Attention-Deficit/Hyperactivity Disorder and Very Preterm/Very Low Birth Weight: A Meta-analysis

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CONTEXT: Although very preterm (VP), extremely preterm (EP), very low birth weight (VLBW), and extremely low birth weight (ELBW) newborns seem to have a higher risk of later attention-deficit/hyperactivity disorder (ADHD), the magnitude of the risk is not well-defined.

OBJECTIVE: To systematically review and meta-analyze the risk of VP/VLBW and EP/ELBW individuals to develop a ADHD categorical diagnosis or dimensional symptomatology compared with controls with normal weight and/or birth age.

DATA SOURCES: We used PsycINFO, Medline, Embase, and Cochrane databases.

STUDY SELECTION: We selected cross-sectional, prospective, or retrospective studies with no time or language restriction.

DATA EXTRACTION: Independent reviewers screened and extracted data using predefined standard procedures.

RESULTS: In 12 studies (N = 1787), researchers relying on a categorical diagnosis showed that both VP/VLBW and EP/ELBW subjects have a higher ADHD risk (odds ratio [OR] = 3.04 higher than controls; 95% confidence interval [CI] 2.19 to 4.21). In subgroup analyses, we demonstrated that the more extreme the cases, the higher the ORs (VP/VLBW: OR = 2.25 [95% CI 1.56 to 3.26]; EP/ELBW: OR = 4.05 [95% CI 2.38 to 6.87]). We drew data from 29 studies (N = 3504) on ADHD symptomatology and found significant associations with inattention (standardized mean difference [SMD] = 1.31, 95% CI 0.66 to 1.96), hyperactivity and impulsivity (SMD = 0.74, 95% CI 0.35 to 1.13), and combined symptoms (SMD = 0.55, 95% CI 0.42 to 0.68) when compared with controls.

LIMITATIONS: Heterogeneity was significantly high for all analyses involving the 3 ADHD dimensions.

CONCLUSIONS: With our results, we provide evidence that VP/VLBW subjects have an increased risk of ADHD diagnosis and symptomatology compared with controls, and these findings are even stronger in the EP/ELBW group. Future researchers should address which risk factors related to prematurity or low birth weight lead to ADHD.
Prematurity is an important public health issue because of its high prevalence rates and related morbidity and mortality. In 2010, the worldwide prevalence of preterm births was estimated at 11.1% (14.9 million), and a significant amount of these were born very preterm (VP) (10.4%, 1.6 million) and extremely preterm (EP) (5.2%, 0.78 million).

Preterm or low birth weight (LBW) children seem to have more cognitive and psychiatric disorders as well as an increased risk of attention-deficit/hyperactivity disorder (ADHD). ADHD is a neurodevelopmental disorder characterized by a nongenetic pattern of inattentive and/ or hyperactive or impulsive symptoms occurring more frequently than expected for the patient’s age. The worldwide ADHD prevalence is estimated to be between 3.4% and 5.3% in children and adolescents, and the disorder can persist over time, with an adult prevalence rate of ~2.5%. Compared with those with typical development, children and adolescents affected by ADHD frequently present lower educational achievement and self-esteem and higher levels of social impairment, antisocial behavior, and substance abuse as well as greater involvement in criminal activities and traffic accidents.

Researchers in some studies suggest a gradient correlation, by which the higher the level of prematurity or LBW, the higher the ADHD prevalence or risk. Thus, VP/very low birth weight (VLBW) and EP/extremely low birth weight (ELBW) individuals represent the highest risk groups for ADHD. There is also evidence from a longitudinal prospective cohort study that ADHD diagnosis is more stable in these groups from childhood through adulthood than in term-born individuals.

Despite the data suggesting that VP/VLBW and/or EP/ELBW is clinically relevant to ADHD, no meta-analysis specifically designed to address the risk of VP/VLBW individuals to develop ADHD has been published. Moreover, significant shortcomings are present in the few meta-analyses in which researchers evaluated associations between more general neurodevelopmental disorders and prematurity or LBW. In a previous meta-analysis of the cognitive and behavioral outcomes of preterm-born, school-aged children, Bhutta et al limited their search to case-control studies and excluded articles in which primarily LBW children were evaluated. In addition, the small number of included studies (7 samples from 6 studies) makes their results less robust. Bhutta et al showed that children born preterm had a 2.64-fold increased risk for ADHD and frequently manifested externalizing symptoms by the time they reached school age. In another meta-analysis, VP/VLBW children’s academic achievement and behavioral and executive functioning were evaluated, but its literature search was limited to a 10-year span, which could exclude relevant studies. The authors noted that the small number of studies limited the power of some correlational analyses, and they also detected potential publication bias in studies on teacher ratings of behavioral problems.

Although a definitive ADHD etiology has not yet been elucidated, a multifactorial interplay of genes and noninherited factors are implicated in its causal pathway. Several pre- and perinatal factors and preterm morbidities (eg, necrotizing enterocolitis, periventricular hemorrhage, leukomalacia, bronchopulmonary dysplasia, neonatal chronic lung disease, low Apgar score, white matter injury, slow head growth, etc) may play a significant role in the etiology of ADHD in premature individuals.

We conducted a systematic review and meta-analysis on the effects of VP/VLBW on ADHD diagnosis and dimensional symptoms. Our primary aim with this study was to verify the risk of VP/VLBW and EP/ELBW subjects to be given a diagnosis of ADHD obtained by validated diagnostic instruments. Our second aim was to examine ADHD diagnosis according to validated dimensional rating scales. Additionally, we sought to describe the most frequent perinatal characteristics, such as clinical/neurologic comorbidities, found in VP/VLBW subjects that might be associated with the occurrence of ADHD. We hypothesized that there would be a strong and clinically relevant risk of VP/VLBW children, adolescents, and adults to develop categorically and dimensionally defined ADHD.

**METHODS**

**Eligibility Criteria**

Studies included in this systematic review were peer-reviewed, cross-sectional, prospective (including cohorts) or retrospective follow-up studies of subjects diagnosed with ADHD or dimensional symptoms and who were VP, VLBW, EP, or ELBW. The search parameters included no initial cutoff date, and the final search was performed in April 2017. No publication language was ruled out.

