ORIGINAL ARTICLE

Stability of Psychiatric Outcomes of Low Birth Weight

A Longitudinal Investigation

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Context: Research on psychiatric disturbances in low-birth-weight (LBW) children (≤2500 g), which has focused primarily on the extreme low end of the LBW distribution, has suggested an increased risk of attention, externalizing, and internalizing problems.

Objective: To examine the long-term effects of LBW on psychiatric problems in socially disadvantaged children and in middle-class children.

Design: A stratified random sample assessed at ages 6, 11, and 17 years.

Setting: Random samples of LBW and normal-birth-weight children from newborn discharge lists (1983 through 1985) of 2 major hospitals in southeast Michigan, one serving an inner city and the other serving middle-class suburbs.

Participants: Cohort members with 1 or more assessments (n=823).

Main Outcome Measures: Attention, internalizing, and externalizing problems rated by mothers and teachers (Child Behavior Checklist and Teacher's Report Form, respectively) at ages 6, 11, and 17 years, using standard cutoffs that identify children with disturbances above the normal range.

Results: Low-birth-weight children had modest excesses of externalizing and internalizing disturbances (adjusted odds ratios=1.53 and 1.28, respectively) (P=.001 and .02, respectively). An increased risk of attention problems was associated with LBW only in the urban community (adjusted odds ratio=2.78) (P=.001) and was greater among very LBW children (≤1500 g) than heavier LBW children (1501-2500 g). In the suburban community, there was no increased risk for attention problems associated with LBW. Psychiatric outcomes of LBW did not vary across ages of assessments.

Conclusions: Effects of LBW on psychiatric disturbance appear to be stable through the period of school attendance. The differential effect of LBW on attention problems between the 2 communities suggests the possibility of interplay between prenatal adversity and social environment.

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Advances in neonatal medicine have raised the survivorship of low-birth-weight (LBW) infants (≤2500 g), especially very LBW (VLBW) infants (≤1500 g) and extremely LBW infants (≤1000 g). Low birth weight has served as an index for prenatal adversity and a marker for high-risk newborns.[1-8] Previous research on long-term outcomes of LBW has focused primarily on the extreme low end of the LBW distribution (ie, VLBW or extremely LBW) and on small-for-gestation LBW. Studies have reported an increased risk of internalizing,[9-17] externalizing,[11,12,14,16,18] and attention[10,12-16,18-26] problems. A distinct pattern of behavior problems has been identified, with high levels of activity and inattention, the chief features of attention-deficit/hyperactivity disorder (ADHD).[13,16,19,25,26] The few studies that have followed up VLBW cohorts have shown that problems persist into young adulthood (see the articles by Hack et al[27,28]).

We have previously described psychiatric outcomes of the entire range of LBW, up to and including 2500 g, based on data from 2 socioeconomically disparate communities, an urban inner city and surrounding middle-class suburbs.[22,23] At age 6 years, the prevalence of *DSM-III-R* ADHD based on diagnostic interviews with mothers was higher in LBW children compared with normal-birth-weight (NBW) children, especially in the urban community.[22] At age 11 years, LBW children had an excess of attention problems in the urban but not suburban community according to mothers' and teachers' ratings on

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standardized checklists of behavior problems.[23] At age 11 years, LBW children also had an excess of externalizing problems.[23]

In this article, we extend the investigation up to age 17 years, when the children were about to complete high school. Mothers' and teachers' ratings of children's psychiatric problems at ages 6, 11, and 17 years are used to identify children above the scales' cutoffs that distinguish the normal range from borderline or clinical disturbance according to validated guidelines.[29,30] The study design offers an important advantage in that it allows for disentangling the effects of LBW from the effects of socioeconomic disadvantage with which they are confounded. We address several questions. Are the effects of LBW on the risk for psychiatric disturbances uniform across the urban and suburban communities? Are the LBW effects stable or do they decline or increase as children grow up?

