The Prevalence of DSM-IV Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review

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Abstract This article describes a comprehensive meta-analysis that was conducted to estimate the prevalence of attention-deficit/hyperactivity disorder (ADHD), as defined by the *Diagnostic and Statistical Manual of Mental Disorders, fourth edition* (DSM-IV). A systematic literature review identified 86 studies of children and adolescents (N= 163,688 individuals) and 11 studies of adults (N=14,112 individuals) that met inclusion criteria for the meta-analysis, more than half of which were published after the only previous meta-analysis of the prevalence of ADHD was completed. Although prevalence estimates reported by individual studies varied widely, pooled results suggest that the prevalence of DSM-IV ADHD is similar, whether ADHD is defined by parent ratings, teacher ratings, or a best estimate diagnostic procedure in children and adolescents (5.9–7.1 %), or by self-report measures in young adults (5.0 %). Analyses of diagnostic subtypes indicated that the predominantly inattentive type is the most common subtype in the population, but individuals with the combined type are more likely to be referred for clinical services. Additional research is needed to determine the etiology of the higher prevalence of ADHD in males than females and to clarify whether the prevalence of ADHD varies as a function of socioeconomic status or ethnicity. Finally, there were no significant prevalent differences between countries or regions of the world after controlling for differences in the diagnostic algorithms used to define ADHD. These results provide important support for the diagnostic validity of ADHD, and argue against the hypothesis that ADHD is a cultural construct that is restricted to the United States or any other specific culture.

In 2007, Polanczyk et al. [1] completed the first comprehensive meta-analysis of the prevalence of attention-deficit/hyperactivity disorder (ADHD) in children and adolescents. The worldwide prevalence of ADHD was estimated to be 5.29 %, but specific estimates varied widely across the 103 studies included in the analysis. Significant moderators that accounted for a portion of the heterogeneity among studies included the diagnostic criteria used to define ADHD, the method used to assess ADHD symptoms, the specific algorithm used to combine multiple sources of information, and the incorporation of functional impairment as part of the definition of ADHD. Their results also suggested that the prevalence of ADHD was higher in males than females, and highest in young children, but age and gender were not included in final multivariate models, because too few studies reported results stratified on these variables.

Interpretation of prevalence studies is complicated by significant changes to the diagnostic criteria for ADHD for the past 30 years, culminating in the current definition specified in the *Diagnostic and Statistical Manual of Mental Disorders, fourth edition* (DSM-IV) [2]. The DSM-IV defined 3 nominal subtypes of ADHD, based on differential elevations on 2 dimensions of inattention symptoms and hyperactivity-impulsivity symptoms. The predominantly inattentive type (ADHD-I) describes individuals with maladaptive levels of inattention, but not hyperactivity-impulsivity; the predominantly hyperactive-impulsive type (ADHD-H) is characterized by maladaptive levels of hyperactivity-impulsivity, but not inattention; and the

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combined type (ADHD-C) describes individuals who exhibit significant symptoms of both inattention and hyperactivity-impulsivity. Additional DSM-IV criteria required onset of ADHD symptoms prior to age 7 and required that current ADHD symptoms lead to significant impairment in multiple settings. Finally, a diagnosis of ADHD was precluded if the individual met the criteria for a pervasive developmental disorder or psychotic disorder.

A recent meta-analysis of the validity of the DSM-IV model of ADHD [3] provided strong support for the internal and external validity of the inattention and hyperactivity-impulsivity symptom dimensions, but results were mixed regarding the validity of the nominal subtypes. In addition, other reviews raised questions regarding the validity of the DSM-IV age-of-onset criterion [4] and the criterion requiring significant impairment in multiple settings [5].

The Current Review

This article presents results of a comprehensive meta-analysis of the prevalence of DSM-IV ADHD. Although the primary goal of the study was to estimate the number of individuals identified by current diagnostic criteria for ADHD, several specific results have important implications for DSM-5 and other future diagnosis systems. These results extend the benchmark meta-analysis by Polanczyk et al. [1] in several ways:

1. Only 44 of the 103 studies included in the previous meta-analysis defined ADHD based on DSM-IV criteria, and 53 additional studies have been published since the completion of their analysis. These include 11 studies of adults, facilitating the first meta-analysis of the prevalence of DSM-IV ADHD in adults.
2. In addition to estimating the prevalence of ADHD as a whole, the current review provides the first prevalence estimates for the 3 nominal DSM-IV subtypes of ADHD, and compares the relative prevalence of the subtypes across development from early childhood to adulthood.
3. The meta-analysis was used to test the extent to which the prevalence of ADHD changed when ADHD was defined by symptom criteria only *versus* full DSM-IV diagnostic criteria. In addition, new analyses were conducted in a large population-based sample of children to directly test the impact of each specific DSM-IV diagnostic criterion on the prevalence of ADHD.
4. Both the meta-analysis and analyses of the community sample were used to estimate the impact on the prevalence of ADHD when different algorithms were used to combine multiple sources of clinical information.
5. Finally, when sufficient data were provided regarding potential moderators, secondary analyses were conducted to test whether the prevalence of ADHD varied as a function of gender, socioeconomic status (SES), ethnicity, or country or region of the world.