**Participants**

We included studies with children, adolescents, and adults in which 1 or more of the following conditions was assessed: VP, VLBW, EP, or ELBW. Premature or LBW individuals must have been compared with a control group of subjects born near or at normal birth weight (NBW (≥2500 g) or near, at, or over 37 weeks of gestational age. A categorical ADHD diagnosis must have been established according to the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM-III); DSM-III-R; DSM-IV; or DSM-5 criteria. A hyperkinetic disorder diagnosis was also accepted according to
International Classification of Diseases, Ninth Revision (ICD-9) or ICD-10 criteria. Clinical assessment must have been performed either with validated diagnostic instruments (Supplemental Table 3) or with validated scales for assessing ADHD symptoms and questions addressing other pertinent DSM or ICD criteria. To select adequate instruments to assess ADHD dimensionally, we accepted a list of scales included in a recently published Cochrane meta-analysis on the dimensional diagnosis of ADHD, and we included 2 other instruments: the Attention Problem scale of the Child Behavior Checklist (CBCL) and the Hyperactivity scale of the Strengths and Difficulties Questionnaire (SDQ). These scales were included because they are part of the 2 best-known instruments for assessing psychopathology in children and adolescents, and their accuracy has been tested for ADHD symptomatology (Supplemental Table 4).

Information Sources
The bibliographic search included the PsycINFO, Medline, Embase, and Cochrane databases. The search strategy for each database can be found in Supplemental Table 5. Hand searches for published, unpublished, and ongoing studies were performed by reviewing the bibliography sections of the included full texts. We also e-mailed the most productive researchers in the field to obtain information on any ongoing or unpublished studies. If the author did not respond after 2 weeks, a second e-mail was sent.

Study Records
Data Management
The studies were uploaded to the Covidence production platform (https://www.covidence.org/), where duplicates were identified and manually excluded. The data were extracted to a Google spreadsheet according to predefined criteria (described in this section) and independently entered by 2 authors.

Selection Process
The 2-step online selection process began with title and abstract screening: 3 independent reviewers (A.P.F., G.U.B., and H.B) read the titles and abstracts and included studies according to the inclusion and exclusion criteria. Any discrepancies were resolved among the reviewers. An independent reviewer (L.A.R.) acted as arbitrator whenever consensus could not be achieved. The process concluded with full-text screening: 4 independent reviewers (A.P.F., G.U.B., H.B., and C.R.M.-M.) working in pairs read the full text of the studies selected in step 1 to determine if the inclusion criteria were met. At this point, any discrepancies were resolved among the reviewers. A third reviewer (L.A.R.) acted as arbitrator whenever consensus was not reached.

Data Collection Process
Data were collected and double-checked by 2 reviewers (A.P.F. and C.R.M.-M.), with a third reviewer (L.A.R.) acting as arbitrator. When multiple reports from the same group of individuals were identified, the following inclusion criteria were used: (1) the most complete data necessary for the meta-analysis, (2) age range for data collection (<18 years old), and (3) larger sample size.

Whenever necessary, the authors were contacted by e-mail to resolve questions emerging from the extraction process or to request additional data. If no response was received from the corresponding author, a second message was sent after 2 weeks. If there was no response, we sent an e-mail to the senior author before discarding the study from the data collection process.

Included Data
We collected the following information from each selected study: first author and year of publication; country in which the sample was collected; place (ie, hospital, neighborhood, or study sample name) and year of data collection; study design; presence of multiple births; mean age (weeks) and mean weight (grams) at birth; sex; mean age or age range at ADHD evaluation, severity of prematurity or underweight (ie, whether VP, EP, VLBW, or ELBW), and information source (ie, parents, teachers, or self-report); the name of the diagnostic instrument and ADHD rating scale; and clinical or neurologic and psychiatric comorbidities.

Study Factor and Outcomes
VP and VLBW were defined as gestational age < 32 weeks and birth weight < 1500 g, respectively. EP and ELBW are subgroups of VP/VLBW with higher degrees of prematurity or LBW: < 28 weeks and < 1000 g, respectively.

The primary outcome was categorically defined ADHD. The diagnosis could have been established through structured diagnostic interviews with parents or adult subjects. The same procedure was applied to ADHD rating scales filled out by subjects, parents, and/or teachers to collect data on ADHD dimensional symptoms.

Risk of Bias Assessment
All studies included for data extraction were independently assessed for bias. Two researchers (A.P.F. and C.R.M.-M.) independently rated the studies according to a modified version of the Newcastle-Ottawa scale (NOS), which assesses the quality of nonrandomized studies for systematic reviews and meta-analyses. A similar procedure was used in a recent publication. On its original scale, a study is judged from 3 major perspectives: (1) the
selection of study groups, (2) the comparability of the groups, and (3) ascertainment of either the exposure or outcome of interest for case-control or cohort studies, respectively.\textsuperscript{21} We used only the first 2 perspectives because the third item was already part of the inclusion criteria for our review (Supplemental Fig 6). All 4 subitems of the “selection” perspective could receive a maximum score of 1 star, whereas “comparability” could receive 2 stars. Thus, each study could have received a minimum of 0 stars (low quality and high risk of bias) and a maximum of 6 stars (high quality, low risk of bias).

**Data Synthesis**

Effect sizes were calculated as odds ratios (ORs) with 95% confidence intervals (CIs) for categorical data according to the number of ADHD and non-ADHD subjects among the VP and/or VLBW subjects, EP and/or ELBW subjects, and controls. To avoid 0 cases, the Cochrane-recommended approach of including 0.5 was applied.\textsuperscript{23} For rating scales with continuous data, we calculated the standardized mean difference (SMD) with a 95% CI. Given the expected diversity of methodology in the studies, we used DerSimonian and Laird’s random-effects models,\textsuperscript{24} which incorporate the effect of heterogeneity in the overall result to estimate the pooled effect sizes for both categorical and dimensional variables. When researchers provided data from more than 1 information source (ie, parents, teachers, and patients) in their studies, a priori preference was given to parent data. To evaluate the effect of individual studies on effect size, the jackknife method was applied. Jackknife sensitivity analysis is a common procedure used in meta-analysis to test the stability of the outcomes. This is done by recalculating the effect size by removing a different study each time and then repeating the analyses.\textsuperscript{25} Heterogeneity was assessed with the \( I^2 \) statistic. To further evaluate the effects of heterogeneity, we performed meta-regression analyses, examining the effects of age, article quality, the occurrence of multiple births, information source, country, and rating scale. For the final multivariate meta-regression model, we selected only those covariables associated with a \( P \leq .2 \) in univariate analyses.\textsuperscript{26} In addition, we evaluated publication bias using Egger’s statistical test.\textsuperscript{27} Meta-analysis was computed in the R software meta-package (version 4.7.0)\textsuperscript{28} Meta-regression analyses were performed in Stata 13.0 (StataCorp, College Station, TX).