METHODS

SAMPLE

Random samples of LBW and NBW children were drawn from discharge lists of newborns from 1983 through 1985 in 2 major hospitals in southeast Michigan, one located in the city of Detroit and serving primarily the residents of the city (urban) and the other located in a suburb of Detroit and serving residents of the surrounding middle-class suburbs. Forty-seven children with severe neurologic impairment, including severe communication impairment, blindness, and cerebral palsy, were excluded from the sample at the time of recruitment. Of the 1095 eligible children, 823 (75.2%) participated in the initial assessment in 1990 to 1992 when they passed their sixth birthday. Subsequent assessments were conducted in 1995 to 1997 when the children were 11 years of age (n=717) and in 2000 to 2002 when the children were 17 years of age (n=713). Detailed information on the sample is available elsewhere.[22,31] The institutional review boards of the participating institutions approved the study.

MEASUREMENT

Children were rated by mothers and teachers at each assessment using the Child Behavior Checklist[29] (CBCL) and the Teacher's Report Form[30] (TRF), respectively. The CBCL asks mothers to rate their children on behavior in the past 6 months. It consists of 118 items rated from 0 to 2 (0 indicates not true [as far as they know]; 1, somewhat or sometimes true; and 2, very or often true). The items form 8 syndrome scales: withdrawn, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. The CBCL also yields scores on 2 broadband scales measuring externalizing and internalizing spectra. The externalizing broadband scale comprises the delinquent behavior and aggressive behavior scales. The internalizing broadband scale comprises the withdrawn, somatic complaints, and anxious/depressed scales. The outcomes of interest in this study are the attention syndrome scale and the externalizing and internalizing broadband scales. The attention syndrome scale measures characteristic symptoms of ADHD and maps on the *DSM* criteria for the disorder (eg, fails to finish things he or she starts; cannot concentrate; cannot pay attention for long; cannot sit still; fidgets; daydreams or gets lost in his or her thoughts; has difficulty following directions; is impulsive or acts without thinking; does messy work; is inattentive; is easily distracted; fails to carry out assigned tasks). The TRF parallels the CBCL in its content and asks teachers to rate the children's behavior based on observations of classroom behavior during the preceding 2 months. The CBCL and TRF have been widely used and have good reliability and validity.[29,30] Both the CBCL and TRF scale scores are standardized (*T*) scores based on age and sex distributions of normative samples.[29,30] Specified cutoffs on the *T* scores identify children above the normal range and signify borderline or clinical disturbances. Scores in the borderline or clinical range significantly discriminate between children referred for mental health services and demographically similar children who are not referred.[32] A score of 60 is the cutoff on the internalizing and externalizing broadband scales; a score of 67 is the cutoff on the attention problems scale.[29,30]

STATISTICAL ANALYSIS

We used a logistic regression approach, applying generalized estimating equations (GEE),[33,34] to estimate the risk for each of the 3 psychiatric outcomes associated with LBW. The GEE allowed consideration of multiple observations from multiple informants simultaneously.[35] Differential associations of LBW with behavior problems between urban and suburban children (interactions) were evaluated by including product terms. The equation for the logistic GEE model that is used to estimate the risk for each of the 3 outcomes is as follows: $Y = \alpha + \beta_1(\text{LBW}) + \beta_2(\text{urban}) + \beta_3(\text{LBW} \times \text{urban}) + \beta_4(\text{informant}) + \beta_5(\text{age 11 years}) + \beta_6(\text{age 17 years}) + \beta_7(\text{sex})$, where the presence or absence of a given disturbance (ie, attention, externalizing, or internalizing) at ages 6, 11, and 17 years based on the 2 informants (for a total of 6 records per individual) is the outcome (Y); LBW equals 1 if LBW and 0 if NBW; urban equals 1 if urban and 0 if suburban; informant equals 1 if mother and 0 if teacher; age 11 years equals 1 if age is 11 years and 0 if age is 6 or 17 years; age 17 years equals 1 if age is 17 years and 0 if age is 6 or 11 years; and sex equals 1 if male and 0 if female. The interaction of LBW and urban (vs suburban) (β_3) tests whether the association of LBW with a behavior disturbance varied significantly between the 2 communities. The coefficient β_3 estimates the difference between the effect of LBW in the urban and suburban community; β_1 estimates the LBW effect in the suburban community; and $\beta_1 + \beta_3$ estimates the LBW effect in the urban community. Other 2- and 3-way interactions involving LBW and urban community, informant, assessment age, and sex were tested; none were detected at $\alpha = .15$.

