Sleep-Disordered Breathing in a Population-Based Cohort: Behavioral Outcomes at 4 and 7 Years
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Sleep-Disordered Breathing in a Population-Based Cohort: Behavioral Outcomes at 4 and 7 Years

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KEY WORDS
sleep-disordered breathing, behavior, longitudinal

ABBREVIATIONS
ALSPAC—Avon Longitudinal Study of Parents and Children
CI—confidence interval
HOME—Home Observation for Measurement of the Environment
OR—odds ratio
SDB—sleep-disordered breathing
SDQ—Strengths and Difficulties Questionnaire
SES—socioeconomic status

All authors meet the criteria for authorship; Dr Bonuck conceptualized and designed the study, drafted the initial manuscript, reviewed and modified the analyses in collaboration with Drs Freeman and Xu, and incorporated coauthor feedback into the final manuscript. Dr Freeman worked to develop the methods, carried out initial analyses, supervised final analyses of Dr Xu, and reviewed and revised the final manuscript. Dr Chervin advised on study design and analyses, and carefully reviewed and revised multiple versions of the manuscript. Dr Xu collaborated on statistical design issues, completed final analyses, and reviewed and revised the final version of the article.

Dr Xu’s current affiliation is Department of Pediatrics, Baylor College of Medicine. Dr Freeman is currently semi-retired.

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WHAT’S KNOWN ON THIS SUBJECT: Sleep-disordered breathing is associated with neurobehavioral morbidity in children. Prior related research has generally been cross-sectional or short (ie, 1–2 years) follow-up studies of a single symptom (ie, snoring, obstructive sleep apnea, mouth breathing), with limited control for confounders.

WHAT THIS STUDY ADDS: Sleep-disordered breathing was assessed as a trajectory of combined symptoms from 6 months to 69 months, in more than 11 000 children. Sleep-disordered breathing was associated with 40% and 60% more behavioral difficulties at 4 and 7 years, respectively.

Abstract

OBJECTIVES: Examine statistical effects of sleep-disordered breathing (SDB) symptom trajectories from 6 months to 7 years on subsequent behavior.

METHODS: Parents in the Avon Longitudinal Study of Parents and Children reported on children’s snoring, mouth breathing, and witnessed apnea at ≥2 surveys at 6, 18, 30, 42, 57, and 69 months, and completed the Strengths and Difficulties Questionnaire at 4 (n = 9140) and 7 (n = 8098) years. Cluster analysis produced 5 “Early” (6–42 months) and “Later” (6–69 months) symptom trajectories (“clusters”). Adverse behavioral outcomes were defined by top 10th percentiles on Strengths and Difficulties Questionnaire total and subscales, at 4 and 7 years, in multivariable logistic regression models.

RESULTS: The SDB clusters predicted ∼20% to 100% increased odds of problematic behavior, controlling for 15 potential confounders. Early trajectories predicted problematic behavior at 7 years equally well as at 4 years. In Later trajectories, the “Worst Case” cluster, with peak symptoms at 30 months that abated thereafter, nonetheless at 7 years predicted hyperactivity (1.85 [1.30–2.63]), and conduct (1.60 [1.18–2.16]) and peer difficulties (1.37 [1.04–1.80]), whereas a “Later Symptom” cluster predicted emotional difficulties (1.65 [1.21–2.07]) and hyperactivity (1.88 [1.42–2.49]). The 2 clusters with peak symptoms before 18 months that resolve thereafter still predicted 40% to 50% increased odds of behavior problems at 7 years.