**RESULTS**

Of 519 references identified in the literature search, 34 studies were included in the final analysis. In Fig 1, we present the Preferred Reporting Items for Systematic Reviews and Meta-Analysis\textsuperscript{29} trial selection flowchart. Studies included in the final analysis are reported in Table 1 (characteristics of studies included as categorical ADHD diagnosis for VP/VLBW or EP/ELBW) and Table 2 (characteristics of studies included as ADHD rating scales with continuous data for VP/VLBW or EP/ELBW). The 94 full texts excluded from the final analysis and the reasons for their exclusion can be found in Supplemental Table 11. The most frequent reason for eligibility phase exclusion was “measure not assessing or deriving strictly DSM or ICD ADHD diagnosis or dimensional scores” \((n = 37)\) (the list of instruments accepted for inclusion can be found in Supplemental Tables 3 and 4). E-mail correspondence with the most productive researchers in the field identified no ongoing or unpublished studies. Seven studies\textsuperscript{13,32,33,35–37,40} were entered as both diagnostic instruments (categorical data) and rating scales (continuous data) in the meta-analysis. The Extremely Premature Infants Cure (EPI Cure) Study was entered in both dimensional and categorical analyses because the same population was assessed at different times and with distinct evaluation methods: by Samara et al\textsuperscript{41} in 2008 (dimensional) and Johnson et al\textsuperscript{44} in 2010 (categorical), The same was done for the Central-West Canadian Cohort by Boyle et al\textsuperscript{42} in 2011 (dimensional) and Van Lieshout et al\textsuperscript{43} in 2015 (categorical). Woodward et al\textsuperscript{40} 2017 was also entered in both categorical and dimensional analyses because information from the dimensional scale (SDQ) was collected from the subjects at 2 years of age, and a categorical diagnosis was obtained at 9 years of age with the Development and Well-being Assessment (DAWBA). In 1 publication\textsuperscript{36} researchers included 2 cohorts, but data were only available under request from the 2004 Pelotas cohort data managers. The “Rainbow Babies and Children’s Hospital” name was given to 2 different cohorts. The participants were born between 1977 and 1979 for one\textsuperscript{49} and between 1992 and 1995 for the other.\textsuperscript{50}

Twelve studies involving 1787 subjects were included in the categorical diagnosis analysis. Subjects’ mean age and birth weight ranged from 26\textsuperscript{17} to 30.6\textsuperscript{13} weeks and from 818\textsuperscript{37} to 1320 g,\textsuperscript{13} respectively. Researchers reported patient assessment during childhood in 8 studies,\textsuperscript{13,32,34–38,40} during adolescence in 3 studies,\textsuperscript{30,31,33} and during adulthood in 1 study.\textsuperscript{39} Researchers reported female predominance in 5 studies,\textsuperscript{30,31,33,37,39} male predominance in 4 studies,\textsuperscript{13,33,38,40} and did not report on sex in 3 studies.\textsuperscript{32,34,36}

Twenty-nine studies (3504 individuals) were included for analysis of ADHD symptomatology.
according to ADHD rating scales. The age and birth weight ranged from 24.9 to 31 weeks and from 719 to 1320 g, respectively. Researchers assessed ADHD during childhood in 23 studies, during adolescence in 4 studies, and during adulthood in 2 studies. We again found a predominance of female subjects in the 15 studies. In both the categorical (Table 1) and the dimensional (Table 2) studies, clinical or neurologic correlates and psychiatric comorbidities were only sporadically reported, so no further analysis could be performed.

**Prematurity, LBW, and ADHD Diagnosis**

We found a significant risk of both VP/VLBW and EP/ELBW subjects to develop ADHD (pooled OR = 3.04 [95% CI 2.19 to 4.21], $I^2 = 17\%$, $P = .27$), as shown in Fig 2. The subgroup analysis demonstrated that the more extreme the case, the higher the OR (VP/VLBW: OR = 2.25 [95% CI 1.56 to 3.26], $I^2 = 0\%$, $P = .82$; EP/ELBW: OR = 4.05 [95% CI 2.38 to 6.87], $I^2 = 34\%$, $P = .21$). The subgroup analysis according to raters showed an OR = 3.13 (95% CI 2.10 to 4.68), $I^2 = 27\%$, $P = .20$ for parents and an OR = 2.53 (95% CI 1.31 to 4.89), $I^2 = 0\%$, $P = .41$ for patients (Supplemental Fig 7). No potential publication bias was found in this group of studies according to Egger’s test ($t = 0.89$ [$P = .39$]).

The sensitivity analysis is presented in Supplemental Table 6. In the EP/ELBW group, the procedure did not change the OR significantly, but the exclusion of Burnett et al (2014) and Scott et al (2012) dropped the heterogeneity from 34% to 0% ($P = .50$). In the overall analysis, there was no significant change in the OR, but the heterogeneity dropped from 17% ($P = .27$) to 0% ($P = .56$ and $P = .85$) with the exclusion of Breeman et al (2016) and Scott et al (2012), respectively.

**Prematurity, LBW, and ADHD Symptomatology**

The forest plot of the overall pooled SMD for inattention, hyperactivity or impulsivity (H/I), and combined symptoms are presented in Figs 3–5. Compared with controls, the SMD was significantly higher for H/I (SMD = 0.74 [95% CI 0.35 to 1.13], $I^2 = 95\%$, $P < .01$), inattention (SMD = 1.31 [95% CI 0.66 to 1.96], $I^2 = 97\%$, $P < .01$), and combined symptoms (SMD = 0.55 [95% CI 0.42 to 0.68], $I^2 = 81\%$, $P < .01$) because no intervals crossed the 0 axis. On the other hand, the comparison among the 3 dimensions is not significant because all 95% CIs are included in the same range, as demonstrated in Figs 3–5.

The overall heterogeneity was high for all 3 dimensions except the combined dimension in the VP/VLBW group (moderate $I^2 = 54\%$, $P < .01$). No potential publication bias was found, as demonstrated by Egger’s test ($t = 2.10$ [$P = .07$] and $t = 1.81$ [$P = .10$] for inattention and H/I, respectively). However, a potential bias was detected for the combined dimension ($t = 2.38$ [$P = .02$]).