The GEE models use data on all individuals in the sample, including those with incomplete data. The GEE models estimate regression coefficients and standard errors, taking into account correlations across the repeated assessments by the 2 informants. The GEE models reduce the potential bias in the standard errors that may arise from using multiple assessments on the same individuals. We specified the working correlation structure to be exchangeable. The GEE models use robust variance estimators, which produce valid estimates of the standard errors even when the correlation structure is incorrectly specified. From the regression coefficients and standard errors, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using the logit link function. All of the statistical analyses were conducted using Stata version 9.0 statistical software (Stata Corp, College Station, Texas).

RESULTS

SAMPLE CHARACTERISTICS

The urban and suburban samples differed markedly in racial composition, maternal education, and percentages of single mothers (**Table 1**). However, differences

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Table 1. Sample Characteristics

Characteristic	Urban Children, %			Suburban Children, %		
	Total (n=413)	LBW[a] (n=252)	NBW (n=161)	Total (n=410)	LBW[a] (n=221)	NBW (n=189)
Black	80.4	82.5	77.0	5.1	4.5	5.8
Male	44.8	42.9	47.8	52.4	51.1	54.0
Education of mother						
< High school	26.6	28.6	23.6	7.1	7.2	6.9
High school	26.4	25.4	28.0	28.5	28.5	28.6
Some college	37.5	38.1	36.6	37.1	38.0	36.0
College	9.4	7.9	11.8	27.3	26.2	28.6
Single mother	56.8	58.8	53.8	8.8	11.4	5.9
Low birth weight, g						
≤1500	9.9	16.3	NA	8.6	15.8	NA
1501-2000	13.3	21.8	NA	9.3	17.2	NA
2001-2500	37.8	61.9	NA	36.2	67.0	NA
SGA[b]	18.7	25.4	8.2	13.5	19.1	7.0

Abbreviations: LBW, low birth weight; NA, not applicable; NBW, normal birth weight; SGA, small for gestational age.
[a] Birth weight of 2500 g or less.
[b] Less than the 10th percentile.

Table 2. Children Above the Cutoffs on Behavior Problem Scales at Ages 6, 11, and 17 Years According to Mothers' Ratings on the Child Behavior Checklist[a]

Age and Scale	Urban Children				Suburban Children			
	LBW[b]		NBW		LBW[b]		NBW	
	No.	% (SE)	No.	% (SE)	No.	% (SE)	No.	% (SE)
Age 6 y	252		161		219		189	
Attention[c]		14.7 (2.2)		4.3 (1.6)		5.9 (2.0)		4.2 (1.5)
Externalizing[d]		21.8 (2.6)		9.3 (2.3)		14.2 (2.4)		13.8 (2.5)
Internalizing[e]		16.3 (2.3)		11.8 (2.6)		17.4 (2.6)		17.5 (2.8)
Age 11 y	230		143		181		163	
Attention[c]		22.2 (2.7)		10.5 (2.6)		10.5 (2.3)		9.2 (2.3)
Externalizing[d]		26.1 (2.9)		21.0 (3.4)		19.9 (3.0)		11.0 (2.5)
Internalizing[e]		24.8 (2.9)		21.7 (3.5)		22.7 (3.1)		16.0 (2.9)
Age 17 y	218		140		181		159	
Attention[c]		11.9 (2.2)		7.1 (2.2)		3.9 (1.4)		2.5 (1.2)
Externalizing[d]		24.3 (2.9)		15.0 (3.0)		12.7 (2.5)		9.4 (2.3)
Internalizing[e]		19.3 (2.7)		15.0 (3.0)		17.7 (2.8)		10.7 (2.5)

Abbreviations: LBW, low birth weight; NBW, normal birth weight.
[a] Cutoffs signify boundaries defining children in the borderline or clinical range.
[b] Birth weight of 2500 g or less.
[c] Attention problems cutoff is a score of 67 or higher.
[d] Externalizing problems cutoff is a score of 60 or higher.
[e] Internalizing problems cutoff is a score of 60 or higher.

between the LBW and NBW groups within communities were small. The urban sample was primarily black, had a higher percentage of mothers with less than a high school education, and had a higher percentage of single mothers compared with the suburban sample. A comparison of the initial sample of 823 children with the follow-up samples of 717 children at age 11 years and 713 children at age 17 years revealed negligible differences. (In 2 previous articles from this study, the hospital of birth was used to define urban vs suburban community.[22,23] In this article as in other recent publications,[36,37] we use place of residence to define urban vs suburban community.)