CONCLUSIONS: In this large, population-based, longitudinal study, early-life SDB symptoms had strong, persistent statistical effects on subsequent behavior in childhood. Findings suggest that SDB symptoms may require attention as early as the first year of life. Pediatrics 2012;129:1–9.
Neurobehavioral morbidity is common in childhood sleep-disordered breathing (SDB) that can range from snoring to obstructive sleep apnea. Mouth breathing is another frequent clinical finding. SDB causes abnormal gas exchange, interferes with sleep’s restorative processes, and disrupts cellular and chemical homeostasis. The supposed resultant dysfunction of the prefrontal cortex impairs attention, executive functioning, behavioral inhibition, self-regulation of affect and arousal, and other socio-emotional behaviors. Behavioral manifestations include both externalizing (eg, hyperactivity, aggression, impulsivity) and internalizing (eg, somatic complaints, social withdrawal) behaviors. SDB reportedly peaks from 2 to 6 years of age, but also occurs in younger children. SDB’s neurologic effects may be irreversible, highlighting the saliency of under-detection. SDB presents as a heterogeneous disorder in children. Understanding how and when SDB symptom patterns in early life affect neurobehavioral outcomes has clinical implications for deciding whether, how, and in whom to intervene. Yet, existing studies of SDB’s neurobehavioral effects in children are primarily cross-sectional, and limited by poor sampling, insufficient consideration of confounders, and imprecise use of statistical tools. The few longitudinal studies are either before or after tonsillectomy or follow children for ≤2 years. This study describes the combined trajectory of 3 hallmark SDB symptoms (snoring, mouth breathing, and witnessed apnea) and their longitudinal statistical effects on behavior. Our research questions were (1) What effect do early SDB trajectories, from 6 through 42 months of age, have on social-emotional behavior at 4 and 7 years? and (2) What effect do SDB trajectories from 6 months through 69 months have on behavior at 7 years of age? We analyzed previously collected observational data from a critical period in SDB development, from 6 months through nearly 7 years of age in a prospective, population-based cohort.

**METHODS**

**Population**

The Avon Longitudinal Study of Parents and Children (ALSPAC), a geographically based cohort study of children, enrolled pregnant women residing in a defined part of the former county of Avon in southwest England with an expected date of delivery between April 1991 and December 1992. A total of 14,541 pregnant women were enrolled. The cohort, described in detail elsewhere, is broadly representative of the UK population in terms of socioeconomic status (SES), although with a slight underrepresentation of ethnic minority families, and overrepresentation of wealthier families. Our analyses excluded twin, triplet, and quadruplet births; children who did not survive to 1 year; and children with conditions, such as major congenital disorders, that are likely to affect SDB or behavioral assessment. The resulting base sample, used to derive SDB clusters and behavioral outcomes, was 13,467 infants.

ALSPAC’s internal law and ethics committee reviews all proposals for secondary analyses and approves policies for data handling and analysis. Ethical approval for this analysis was obtained from the ALSPAC Law and Ethics Committee and UK Local Research Ethics Committee. All participants provided informed consent.

**SDB Assessment**

Questionnaires, designed and mailed as part of the original ALSPAC study when children were 6, 18, 30, 42, 57, and 69 months of age, asked parents to report on their child’s snoring, apnea, and mouth breathing. These items were as follows: (1) Mouth breathing: “Does he or she breathe through the mouth rather than the nose?” At 57 months and older, parents were asked to report separately for mouth breathing when awake versus asleep, although only the latter was used in analyses. (2) Snoring: “Does he or she snore for more than a few minutes at a time?” (3) Apnea: “When asleep, does he or she seem to stop breathing or hold breath for several seconds at a time?” The ALSPAC parent-reported SDB measures are similar or identical to items validated against polysomnographic data from sleep laboratories. Some validated questionnaires have included parent report of all 3 SDB symptoms, whereas others have included only snoring and apnea.

Responses were categorized along ordinal scales of 3, 4, or 5 levels. Given this inconsistency in (preexisting) response categories, we extrapolated the values to a common scale (0–100) with the “Always” responses anchored at one end and the “Never” or “Rarely/Never” responses anchored at the other, and proportionate spacing in-between (ie, a 4-category scale was recoded as 0, 33, 66, 100). Variables were then transformed to z scores, with higher scores indicating greater symptom burden.