The sensitivity analysis for the combined presentation can be found in Supplemental Table 7. The exclusion of Dahl et al (2006) and Hack et al (2004) reduced the
**Table 1** Characteristics of Studies Included as Categorical ADHD Diagnosis for VP/VLBW or EP/ELBW Subjects

<table>
<thead>
<tr>
<th>Author, y</th>
<th>Sample (Birth y)</th>
<th>Country</th>
<th>N</th>
<th>Mean Age at Birth, wk (Mean or Range)</th>
<th>Mean wt at Birth (g)</th>
<th>Age at Evaluation, y (Mean or Range)</th>
<th>Male (%)</th>
<th>Scale</th>
<th>Rater</th>
<th>Clinical or Neurologic Comorbidities, n (%)</th>
<th>Psychiatric Comorbidities, n (%)</th>
<th>Case-Control</th>
<th>Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breman et al, 2016</td>
<td>The Bavarian Longitudinal Study (1985–1989)</td>
<td>Germany</td>
<td>260</td>
<td>30.6</td>
<td>1320</td>
<td>6–8</td>
<td>53.1</td>
<td>MPI</td>
<td>Parents</td>
<td>SGA: 108 (41.5); Sev.D: 50 (19.2)</td>
<td>MD: 28 (14); BP: 1 (0.5); DD: 6 (3); GAD: 10 (5); Soc.P: 2 (1); Spe.P: 8 (4); PTSD: 3 (1); PD: 5 (2); agoraphobia: 1 (0.5); OCD: 4 (2)</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>Burnett et al, 2014</td>
<td>Victorian Infant Collaborative Study Group (1991–1992)</td>
<td>Australia</td>
<td>215</td>
<td>26.6</td>
<td>1218</td>
<td>17.9</td>
<td>45</td>
<td>CHIPS</td>
<td>Subject</td>
<td>MNI: 22 (10); SGA: 34 (16); PCU: 31 (67)</td>
<td>MDD: 28 (14); BP: 1 (0.5); DD: 6 (3); GAD: 10 (5); Soc.P: 2 (1); Spe.P: 8 (4); PTSD: 3 (1); PD: 5 (2); agoraphobia: 1 (0.5); OCD: 4 (2)</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Cooke and Abernethy, 1989</td>
<td>Liverpool Maternity Hospital (January 1980 to June 1981)</td>
<td>United Kingdom</td>
<td>87</td>
<td>28.6</td>
<td>1103</td>
<td>13</td>
<td>46</td>
<td>CAPA</td>
<td>Parents</td>
<td>PWH: 19 (21.8); MCL: 2 (2.2); convulsions: 7 (8); PBC: 22 (25.2%)</td>
<td>NS</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Indredavik et al, 2010</td>
<td>EPIcure Study: United Kingdom and Ireland (March to December 1995)</td>
<td>United Kingdom</td>
<td>219</td>
<td>≤26</td>
<td>NS</td>
<td>11</td>
<td>NS</td>
<td>DAWBA</td>
<td>Parents</td>
<td>NS</td>
<td>Aut.D: 16 (8); SAD: 5 (2.9); Spe.P: 3 (1.9); Soc.P: 1 (0.5); PTSD: 1 (0.5); GAD: 4 (2); MD: 3 (1.5); ODD: 11 (6); CD: 1 (0.5); TD: 2 (1)</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>Johnson et al, 2010</td>
<td>Dublin Maternity Hospital (1995–1998)</td>
<td>Ireland</td>
<td>64</td>
<td>30</td>
<td>1172</td>
<td>11.6</td>
<td>37.5</td>
<td>DAWBA</td>
<td>Parents</td>
<td>IVH: 12 (18.7); ACU: 40 (62.5)</td>
<td>ADNS: 8 (12.5); CD: 1 (1.5); Asp.D: 3 (4.6)</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Murray et al, 2016</td>
<td>2004 Pelotas cohort</td>
<td>Brazil</td>
<td>48</td>
<td>≤32</td>
<td>≤1500</td>
<td>6.7</td>
<td>NS</td>
<td>DAWBA</td>
<td>Parents</td>
<td>NS</td>
<td>NS</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Scott et al, 2012</td>
<td>Rainbow Babies and Children’s Hospital (2001–2003)</td>
<td>United States</td>
<td>148</td>
<td>26</td>
<td>818</td>
<td>5.96</td>
<td>46</td>
<td>P-ChIPS</td>
<td>Parents</td>
<td>ODD: 27 (19); CD: 8 (6); Spe.P: 24 (6); Sad: 8 (6); GAD: 4 (3)</td>
<td>SAD: 6 (3); Spe.P: 7 (4); GAD: 4 (2%); depression: 1 (0.5); ODD: 3 (2)</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>Treyvaud et al, 2013</td>
<td>Victorian Infant Brain Studies (2001–2003)</td>
<td>Australia</td>
<td>177</td>
<td>27.5</td>
<td>975</td>
<td>7</td>
<td>53</td>
<td>DAWBA</td>
<td>Parents</td>
<td>SGA: 16 (9); GBA: 117 (66.1); NDD: 9 (5.08)</td>
<td>SAD: 6 (3); Spe.P: 7 (4); GAD: 4 (2%); depression: 1 (0.5); ODD: 3 (2)</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Van Lieshout et al, 2015</td>
<td>CentralWest Ontario (1977–1982)</td>
<td>Canada</td>
<td>84</td>
<td>27.05</td>
<td>829</td>
<td>32.02</td>
<td>37</td>
<td>MINI</td>
<td>Subject</td>
<td>SGA: 26 (51); ACU: 46 (39)</td>
<td>Anx.D: 14 (18.6); AB: 7 (8.3); APP: 17 (20.2); depression 13 (15.4)</td>
<td>—</td>
<td>4</td>
</tr>
</tbody>
</table>
heterogeneity from moderate to low levels in the VP/VLBW group. In the EP/ELBW group, the exclusion of Grunewaldt et al38 (2014) reduced the heterogeneity from 90% to 72%, whereas the study’s exclusion reduced heterogeneity in the overall analysis from 81% (P < .01) to 62% (P < .01).

The most important modifications in the sensitivity analysis for H/I (Supplemental Table 8) were the lack of significance in the VP/VLBW analysis with the exclusion of Brogan et al44 (2014), Hack et al49 (2004), Indredavik et al33 (2010), and Levy-Shiff et al54 (1994). The exclusion of Grunewaldt et al48 (2014) reduced the heterogeneity from 92% (P < .01) to 0% (P = .45) in the EP/ELBW group. Regarding inattention (Supplemental Table 9), the exclusion of Brogan et al44 (2014), Hack et al49 (2004), and Indredavik et al33 (2010) resulted in a lack of significance in the VP/VLBW analysis. Heterogeneity dropped from high to moderate after the exclusion of Grunewaldt et al38 (2014) and Indredavik et al33 (2010) in the EP/ELBW and VP/VLBW groups, respectively. The exclusions altered neither the significance of the overall SMD nor the heterogeneity in either dimension.