PERCENTAGES OF CHILDREN WITH BORDERLINE OR CLINICAL PSYCHIATRIC PROBLEMS AT EACH ASSESSMENT

Table 2 and **Table 3** present percentages of LBW and NBW children above the cutoffs that define the borderline or clinical range in the 2 communities at ages 6, 11, and 17 years according to mothers' ratings (CBCL) and teachers' ratings (TRF), respectively. The general pattern has 3 key features. First, the percentages of children with externalizing and internalizing problems above the cutoffs were higher in LBW children than in NBW children within each of the 2 communities. Second, in the urban community, there were

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Table 3. Children Above the Cutoffs on Behavior Problem Scales at Ages 6, 11, and 17 Years According to Teachers' Ratings on the Teacher's Report Form[a]

	Urban Children				Suburban Children			
	LBW[b]		NBW		LBW[b]		NBW	
Age and Scale	No.	% (SE)	No.	% (SE)	No.	% (SE)	No.	% (SE)
Age 6 y	243		158		218		182	
Attention[c]		17.3 (2.4)		5.1 (1.7)		5.5 (1.5)		6.0 (1.8)
Externalizing[d]		30.0 (2.9)		20.3 (3.2)		11.9 (2.2)		13.7 (2.6)
Internalizing[e]		25.5 (2.8)		15.2 (2.9)		16.1 (2.5)		16.5 (2.8)
Age 11 y	198		129		172		158	
Attention[c]		15.7 (2.6)		7.8 (2.4)		2.9 (1.3)		4.4 (1.6)
Externalizing[d]		33.8 (3.4)		24.0 (3.8)		10.5 (2.3)		7.6 (2.1)
Internalizing[e]		19.7 (2.8)		19.4 (3.5)		15.7 (2.8)		15.2 (2.9)
Age 17 y	149		95		159		139	
Attention[c]		8.1 (2.2)		3.2 (1.8)		2.5 (1.2)		2.9 (1.4)
Externalizing[d]		20.8 (3.3)		16.8 (3.9)		12.6 (2.6)		6.5 (2.1)
Internalizing[e]		16.1 (3.0)		13.7 (3.5)		10.7 (2.5)		9.4 (2.5)

Abbreviations: LBW, low birth weight; NBW, normal birth weight.
[a] Cutoffs signify boundaries defining children in the borderline or clinical range.
[b] Birth weight of 2500 g or less.
[c] Attention problems cutoff is a score of 67 or higher.
[d] Externalizing problems cutoff is a score of 60 or higher.
[e] Internalizing problems cutoff is a score of 60 or higher.

Table 4. Results From Generalized Estimating Equations Regressions for Borderline or Clinical Problems in 823 Children at Ages 6, 11, and 17 Years[a]

	Attention		Externalizing		Internalizing	
Variable	β (SE)	*P* Value	β (SE)	*P* Value	β (SE)	*P* Value
LBW vs NBW[b]	0.08 (0.27)	.76	0.42 (0.12)	.001	0.25 (0.10)	.02
Urban vs suburban	0.25 (0.28)	.38	0.73 (0.12)	.001	0.20 (0.10)	.047
Mother's rating vs teacher's rating	0.26 (0.11)	.02	−0.10 (0.08)	.22	0.08 (0.08)	.34
Age 11 y vs 6 y	0.29 (0.11)	.01	0.14 (0.08)	.09	0.15 (0.09)	.08
Age 17 y vs 6 y	−0.43 (0.15)	.004	−0.08 (0.10)	.41	−0.20 (0.10)	.04
Male vs female	0.38 (0.15)	.01	0.10 (0.11)	.40	0.22 (0.10)	.03
LBW × urban	0.94 (0.36)	.008	NA	NA	NA	NA

Abbreviations: LBW, low birth weight; NA, not applicable; NBW, normal birth weight.
[a] The generalized estimating equations models are adjusted for all of the other variables in the table. The LBW effects as adjusted odds ratios calculated from the adjusted partial regression coefficients were as follows: for attention problems in suburban children, 1.08 (95% confidence interval, 0.64-1.85); for attention problems in urban children, 2.78 (95% confidence interval, 1.77-4.37); for externalizing problems, 1.53 (95% confidence interval, 1.21-1.93); and for internalizing problems, 1.28 (95% confidence interval, 1.04-1.57).
[b] Low birth weight indicates birth weight of 2500 g or less.

marked differences between LBW and NBW children in the percentages with attention problems above the cutoff; only small differences were observed in the suburban community. Third, higher percentages of urban children, both LBW and NBW, scored above the clinical cutoffs compared with their suburban counterparts.