**Behavior Assessment**

The Strengths and Difficulties Questionnaire (SDQ), a widely used behavioral screen, was completed by mothers when children were ~4 and 7 years old. The 25-item SDQ has 5 scales: inattention/hyperactivity, emotional symptoms (anxiety and depression), peer problems, conduct problems (aggressiveness and rule breaking), and a pro-social scale (sharing, helpfulness, and so forth). A total difficulties (range = 0–40) score is generated by summing all but the latter scale because the absence of pro-social behavior is conceptually different from the
presence of psychological difficulties. Higher scores denote more problems. Missing data were prorated according to psychometric testing. The SDQ scores were dichotomized at the upper 10% based on SDB data for 8064 participants, included 7383 (92%) with SDB data for ≥3/4 time points. Likewise, Later cluster analyses (SDQ 7-year data) for 8064 participants, included 7383 (92%) with SDB data for ≥5/6 time points. Missing SDQ or SDB data were significantly associated with non-white race, prematurity, low birth weight, manual (versus professional) paternal employment, lower (versus higher) maternal educational status, housing inadequacy, not being breastfed, and higher levels of wheezing (not shown).

**RESULTS**

**Data Completion and Attrition**

SDB longitudinal data were relatively complete. Early cluster analyses of the 7996 participants with SDQ 7-year outcomes included 7716 (95%) with SDB data for ≥3/4 time points. Likewise, Later cluster analyses (SDQ 7-year data) for 8064 participants, included 7383 (92%) with SDB data for ≥5/6 time points. Missing SDQ or SDB data were significantly associated with non-white race, prematurity, low birth weight, manual (versus professional) paternal employment, lower (versus higher) maternal educational status, housing inadequacy, not being breastfed, and higher levels of wheezing (not shown).

**Sample Characteristics and Association With Top 10% of SDQ Total Scores**

Characteristics of the base sample and associations with behavioral outcomes are shown in Table 1. Children in the upper 10% of SDQ scores had significantly more adverse characteristics (eg, higher maternal smoking, older delivery age, lower maternal education, higher Family Adversity Index scores, lower HOME scores, housing inadequacy, prematurity, low birth weight, and being male) than the remaining 90% at 4 and 7 years, but there were no differences by race, maternal alcohol intake during pregnancy, or tonsils removal.

**Cluster Description and Association With Sample Characteristics**

Cluster analyses yielded 1 asymptomatic (“Normals,” 45% of sample) and 4 symptomatic (55% of sample) trajectories. Early clusters, shown in Fig 1, can be summarized as (1) symptoms “Peak @ 6” and then abate, (2) symptoms “Peak @ 18” months and then abate, (3)

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symptoms peak at 30 months and then persist (“Worst Case”), (4) symptoms emerge at 42 months and then persist (“Late Symptom”) and (5) “Normals” who are asymptomatic throughout. Snoring levels were nearly double those of apnea or mouth breathing in Worst Case and Late Symptom versus comparable symptom levels in other clusters. Whether assessed as a continuous or dichotomous (10% vs 90%) variable, SDQ total scores differed significantly across the 4 symptomatic clusters, and in combined symptomatic clusters versus Normals (Table 2). Early clusters’ descriptive characteristics are shown in Supplemental Table 6.

Five comparable Later clusters are illustrated in Fig 2. Patterns are similar to the Early clusters, except that in this Late Symptom cluster, snoring and mouth breathing peak together at lower levels at 57 months with no marked apnea, and the Peak @ 6 apnea levels are nearly double those of the Early clusters.