Meta-regression

A meta-regression was not performed for categorically defined ADHD because low heterogeneity was found in the meta-analysis of this group.

With respect to the ADHD rating scales, we performed individual analyses for continuous and categorical covariables to better understand their heterogeneity. We included 1 covariable into the model at a time for each of the ADHD symptom dimensions: age, article quality, country, occurrence of multiple births, and information source (raters). As shown in Supplemental Table 10, countries
<table>
<thead>
<tr>
<th>Author, y</th>
<th>Sample (Birth y)</th>
<th>Country</th>
<th>N</th>
<th>Mean Age at Birth, wk (Mean or Range)</th>
<th>Mean wt at Birth (g)</th>
<th>Age at Evaluation, y (Mean or Range)</th>
<th>Male (%)</th>
<th>Scale</th>
<th>Rater</th>
<th>Clinical or Neurologic Comorbidities, n (%)</th>
<th>Psychiatric Comorbidities, n (%)</th>
<th>NOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al, 2011</td>
<td>State of Victoria (January to December 1997)</td>
<td>Australia</td>
<td>189</td>
<td>26.5</td>
<td>833</td>
<td>8.1</td>
<td>NS</td>
<td>Conners</td>
<td>Parents</td>
<td>CP: 22 (12); NV grade 3–4: 7 (4); CPL: 6 (3%); NE: 10 (5); RP: 97 (51%); BD: 119 (63); ACU: 166 (88); PCU: 70 (37)</td>
<td>SGA: 35 (26.8); NI: 23 (27)</td>
<td>NS</td>
</tr>
<tr>
<td>Bremner et al, 2016</td>
<td>The Bavarian Longitudinal Study (1985–1986)</td>
<td>Germany</td>
<td>290</td>
<td>30.6</td>
<td>1320</td>
<td>6–8</td>
<td>53.1</td>
<td>CBCL</td>
<td>Parents</td>
<td>SGA: 108 (41.5); SevD: 50 (19.2)</td>
<td>NS</td>
<td>—</td>
</tr>
<tr>
<td>Dahl et al, 2006</td>
<td>Two counties of Norway (1998–2004)</td>
<td>Norway</td>
<td>99</td>
<td>29.3</td>
<td>1188</td>
<td>13–18</td>
<td>44.4</td>
<td>CBCL, YSR</td>
<td>Parents, subject</td>
<td>CP: 8 (8.1); NV grade 3–4: 2 (3.9); BD: 11 (13.6); sepsis: 10 (10.1); PDA: 13 (15.3)</td>
<td>SGA: 18 (27.3); sepsis: 42 (63.8); BD: 19 (28.8); IVH: 14 (21.2)</td>
<td>ACU: 53 (80.3)</td>
</tr>
<tr>
<td>de Kieviet et al, 2012</td>
<td>VU University Medical Center Amsterdam (September 2001 to July 2003)</td>
<td>Netherlands</td>
<td>66</td>
<td>29.3</td>
<td>1241</td>
<td>7.5</td>
<td>50</td>
<td>CBCL</td>
<td>Parents</td>
<td>SGA: 18 (27.3); sepsis: 42 (63.8); BD: 19 (28.8); IVH: 14 (21.2)</td>
<td>ACU: 53 (80.3)</td>
<td>NS</td>
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<tr>
<td>Grunau et al, 2004</td>
<td>British Columbia's Children's Hospital (January 1981 to February 1986)</td>
<td>Canada</td>
<td>53</td>
<td>25.8</td>
<td>719</td>
<td>17.3</td>
<td>32</td>
<td>CBCL</td>
<td>Parents</td>
<td>SGA: 9 (17)</td>
<td>NS</td>
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<tr>
<td>Gruneisen et al, 2014</td>
<td>Trondheim University Hospital (1999–2001)</td>
<td>Norway</td>
<td>31</td>
<td>26.1</td>
<td>773</td>
<td>10.2</td>
<td>48</td>
<td>ADHD-RS</td>
<td>Parents</td>
<td>IVH: 11 (47); sepsis: 7 (30.4); PDA: 7 (30); ACU: 18 (58); PCU: 12 (39)</td>
<td>NS</td>
<td>—</td>
</tr>
<tr>
<td>Author, y Sample (Birth y)</td>
<td>Country</td>
<td>N</td>
<td>Mean Age at Birth, wk (Mean or Range)</td>
<td>Mean wt at Birth (g)</td>
<td>Age at Evaluation, y (Mean or Range)</td>
<td>Male (%)</td>
<td>Scale</td>
<td>Rater</td>
<td>Clinical or Neurologic Comorbidities, n (%)</td>
<td>Psychiatric Comorbidities, n (%)</td>
<td>Case Control</td>
<td>Cohort</td>
</tr>
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</tr>
<tr>
<td>Hack et al, 2009 Rainbow Babies and Children's Hospital (1992–1993)</td>
<td>United States</td>
<td>219</td>
<td>26.4</td>
<td>810</td>
<td>8</td>
<td>41</td>
<td>CSI-4</td>
<td>Parents</td>
<td>BD: 93 (43); sepsis: 108 (49); NE: 11 (5); IVH or PL: 51 (23)</td>
<td>ODD: 12 (6); CD: 19 (9); GAD: 7 (3); MDD: 4 (2); Aut.D: 4 (2); Asp.D: 3 (1); Soc.P: 16 (7); SAD: 9 (4); Spe.P: 108 (50)</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>Hanke et al, 2003 Department of Pediatrics in Marburg (January 1994 to December 1998)</td>
<td>Germany</td>
<td>60</td>
<td>29</td>
<td>1124</td>
<td>6.2</td>
<td>45</td>
<td>CBCL, HKS</td>
<td>Parents</td>
<td>SGA: 11 (18.3); IVH: 16 (26.6); BD: 20 (33.3)</td>
<td>NS</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Hatch et al, 2014 New York City metropolitan area</td>
<td>United States</td>
<td>197</td>
<td>NS</td>
<td>978.06</td>
<td>3–4</td>
<td>NS</td>
<td>ADHD-RS</td>
<td>Parents, teachers</td>
<td>NS</td>
<td>NS</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Huang et al, 2012 Kaohsiung Medical University Hospital and Kaohsiung Municipal Hsiao-Kang Hospital</td>
<td>Taiwan</td>
<td>20</td>
<td>28.95</td>
<td>&lt;1500</td>
<td>2</td>
<td>64</td>
<td>DBRS-Toddler</td>
<td>Parents</td>
<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Indredavik et al, 2010 University Hospital in Trondheim (1988–1988)</td>
<td>Norway</td>
<td>65</td>
<td>29</td>
<td>1180</td>
<td>14</td>
<td>54</td>
<td>ADHD-RS</td>
<td>Parents</td>
<td>SGA: 24 (37); CP: 8 (12); IVH: 11 (4)</td>
<td>NS</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>Leijon et al, 2015b SouthEast region of Sweden (January 1998 to December 1998)</td>