RESULTS FROM GEE ANALYSIS OF DATA FROM MOTHERS AND TEACHERS AT AGES 6, 11, AND 17 YEARS

Table 4 depicts the results from the GEE models that estimate the effects of LBW on the risk for psychiatric problems above the cutoffs. Models include community (urban vs suburban), informant (mother vs teacher), assessment age, and sex as covariates.

For attention problems, a significant interaction was found between LBW and urban (vs suburban) community, indicating that the estimated effect of LBW was significantly different between urban and suburban children ($P = .008$). In the suburban community, the LBW effect on attention problems was not significant as estimated by the coefficient for LBW in this model, which includes an interaction term of LBW × urban ($\beta = 0.08$; adjusted OR [AOR] = 1.08; 95% CI, 0.64-1.85). In contrast, in the urban community, the LBW effect on the occurrence of attention problems was robust as estimated by the sum of the coefficients for LBW and the LBW × urban interaction term ($\beta = 0.08 + 0.94 = 1.02$; AOR = 2.78; 95% CI, 1.77-4.37).

The LBW × urban interactions for externalizing and internalizing disturbances did not reach statistical signifi-

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Table 5. Results From Generalized Estimating Equations Regression for Borderline or Clinical Attention Problems in 823 Children by Level of Low Birth Weight[a]

Variable	Attention β (SE)	Attention *P* Value
LBW vs NBW[b]		
≤1500 g	0.46 (0.42)	.28
1501-2500 g	−0.01 (0.29)	.97
Urban vs suburban	0.24 (0.28)	.39
Mother's rating vs teacher's rating	0.27 (0.11)	.02
Age 11 y vs 6 y	0.29 (0.12)	.01
Age 17 y vs 6 y	−0.44 (0.15)	.003
Male vs female	0.34 (0.15)	.03
≤1500 g × urban	1.19 (0.52)	.02
1501-2500 g × urban	0.86 (0.38)	.02

Abbreviations: LBW, low birth weight; NBW, normal birth weight.
[a]The generalized estimating equations model is adjusted for all of the other variables in the table. The LBW effects as adjusted odds ratios calculated from the adjusted partial regression coefficients were as follows: for attention problems in suburban children with birth weights of 1500 g or less, 1.58 (95% confidence interval, 0.69-3.61); for attention problems in suburban children with birth weights from 1501 to 2500 g, 0.99 (95% confidence interval, 0.56-1.76); for attention problems in urban children with birth weights of 1500 g or less, 5.17 (95% confidence interval, 2.86-9.34); and for attention problems in urban children with birth weights from 1501 to 2500 g, 2.35 (95% confidence interval, 1.48-3.73).
[b]Low birth weight indicates birth weight of 2500 g or less.

cance (*P*=.26 and .53, respectively). Because no significant interactions were detected between LBW and urban vs suburban for externalizing or internalizing problems, we cannot reject the hypothesis that the LBW effects on these disturbances were uniform across the 2 communities. In both communities, LBW increased the risk for externalizing problems (β=0.42; AOR=1.53; 95% CI, 1.21-1.93) and internalizing problems (β=0.25; AOR=1.28; 95% CI, 1.04-1.57) after adjustment for covariates.