**SDQ Total Score**

The SDB clusters significantly predict SDQ total scores at 4 and 7 years (Table 3). Early cluster effects are 20% to 70% in multivariate analyses. The strongest and most persistent is for Worst Case, with comparable outcomes at 4 (OR = 1.49, 95% CI = 1.11–1.99) and 7 years (OR = 1.72, 95% CI = 1.31–2.25). Later clusters’ effects are 40% to 100% in multivariate analyses, including a ≈40% effect for Peak @ 6 and ≈50% effect for Peak @ 18. Membership in any symptomatic cluster is associated with being in the upper 10% of total SDQ scores (versus Normals), an effect that increases slightly from 4 (OR = 1.33, 95% CI = 1.14–1.56) to 7 years (OR = 1.52, 95% CI = 1.24–1.85: Later clusters). Multivariate effects are strongly attenuated from unadjusted effects (Supplemental Table 7).

**SDQ Subscores**

In adjusted analyses, nearly every cluster-subscale association was significant (Table 4), with effects of 20% to 100% (see Supplemental Table 7 for unadjusted effects.) Details are in the following paragraphs.
Pro-social

Peak @ 6 was associated with ≈30% greater odds of being in the lowest decile across outcomes at 4 and 7 years. All of the remaining associations were not significant.

Hyperactivity

With 1 exception, all effects (≈20%–100%) were significant, and increased from 4 to 7 years. Furthermore, Early cluster effects at 4 years for Worst Case and Late Symptom equaled or increased at 7 years.

Emotional

With 1 exception at 4 years, all effects were significant (range ≈20%–65%), and most increased from 4 to 7 years. Late Symptom had the strongest effect at 4 and 7 years based on Early cluster models, with effects persisting to 7 years in Later cluster models.

Conduct

With 1 exception, all effects were significant (range ≈30%–70%). Both Worst Case and Peak@18 effects increased from 4 to 7 years, whereas Late Symptom and Peak @ 6 effects attenuated over that time.

Peer

Half of the cluster-subscale associations were significant, and SDB effects were more modest (range ≈30%–50%) and stable over time, compared with the other subscales. Effects were strongest for Worst Case.

DISCUSSION

We examined the effects of snoring, apnea, and mouth-breathing patterns (clusters) on behavior, from infancy through 7 years in more than 11 000 children. By 4 years, children in the symptomatic clusters were ≈20% to 60% more likely to exhibit behavioral difficulties consistent with a clinical diagnosis; by 7 years, they were ≈40% to 100% more likely. These effects, in a population-based cohort that controlled

TABLE 2 Association Between Early Clusters (n = 11c049) and SDQ outcome

<table>
<thead>
<tr>
<th>Outcome SDQ</th>
<th>Peak at 6 (n = 2277)</th>
<th>Peak at 8 (n = 1881)</th>
<th>Worst Case (n = 878)</th>
<th>Late Symptom (n = 1023)</th>
<th>Normals (n = 4990)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDQ top 10% at 4 y*</td>
<td>13.7%</td>
<td>15.0%</td>
<td>18.8%</td>
<td>19.5%</td>
<td>10.1%</td>
</tr>
<tr>
<td>SDQ top 10% at 7 y*</td>
<td>12.1%</td>
<td>12.9%</td>
<td>17.7%</td>
<td>14.9%</td>
<td>8.4%</td>
</tr>
<tr>
<td>SDQ continuous at 4 y, mean (SD)*</td>
<td>14.59 (3.59)</td>
<td>14.66 (3.70)</td>
<td>15.32 (3.96)</td>
<td>15.35 (3.91)</td>
<td>13.88 (3.44)</td>
</tr>
<tr>
<td>SDQ continuous at 7 y, mean (SD)*</td>
<td>8.13 (4.98)</td>
<td>7.94 (4.93)</td>
<td>8.83 (5.51)</td>
<td>8.36 (4.91)</td>
<td>6.76 (4.49)</td>
</tr>
<tr>
<td>SDQ top 10% at 4 y*</td>
<td>15.74%</td>
<td>10.07%</td>
<td>8.41%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDQ top 10% at 7 y*</td>
<td>13.46%</td>
<td>13.88 (3.44)</td>
<td>6.76 (4.49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDQ continuous at 4 y, mean (SD)*</td>
<td>14.84 (3.74)</td>
<td>13.88 (3.44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDQ continuous at 7 y, mean (SD)*</td>
<td>8.20 (5.01)</td>
<td>6.76 (4.49)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P values are calculated from χ² test for categorical variables and analysis of variance for continuous variables.