<td>Sweden</td>
<td>51</td>
<td>28.8</td>
<td>1105</td>
<td>7.8</td>
<td>37.2</td>
<td>CBCL</td>
<td>Parents</td>
<td>BD: 14 (27); RDS: 23 (45); sepsis: 14 (28); SGA: 29 (27); IVH: 1 (2); PL: 2 (3); RP: 2 (4)</td>
<td>NS</td>
<td>5</td>
<td>—</td>
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<tr>
<td>Levy-Shiff et al, 1994 Kaplan Hospital and Beilinson Hospital EXPRESS (April 2004–March 2007)</td>
<td>Israel</td>
<td>90</td>
<td>29</td>
<td>1190</td>
<td>13.3</td>
<td>NS</td>
<td>Connors</td>
<td>Parents</td>
<td>SGA: 62 (18); CP: 21 (6.1); IVH: 30 (8.7); PL: 14 (4.1); BD: 60 (23.2); NE: 73 (18.52); RP 115 (33.4)</td>
<td>NS</td>
<td>1</td>
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<tr>
<td>Månsson et al, 2014 Stockholm, Sweden</td>
<td>Sweden</td>
<td>344</td>
<td>24.9</td>
<td>780</td>
<td>2.5</td>
<td>54.7</td>
<td>CBCL</td>
<td>Parents</td>
<td>SGA: 2 (18); CP: 21 (6.1); IVH: 30 (8.7); PL: 14 (4.1); BD: 60 (23.2); NE: 73 (18.52); RP 115 (33.4)</td>
<td>NS</td>
<td>4</td>
<td>—</td>
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<tr>
<td>McNicholas et al, 2015 Dublin Maternity Hospital (1995–1998)</td>
<td>Ireland</td>
<td>64</td>
<td>30</td>
<td>1172</td>
<td>11.6</td>
<td>38</td>
<td>SDQ</td>
<td>Parents, subject, teachers</td>
<td>IVH: 12 (18.7)</td>
<td>ADNS: 12 (2.5); CD: 1 (1.5); Asp.D: 3 (4.6)</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>Murray, 2004 Pelotas cohort</td>
<td>Brazil</td>
<td>48</td>
<td>≤32</td>
<td>≤1500</td>
<td>6.7</td>
<td>NS</td>
<td>SDQ</td>
<td>Parents</td>
<td>NS</td>
<td>NS</td>
<td>5</td>
<td>—</td>
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<tr>
<td>Nadeau et al, 2001 Ste-Justine Hospital (January 1987 to October 1990)</td>
<td>Canada</td>
<td>61</td>
<td>27.4</td>
<td>1024.3</td>
<td>7</td>
<td>49</td>
<td>CBCL, TRF</td>
<td>Parents, teachers</td>
<td>NS</td>
<td>NS</td>
<td>—</td>
<td>4</td>
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<td>Author et al.</td>
<td>Sample (Birth y)</td>
<td>Country</td>
<td>N</td>
<td>Mean Age at Birth, wk (Mean or Range)</td>
<td>Mean wt at Birth (g)</td>
<td>Age at Evaluation, y (Mean or Range)</td>
<td>Male (%)</td>
<td>Scale</td>
<td>Rater</td>
<td>Clinical or Neurologic Comorbidities, n (%)</td>
<td>Psychiatric Comorbidities, n (%)</td>
<td>Case-Control</td>
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<tr>
<td>Perkinson-Gloor et al.</td>
<td>University Children’s Hospital Basel (June 2001 to December 2005)</td>
<td>Switzerland</td>
<td>58</td>
<td>29.7</td>
<td>1302.1</td>
<td>8.2</td>
<td>69</td>
<td>SDQ</td>
<td>Parents</td>
<td>RDS: 45 (77.8); AP: 46 (79.3); BD: 3 (5.2)</td>
<td>NS</td>
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<tr>
<td>Samara et al.</td>
<td>Study (March through December 1995)</td>
<td>United Kingdom</td>
<td>241</td>
<td>≤25</td>
<td>740</td>
<td>6</td>
<td>50.2</td>
<td>SDQ</td>
<td>Parents, teachers</td>
<td>CP: 41 (17.4); VM: 76 (31.5)</td>
<td>NS</td>
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<tr>
<td>Scott et al.</td>
<td>Rainbow Babies and Children’s Hospital (2001–2003)</td>
<td>United States</td>
<td>148</td>
<td>26</td>
<td>818</td>
<td>5.96</td>
<td>46</td>
<td>CBCL</td>
<td>Parents</td>
<td>ODD: 27 (19); CD: 8 (6); Spe.P: 24 (6); Soc.P: 9 (6); SAD: 8 (6); GAD: 4 (3)</td>
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<tr>
<td>Shum et al.</td>
<td>Mater Children’s Hospital</td>
<td>Australia</td>
<td>45</td>
<td>26.4</td>
<td>838.2</td>
<td>7–9</td>
<td>48.8</td>
<td>ADHD-RS</td>
<td>Parents, teachers</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Stjernqvist and Svenningsen</td>
<td>Southern Swedish population (1985–1986)</td>
<td>Sweden</td>
<td>65</td>
<td>27.1</td>
<td>1042</td>
<td>10.5</td>
<td>41</td>
<td>CBCL</td>
<td>Parents</td>
<td>SGA: 9 (15); IVH: 15 (21); BD: 11 (18)</td>
<td>NS</td>
<td>5</td>
</tr>
<tr>
<td>Sykes et al.</td>
<td>Royal Maternity Hospital (1978–1981)</td>
<td>Ireland</td>
<td>243</td>
<td>30.4</td>
<td>1272</td>
<td>7.43</td>
<td>41</td>
<td>TRF</td>
<td>Teachers</td>
<td>IVH: 6 (3)</td>
<td>NS</td>
<td>2</td>
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<tr>
<td>Teplin et al.</td>
<td>NICU of the University of North Carolina Hospitals (1980)</td>
<td>United States</td>
<td>28</td>
<td>28</td>
<td>905</td>
<td>6.2</td>
<td>50</td>
<td>Conners</td>
<td>Parents</td>
<td>SGA: 10 (37); MSD: 3 (12); VI: 3 (12); HL: 2 (7)</td>
<td>NS</td>
<td>4</td>
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<tr>
<td>Torrioli et al.</td>
<td>Policlinico Gemelli (1991–1993)</td>
<td>Italy</td>
<td>36</td>
<td>31</td>
<td>1120</td>
<td>4.9</td>
<td>41.6</td>
<td>Conners</td>
<td>Parents</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Woodward et al.</td>
<td>Christchurch Women’s Hospital (November 1998 to December 2000)</td>
<td>New Zealand</td>
<td>223</td>
<td>27.8</td>
<td>1054.4</td>
<td>2</td>
<td>51</td>
<td>SDQ</td>
<td>Parents</td>
<td>MSWMA: 17 (17); IVH grade 3–4: 6 (6); SPNE: 7 (7)</td>
<td>CD 7 (7); Anx.D: 7 (7); depression 3 (3); ASD: 3 (5)</td>
<td>—</td>
</tr>
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</table>