In separate models (not shown), we examined the potential contribution of intrauterine growth retardation, measured as small for gestational age (SGA) (<10th percentile), to the risk of disturbances. We classified children into 4 groups: LBW/SGA, LBW and appropriate for gestational age (AGA), NBW/SGA, and NBW/AGA, with the last group serving as the reference. The LBW/AGA and LBW/SGA urban children showed increased risk for attention problems (AOR=2.55; 95% CI, 1.57-4.15 for LBW/AGA; AOR=3.17; 95% CI, 1.79-5.61 for LBW/SGA) that did not differ significantly (*P*=.34). No increased risk was detected in corresponding categories of suburban children. The LBW/AGA and LBW/SGA children in both communities were at increased risk for externalizing disturbances (AOR=1.44; 95% CI, 1.13-1.85 for LBW/AGA; AOR=1.72; 95% CI, 1.20-2.47 for LBW/SGA) and internalizing disturbances (AOR=1.28; 95% CI, 1.03-1.58 for LBW/AGA; AOR=1.18; 95% CI, 0.84-1.65 for LBW/SGA), with no evidence of significant differences between the LBW/AGA and LBW/SGA groups (*P*=.32 and .64, respectively). In both communities, NBW/SGA children did not differ from NBW/AGA children on any of the outcomes. In summary, SGA did not confer an excess risk of psychiatric disturbance over and above LBW.

The results in Table 4 also show that urban children (with both LBW and NBW) had a higher risk of externalizing problems than suburban children (β=0.73; AOR=2.07; 95% CI, 1.64-2.61). Compared with the baseline assessment at age 6 years, the risk for attention problems was higher at age 11 years (AOR=1.33; 95% CI, 1.06-1.67) but lower at age 17 years (AOR=0.65; 95% CI, 0.50-0.87) (Table 4). The risk for internalizing problems was also lower at age 17 years than at age 6 years (AOR=0.82; 95% CI, 0.68-0.99) but showed no difference at age 11 years vs age 6 years. However, LBW effects on any of the 3 disturbance domains did not change significantly across assessments as can be inferred from the failure to detect interactions between LBW and age at assessment for any of the outcomes. In other words, LBW effects were stable over time. Effects of LBW also did not vary by informant (mother vs teacher) as an interaction between LBW and informant was not detected.

To check the estimates calculated with data from all of the children with 1 or more assessments by either informant (Table 4), we repeated the analysis on the subset of children with complete data on the CBCL and TRF at all of the 3 assessments (n=451). The results were similar to those from the analysis described earlier that used all of the available data. For example, the AOR for attention problems in LBW vs NBW suburban children was 1.06 (95% CI, 0.54-2.11); in LBW vs NBW urban children, the AOR was 3.08 (95% CI, 1.67-5.66) (compared with 1.08 and 2.78, respectively, in the entire sample, including subjects with incomplete data). The GEE regressions using the total sample yielded more precise estimates of the regression coefficients as they have smaller corresponding standard errors.

LEVELS OF LBW

We investigated the extent to which the increased risk for behavior problems above the cutoff in LBW children differed by level of LBW, ie, 1500 g or less (the commonly used cutoff for VLBW) (n=76) and 1501 to 2500 g (n=397) (**Table 5**). Children of NBW served as the reference. For attention problems, significant interactions with urban vs suburban community were detected for both LBW subgroups. The size of the interaction (ie, the differential effect in urban vs suburban) was larger for VLBW (≤1500 g) than for higher LBW (1501-2500 g). The AORs were 5.17 (95% CI, 2.86-9.34) and 2.35 (95% CI, 1.48-3.73), respectively. Although the estimates were significant for both LBW levels, the estimate for VLBW children was significantly larger (*P*=.002). Estimates for externalizing and internalizing problems did not differ between LBW levels.

COMMENT

In this longitudinal study that followed up children through the period of school attendance, we examined the stability of psychiatric outcomes of LBW in 2 socioeconomically disparate communities, combining data from 2 informants at 3 points. The LBW children had modestly elevated risks (compared with NBW children) of the occurrence of externalizing and internalizing prob-

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lems above the normal range, with no evidence of differences between the 2 communities. The relationship between LBW and attention problems during that period differed between the 2 communities: an increased risk of attention problems associated with LBW (vs NBW) was observed only in the urban community, where it was approximately 3-fold. The LBW effect on attention problems in urban children was greater among VLBW children (≤1500 g) than among heavier LBW children (1501-2500 g). In the suburban community, there was no difference in the risk of attention problems between LBW and NBW children. The effects of LBW on these psychiatric disturbances, including the specificity of the LBW effect on attention problems in urban children, were stable during the period of school attendance.