aP < .01 for difference between top 10% versus lower 90%.
for 15 putative confounders, exceeded those of any measured prenatal (ie, maternal age, smoking or alcohol use), gestational age, birth weight, breastfeeding, SES, family adversity, or home environment exposure. Furthermore, SDB effects at 4 years were as predictive of behavioral difficulties at 7 years. The worst symptoms were associated with the worst behavioral outcomes. Among the neurobehavioral domains assessed, hyperactivity was most affected.

Compared with previous parent-reported effects of SDB on Later behavior, our findings are conservative. In a study of 1000 third graders, snoring at baseline was associated with 2- to 10-fold increases in SDQ-assessed hyperactivity, and emotional, conduct, and peer difficulties at 1-year follow-up in age- and gender-adjusted analyses. A pediatric clinic sample of 229 2- to 13-year-olds found that baseline SDB symptoms predicted fourfold increases in hyperactive behaviors at 4-year follow-up, after adjustment for age, gender, and baseline hyperactivity. These studies differed from ours, with smaller, less representative samples, lack of data from the earliest years, use of other (non-SDQ) behavioral measures, and limited control for confounders. Alternatively, several cross-sectional studies that used different operational definitions of SDB and SDQ outcomes found no effects. One, a large nationally representative cross-sectional sample of 5000 Australian 4- to 5-year-olds, found that neither SDQ total, nor the Hyperactivity, Peer, or Emotional scale (actual) scores were greater among children with “snoring and/or breathing difficulties” during sleep ≥4 times per week. Likewise, among 635 6- to 8-year-olds, snoring ≥1 time per week in the past 6 months was not associated with high (upper 10th percentile) SDQ scores. This is the first study to assess SDB as a trajectory of combined symptoms, across a key period of SDB development from 6 months to 81 months, in a large sample. Previous studies had smaller samples that were often cross-sectional, or had shorter follow-up. Many were not population-based, involved school-age children only, or did not adjust for as wide a range of confounders. The potential impact of confounders is illustrated by the fact that several covariates independently associated with the clusters were not significant in multivariate analyses, and most unadjusted effects of SDB attenuated in controlled analyses. Although residual confounding is possible, covariates were selected based on previous ALSPAC analyses of SDQ outcomes, and non-ALSPAC studies of sleep problem effects on SDQ outcomes.

The current study has several limitations. First, SDB data were derived from parent report, rather than objective testing; however, the symptom-items used reflect widely accepted and well-validated SDB risk factors. Second, because parents may hear snoring from another room, they may be more likely to report it than either apnea or mouth breathing. Third, observed apnea during infancy is difficult to distinguish from the more common central apnea; however, our finding that observed apnea in infancy tracked with more clearly obstructive symptoms through 7 years suggests that observed apneas of infancy may not always have

FIGURE 2
Later clusters.
TABLE 3 Cluster Effects on SDQ Total Scores at 4 and 7 Years