AB, antisocial behavior; ACU, antenatal corticosteroid use; ADHD-RS, ADHD rating scale-IV; ADNDS, anxiety disorders (not specified); AP, apnea of prematurity; APP, avoidant personality problems; ApD, Asperger disorder; AutD, autistic disorder; BD, bronchopulmonary dysplasia; CD, conduct disorder; CP, cerebral palsy; CPL, cystic periventricular leukomalacia; CSI-4, Child Symptom Inventory-4; DBRS-Toddler, Disruptive Behavior Rating Scale-Toddler; EXPRESS, Extremely Preterm Infants in Sweden Study; GAD, generalized anxiety disorder; HL, hearing loss; HKS, Questionnaire of Hyperactivity Symptoms; IHD, intraventricular hemorrhage; MDD, major depressive disorder; MSD, mild spastic diplegia; MSWMA, moderate to severe white matter abnormality; NE, necrotizing enterocolitis; NI, neurosensory impairment; ODD, oppositional defiant disorder; PCU, postnatal corticosteroid use; PDA, patent ductus arteriosus; PL, periventricular leukomalacia; PTSD, posttraumatic stress disorder; RDS, respiratory distress syndrome; RP, retinopathy of prematurity; SAD, separation anxiety disorder; Sev.D, severe disability (IQ ≤ 2 SDs, cerebral palsy grade 3 or 4, or blindness or deafness); SGA, small for gestational age; Soc.P, social phobia; Spe.P, specific phobia; SPNE, suspected or proven necrotizing enterocolitis; TD, tic disorder; V, visual impairment; VM, ventriculomegaly; YASR, Young Adult Self-Report and Young Adult Behavior Checklist; YSR, youth self-report; —, not applicable.

Results of this study are also reported in Van Lieshout et al. (2015).

Results of this study are also reported in Johnson et al. (2010).

These studies also contributed with data from ADHD rating scales for the meta-analysis of categorical data.
reaching a flexible $P \leq .2$ were to be included in a final multivariate meta-regression model; however, this was not feasible because of the lack of additional covariates.

**DISCUSSION**

In this systematic review and meta-analysis, we evaluated the risk of VP/VLBW and EP/ELBW individuals to develop ADHD, emphasizing well-defined categorical and dimensional diagnoses and providing evidence of robust associations. In 12 categorical diagnosis studies in which researchers assessed a total of 1787 subjects, it is suggested that VP/VLBW and EP/ELBW individuals are $\sim 3$ times more likely to be diagnosed with ADHD than term-born controls. In the VP/VLBW group, this likelihood is approximately doubled, whereas in the EP/ELBW group it is increased fourfold. Furthermore, in 29 studies on ADHD symptoms involving a total of 3504 individuals, researchers demonstrated that both inattention and H/I symptoms are similarly associated with VP/VLBW newborns, with large effect sizes found for the inattention and H/I dimensions and a moderate effect size for the total symptom scores.

Researchers in previous studies have suggested similar findings. In a meta-analysis of the cognitive and behavioral outcomes of preterm-born, school-aged children, Bhutta et al\textsuperscript{14} (2002) also found a significantly higher risk of an ADHD diagnosis in preterm infants than controls ($OR = 2.64, 95\% CI 1.85$ to $3.78$). In addition, they found that preterm children were at significant risk of reduced cognitive performance and other non–developmentally expected behaviors at school age. Interestingly, they found a gradient correlation because gestational age and birth weight were directly proportional to the mean cognitive test scores. Moreover, in a meta-analysis on academic achievement,
behavioral problems, and executive function, Aarnoudse-Moens et al\textsuperscript{15} (2009) found that attention problems measured by teachers and parents via the CBCL or Teacher Report Form (TRF) were more pronounced in VP/VLBW children than in NBW controls. They also found a strong correlation between adverse outcomes and level of maturity at birth: smaller and more premature children were more prone to internalizing and externalizing behavior problems and poor academic achievement than heavier, more mature infants.

The idea of a gradient correlation\textsuperscript{10–12} between prematurity or LBW and ADHD is endorsed by our finding of higher ADHD risk in the EP/ELBW group than the VP/VLBW group. Regarding the ADHD presentations, we found a similar risk for both inattentive and H/I types. Researchers conducting previous investigations have reported that EP had only a risk to develop the ADHD inattentive type\textsuperscript{34,43} whereas others have reported a risk for both ADHD inattentive type and H/I.\textsuperscript{34,43} Furthermore, we found a predominance of female subjects in the VP/VLBW groups, although ADHD is typically associated with a high prevalence among male subjects in the general population.\textsuperscript{63} Researchers in several studies have suggested that preterm-born individuals with ADHD have phenotypic specificities that diverge from their nonpremature ADHD counterparts. These include a predominance of inattention symptoms, less psychiatric comorbidity,\textsuperscript{64,65} higher diagnostic stability from childhood to adulthood,\textsuperscript{13} more perinatal clinical or neurologic complications, and major disabilities.\textsuperscript{13,15,30,66,67} In addition, the preponderance of male subjects, which is typically seen in nonpremature ADHD, was also not observed in preterm subjects.\textsuperscript{64}

Despite the fact that both clinical or neurologic and psychiatric comorbidities were reported in some of the studies, further analyses were not possible because of the heterogeneity of the data described.

