 (.08–2.6)	.391

^aData analyzed by Mann-Whitney U test.

^bBinary logistic regression

[^]OR adjusted for SES and IQ.