<table>
<thead>
<tr>
<th>Top 10% vs Lower 90%</th>
<th>Early Cluster Models</th>
<th>Later Cluster Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI)</td>
<td>4 y&lt;sup&gt;a&lt;/sup&gt; n = 9007</td>
<td>7 y&lt;sup&gt;b&lt;/sup&gt; n = 7996</td>
</tr>
<tr>
<td>Adjusted without BMI&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6 (1)</td>
<td>1.23 (1.00–1.51)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.25 (1.02–1.53)&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Peak at 18 mo (2)</td>
<td>1.28 (1.01–1.57)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.39 (1.12–1.72)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Worst Case (3)</td>
<td>1.40 (1.11–1.99)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.72 (1.31–2.25)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Late symptom (4)</td>
<td>1.56 (1.19–2.03)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.46 (1.12–1.91)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Smoking during pregnancy</td>
<td>NS.</td>
<td>1.21 (1.01–1.45)&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gender, male</td>
<td>1.18 (1.01–1.37)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.50 (1.29–1.76)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Maternal education, lower</td>
<td>1.40 (1.18–1.68)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.31 (1.11–1.55)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Paternal employment, manual</td>
<td>1.28 (1.08–1.51)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>NS.</td>
</tr>
<tr>
<td>Family Adversity Index</td>
<td>1.20 (1.15–1.24)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.25 (1.20–1.30)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>HOME score</td>
<td>NS.</td>
<td>0.91 (0.87–0.95)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Parity 1 vs 0 ≥2 vs 0</td>
<td>1.00 (0.85–1.19) 0.66 (0.53–0.83)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.72 (0.61–0.86)&lt;sup&gt;d&lt;/sup&gt; 0.58 (0.46–0.72)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Clusters 1, 2, 3 and 4 vs Normals (5)

<table>
<thead>
<tr>
<th>Early Cluster Models</th>
<th>Later Cluster Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 y&lt;sup&gt;a&lt;/sup&gt; n = 9007</td>
<td>7 y&lt;sup&gt;b&lt;/sup&gt; n = 7996</td>
</tr>
</tbody>
</table>

HOME, Home Observation for Measurement of the Environment; NS, not significant.

<sup>a</sup> Adjusted for fish intake, Family Adversity Index, mother and home score, smoking during pregnancy, alcohol during pregnancy, race, breastfeeding ever, housing inadequacy, parity, gestation age, paternal social, maternal education, birth weight, maternal age, gender.

<sup>b</sup> Additional adjusted for tonsils or adenoids removed.

<sup>c</sup> Covariates shown are only those that were significant (P < .05) in reduced models with each of the 4 symptomatic models incorporated as a separate variable (versus combined clusters 1, 2, 3, and 4).

<sup>d</sup> P < .01.

<sup>e</sup> P < .05.

TABLE 4 Adjusted Clusters Effects on SDQ Subscales at 4 and 7 Years

<table>
<thead>
<tr>
<th>Top 10% vs Lower 90% OR (95% CI)</th>
<th>Early Cluster Models</th>
<th>Later Cluster Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI)</td>
<td>4 y&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7 y&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pro-social</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6</td>
<td>1.26 (1.02–1.54)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.29 (1.04–1.60)&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Peak at 18 mo</td>
<td>1.25 (0.99–1.56)</td>
<td>1.21 (0.99–1.48)</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1.24 (0.91–1.68)</td>
<td>1.05 (0.78–1.41)</td>
</tr>
<tr>
<td>Late Symptom</td>
<td>1.01 (0.76–1.34)</td>
<td>0.91 (0.71–1.16)</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6</td>
<td>1.50 (1.23–1.83)</td>
<td>1.48 (1.12–1.97)</td>
</tr>
<tr>
<td>Peak at 18 mo</td>
<td>1.40 (1.13–1.74)</td>
<td>1.51 (1.15–1.98)</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1.98 (1.52–2.58)</td>
<td>1.85 (1.30–2.63)</td>
</tr>
<tr>
<td>Late Symptom</td>
<td>1.57 (1.20–2.05)</td>
<td>1.88 (1.42–2.49)</td>
</tr>
<tr>
<td>Emotional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6</td>
<td>1.38 (1.15–1.66)</td>
<td>1.45 (1.18–1.78)</td>
</tr>
<tr>
<td>Peak at 18 mo</td>
<td>1.32 (1.08–1.61)</td>
<td>1.47 (1.21–1.78)</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1.41 (1.08–1.85)</td>
<td>1.58 (1.21–2.07)</td>
</tr>
<tr>
<td>Late Symptom</td>
<td>1.62 (1.27–2.06)</td>
<td>1.65 (1.35–2.02)</td>
</tr>
<tr>
<td>Conduct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6</td>
<td>1.31 (1.06–1.63)</td>
<td>1.29 (1.01–1.65)</td>
</tr>
<tr>
<td>Peak at 18 mo</td>
<td>1.32 (1.05–1.67)</td>
<td>1.42 (1.13–1.78)</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1.53 (1.13–2.08)</td>
<td>1.60 (1.18–2.16)</td>
</tr>
<tr>
<td>Late Symptom</td>
<td>1.15 (0.83–1.54)</td>
<td>1.40 (1.09–1.78)</td>
</tr>
<tr>
<td>Peer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak at 6</td>
<td>1.14 (0.94–1.58)</td>
<td>1.03 (0.82–1.29)</td>
</tr>
<tr>
<td>Peak at 18 mo</td>
<td>1.18 (0.96–1.46)</td>
<td>1.22 (0.98–1.49)</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1.48 (1.13–1.95)</td>
<td>1.37 (1.04–1.80)</td>
</tr>
<tr>
<td>Late Symptom</td>
<td>1.19 (0.91–1.55)</td>
<td>1.17 (0.93–1.46)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Adjusted for fish intake, Family Adversity Index, mother and home score, smoking during pregnancy, alcohol during pregnancy, race, breastfeeding ever, housing inadequacy, parity, gestation age, paternal social, maternal education, birth weight, maternal age, gender.