It is important to note that our findings suggesting a robust risk of VP/VLBW subjects to develop ADHD are similar to those found in other behavioral and psychiatric disorders. In a previous meta-analysis, Burnett et al\textsuperscript{68} (2011) showed that a prevalence of any psychiatric diagnosis in preterm or LBW individuals was 3.66 times higher (95% CI 2.57 to 5.21) than NBW controls. Similarly, they found a high risk for anxiety or depressive disorder (OR = 2.86, 95% CI 1.73 to 4.73), although they did not provide data on ADHD or other psychiatric diagnoses. Another meta-analysis\textsuperscript{69} found a significant association between autism diagnosis and LBW but not preterm birth. The reasons for increased vulnerability to ADHD and behavioral and psychiatric problems in preterm or LBW individuals remain unknown, but a number of hypotheses have been put forward. These include pre- and postnatal adversities, such as the environmental problems they must face, as well as parental and biological issues such as hypothalamic-pituitary-adrenal axis dysregulations and perinatal systemic inflammation, which could cause structural and functional brain disorders such as ADHD and other psychiatric and developmental disorders.\textsuperscript{17,68,70–72}

Certain limitations should be considered when interpreting our findings. First, potentially important articles were excluded during the eligibility phase for not using validated diagnostic instruments or the rating scales selected in our protocol. Second, many studies were excluded because of different data definitions (ie, different categorizations for prematurity or birth weight levels). Third, although excluding gray literature from our review may have led to the overrepresentation of studies with statistically significant findings,\textsuperscript{73} the OPEN consortium\textsuperscript{74} demonstrated...
in a recent systematic review that the exclusion of such studies has a negligible impact on effect sizes. Fourth, the heterogeneous reporting of clinical or neurologic correlates in VP/VLBW individuals precluded us from comparing those that did and did not develop ADHD for these variables. Fifth, substantially high heterogeneity was found for all 3 ADHD dimensions, indicating that there is clinical or methodological diversity among studies. It is important to note that potential explanatory variables (age, article quality, country, occurrence of multiple births, and information source) entered in meta-regression analyses could not explain such variability. Sixth, our analyses included studies spanning a 30-year period (1977–2007). Although the lack of publication date limits increased the number of subjects in the analysis, the VP/VLBW subjects might not have the same perinatal profile over time given the advances in care management. Such a limitation was also reported in Bhatta et al’s 2002 meta-analysis. Moreover, we also assumed that the different classification systems and versions (DSM-III, DSM-III-R, DSM-IV, DSM-5, ICD-9 or ICD-10) had similar ADHD diagnostic performance. Seventh, the ADHD risk found in our meta-analysis adequately represents the risk in high-income countries, but it cannot be generalized to middle- or low-income countries. Among the 34 included studies, only the 2004 Pelotas cohort came from a middle-income country. In middle- and low-income countries, the risk mechanisms could vary because of different determinant profiles. As for the strengths of our review, we performed a broad literature search of cohort, case-control, and cross-sectional studies with no language restriction, allowing us to find a substantial number of articles. Most importantly, our strict inclusion criteria allowed only studies with a well-defined ADHD categorical diagnosis in the meta-analyses, unlike previous systematic reviews and meta-analyses.

CONCLUSIONS

In conclusion, with our findings we provide robust evidence that VP/VLBW individuals have an increased risk of ADHD both in categorical and dimensional analyses, and there is an even stronger association in the EP/ELBW group. In terms of clinical applicability, we suggest that premature infants need specific neonatology, pediatric, and psychiatric prevention and management interventions to minimize the ADHD burden. Future researchers in this field should clarify specific causal determinants associated with prematurity and LBW that could lead to the development of ADHD.

ACKNOWLEDGMENTS

We would like to thank Burt Hatch, Gerry Taylor, G.J.Q. Verkerk, Kristine Hermansen Grunewalld, Nori Mercuri Minich, and Stephanus Theron Potgieter for contributing requested data.

ABBREVIATIONS

ADHD: attention-deficit/hyperactivity disorder
CBCL: Child Behavior Checklist
CI: confidence interval
DAWBA: Development and Well-being Assessment
DSM: Diagnostic and Statistical Manual of Mental Disorders
ELBW: extremely low birth weight
EP: extremely preterm
EPICure: Extremely Premature Infants Cure
H/I: hyperactivity or impulsivity
ICD: International Classification of Diseases
LBW: low birth weight
NBW: normal birth weight
NOS: Newcastle-Ottawa scale
OR: odds ratio
SDQ: Strengths and Difficulties Questionnaire
SMD: standardized mean difference
TRF: Teacher Report Form
VLBW: very low birth weight
VP: very preterm

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Dr Franz conceptualized and designed the study, helped in data collection, and drafted the initial manuscript; Drs G. Bolat, H. Bolat, Silveira, Procianoy, Matijasevich, and Santos helped in data collection and critically reviewed the manuscript; Dr Moreira-Maia conceptualized and designed the study, helped in data collection, conducted the analyses, and reviewed the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

This trial has been registered with PROSPERO (identifier CRD42016049421) (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?id=CRD42016049421).

DOI: https://doi.org/10.1542/peds.2017-1645

Accepted for publication Oct 13, 2017

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: Drs Moreira-Maia, Matijasevich, and Santos receive financial research support from a Brazilian government agency: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). Dr Rohde receives financial research support from both Coordination for the Improvement of Higher Education Personnel and CNPq; the other authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: The Fundo de Incentivo à Pesquisa e Eventos and the Programa de Transtornos de Déficit de Atenção e Hiperatividade of the Hospital de Clínicas de Porto Alegre supported the study.

POTENTIAL CONFLICT OF INTEREST: Dr Moreira-Maia received fees for the development of educational materials for Novartis, Libbs, and Pfizer and served as a consultant to or on the speakers’ bureau of Novartis and Shire. Dr Moreira-Maia also received travel awards from the Health Technology Assessment Institute and the Federal University of Rio Grande do Sul and travel, accommodation, and registration support to the fourth and fifth World Congress on attention-deficit/hyperactivity disorder (ADHD) from the World Federation of ADHD. Dr Rohde has received grant or research support from, served as a consultant to, and served on the speakers’ bureau of Eli Lilly and Co, Janssen, Medice, Novartis, and Shire. The ADHD and Juvenile Bipolar Disorder Outpatient Programs chaired by Dr Rohde have received unrestricted educational and research support from the following pharmaceutical companies: Eli Lilly and Co, Janssen, Novartis, and Shire. Dr Rohde has received travel grants from Shire to take part in the 2015 World Congress on ADHD; the other authors have indicated they have no potential conflicts of interest to disclose.

COMPANION PAPER: A companion to this article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2017-3488.

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