We evaluated the psychiatric outcomes of LBW in 2 socioeconomically disparate communities, a strategy designed to disentangle the effects of LBW from the effects of the social environment with which it is correlated. The LBW effects that are found to be consistent between the 2 disparate communities are unlikely to be attributable to the social environment. To maintain the integrity of the design, the statistical models did not adjust for maternal education and other factors on which the 2 communities differed markedly. However, it is of interest that when we included these variables, we found that although maternal education and single-parent status contribute to children's behavior problems, their contributions are independent of the effects of LBW. Estimates of the results (Table 4) were only minimally changed.

Our findings of a differential LBW effect on attention problems between the 2 socioeconomically disparate communities might reflect a beneficial influence of the enriched social environment afforded to children in suburban middle-class communities at home, at school, and in the neighborhood.[38] Alternatively, the urban disadvantaged environment might exacerbate the effect of prenatal adversity as indicated by LBW. The differential effect of LBW on clinical levels of attention problems was detected at the first assessment at age 6 years and persisted up to the completion of high school. Evidence for an interaction between biological factors associated with LBW and social environment has been reported previously for several outcomes.[39-42] However, most studies of the LBW–psychiatric disturbances relationship have not specifically tested this interaction. A recent exception is a study[43] in the United Kingdom that found nonuniform LBW effects across socioeconomic classes. A significant excess of high psychological difficulties was found in lower birth weight tertiles for social classes III nonmanual and III manual, but smaller and nonsignificant effects were found for social classes I + II and IV + V.

In this study, psychiatric disturbance was not diagnosed by a clinician and was not based on the official psychiatric classification of childhood disorders. However, the empirically derived rating scales administered to mothers and teachers have been widely used, and their reliability and validity are supported by an extensive body of research.[32] The attention syndrome scale maps onto the *DSM* diagnostic criteria for ADHD, and empirically based cutoffs on these scales define children with clinically significant levels of disturbances.[32] Important strengths of the study deserve mention. First, we combined information from mothers and teachers rather than relying on a single informant.[35] Teachers' reports are based on a broad perspective afforded by evaluating a child in comparison with his or her peers and in the classroom context. Each informant might have a valid perspective; using both sources adds to the integrity of the classification.[44] Second, the study design in which LBW effects are estimated in 2 disparate communities reduces the potential for confounding the effects of LBW (especially the range of LBW that is above the VLBW range in which early deficits are not conspicuous) with the effects of socioeconomic disadvantage. The design offers a clear advantage over studies that rely on statistical controls to separate the effects of prenatal adversity from the effects of socioeconomic disadvantage. Third, we used measures of psychiatric problems from 3 periods: age 6 years, when children are starting school; age 11 years, midway through school; and age 17 years, when secondary school is nearing an end. Fourth, we examined the relationship between LBW and psychiatric problems using the full LBW range (≤2500 g), which allowed for testing of a gradient effect of LBW on psychiatric outcomes.

The psychiatric outcomes in this study are high scores on behavior problem scales that are above the cutoffs defining borderline or clinical disturbance. An increased risk for scoring above the cutoffs signifies an increased likelihood for disturbance that is clinically important. The implications of the findings on outcomes of LBW, which we found to be stable with little improvement during the period of school attendance, are informed by research on the continuity of disorders from childhood to adulthood,[45,46] the effects of disorders on social and work performance in adulthood,[47] and the effects of children's psychiatric disorders, traits, and behaviors on educational attainment, a critical bridge to adult social and economic outcomes.[48-51] Low-birth-weight children were found to be at a modestly increased risk for externalizing and internalizing disturbances. However, a major concern is raised by the 3-fold increased risk for attention problems in LBW urban children, problems that correspond to ADHD. A recent article estimated that 36.3% of adults with history of ADHD in childhood met criteria for current ADHD.[52] The estimated costs in lost work are substantial.[53] Attention problems at the start of schooling predict lower academic achievement later, controlling for key factors that contribute to academic test scores, which in turn predicts termination of schooling and curtailed educational attainment.[54] Attention problems influence academic performance by reducing the time that students devote to class learning and homework assignments and hinder organization and work habits. Early interventions to improve attention skills in urban LBW children might yield better outcomes later.

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