<sup>b</sup> Additional adjusted for tonsils or adenoids removed.

<sup>c</sup> P < .01.

<sup>e</sup> P < .05.

These findings, from the largest-ever cohort study of SDB exposure and neurobehavioral morbidity, provide epidemiologic evidence that early childhood SDB effects may only become apparent years later. The most significant long-term effects occurred in children with the greatest overall levels of snoring, apnea, and mouth breathing throughout, peaking at 30 months. Even very early symptom peaks at 6 and 18 months are associated with ≈40% and 50%, respectively, increased behavioral morbidity at 7 years of age. This may be because of the increased vulnerability to SDB effects during this early critical period of brain development, when there is the greatest need for sleep.

a central etiology. Fourth, missing, lowest SDB and SDQ data were associated with identified SDB risk factors (eg, maternal smoking, lower SES). Although biases that involve selective dropout may alter prevalence estimates, other ALSPAC analyses found only marginal effects on regression models predicting behavioral outcomes. This is likely the case in our study, in which such biases would render our findings more conservative.
SDB is relatively common in childhood. In previous analyses of this cohort, the prevalence of habitual snoring ranged from 10% to 21%, from 6 months to 81 months. The potential clinical and educational implications of untreated SDB, therefore, are notable. As an example, we found significant (nearly twofold), and sustained effects on hyperactivity. In national survey data, children with attention-deficit/hyperactivity disorder had increased adjusted risks of comorbid learning disability (eightfold), anxiety (eightfold), and low social competence (threefold). Further, 40% to 80% of the nation’s 3 million 6- to 21-year-olds who receive special education for a developmental disability or delay also have attention-deficit/hyperactivity.

**CONCLUSIONS**

These population-based data found a strong and persistent association between SDB symptoms and behavior. This has clinical implications for screening and treatment. A 2009 consensus statement by UK pediatricians and pediatric specialists noted that “the natural history of SDB, where a child changes from normality to abnormality, and where the risks of developing complications of the condition outweigh the risks of the surgical intervention, has not been established.” Although data from multicenter, randomized controlled trials, such as the current National Institutes of Health–funded Childhood Adenotonsillectomy study, will provide some evidence of cause-and-effect relationships, our findings provide further epidemiologic evidence to support attention to SDB symptoms beginning as early as the first year of life.

**ACKNOWLEDGMENTS**

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