Methods

Overview of the Literature Search and Meta-Analysis

Due to space constraints, this section provides a brief overview of the review procedures. A full description of the literature search and meta-analytic procedures is provided in our larger meta-analysis of the validity of the DSM-IV ADHD [3] and in the supplemental materials available at http://psych.colorado.edu/~willcutt/prev.htm. Briefly, a comprehensive search of the relevant literature was completed to identify all studies published between 1994 and 2010 that included data relevant to the prevalence of DSM-IV ADHD. Studies across the developmental spectrum were included in the review, but studies of children and adolescents were analyzed separately from studies of adults to evaluate potential developmental changes in the prevalence of ADHD or the distribution of the subtypes. The literature search identified articles describing 86 independent samples of children and adolescents, and 11 samples of adults that met inclusion criteria for the review.

The overall results of the meta-analysis are summarized in Tables 1 and 3, and the details of each analysis are provided in the Supplemental Materials. The first table in the Supplemental Materials lists all of the studies that were included in any part of the meta-analyses and describes key study characteristics and sampling procedures. Supplemental Tables 2 through 11 list the prevalence estimates from individual studies that are included in the overall effect sizes that are presented in the main article and summarize results of analyses used to test for heterogeneity among the effects and potential publication or other selection biases.

Diagnostic Algorithms Used by Studies Included in the Meta-Analysis

Results of the larger meta-analysis of the validity of DSM-IV ADHD [3] indicated that ratings of the DSM-IV ADHD by a single observer have adequate test-retest reliability, but the concordance between 2 different raters is low-to-moderate for the overall diagnosis of the DSM-IV ADHD (mean agreement=45 %) and all 3 subtypes (11–31 %). These modest levels of inter-rater agreement indicate that different raters identify partly nonoverlapping samples of children, and that even when 2 raters agree that an

Table 1 Estimated Prevalence of DSM-IV ADHD Subtypes in Population-Based Samples of Children and Adolescents

Diagnostic algorithm	Samples (total N)	Total ADHD		ADHD-C		ADHD-H		ADHD-I	
		Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.
Parent ratings only									
Symptom criteria only	29 (42,687)[*]	8.8 % (7.7, 9.9)[†]	1.9:1	2.1 % (1.8, 2.5)[†]	2.4:1	3.1 % (2.4, 4.0)[†]	1.7:1	3.2 % (2.7, 3.7)	1.7:1
Full DSM-IV criteria	19 (55,125)[‡]	6.1 % (5.2, 7.1)[†]	2.4:1	2.2 % (1.9. 2.6)	2.6:1	1.3 % (0.9, 1.8)	2.0:1	3.6 % (3.0, 4.4)	2.2:1
Teacher ratings only									
Symptom criteria only	24 (56,970)[§]	13.3 % (11.6, 15.2)	2.2:1	4.0 % (3.4, 4.8)	3.0:1	2.6 % (2.1, 3.2)[†]	2.2:1	6.6 % (5.6, 7.8)	1.8:1
Full DSM-IV criteria	4 (15,373)[¶]	7.1 % (6.6, 7.5)[†]	2.4:1	2.3 % (1.7. 3.2)	2.7:1	1.1 % (0.5, 2.3)	5.2:1	3.4 % (3.1, 3.7)	1.8:1
Self-report only									
Symptom criteria only	3 (1703)	8.5 % (3.3, 19.9)	1.9:1	1.8 % (0.7, 4.8)	1.7:1	2.7 % (1.9, 3.7)	1.5:1	3.2 % (0.9, 11.2)	2.5:1
Combined parent and teacher ratings[‖]									
Or-rule	3 (9396)	12.9 % (8.5, 19.2)	2.1:1	5.1 % (4.1, 6.4)	2.1:1	2.9 % (1.9, 4.4)	1.7:1	6.7 % (5.8, 7.7)	2.1:1
And-rule	2 (9000)	5.7 % (2.4, 12.6)	3.2:1	0.8 % (0.6, 1.0)	4.0:1	1.9 % (0.2, 17.0)	3.8:1	2.1 % (1.4, 3.0)	2.3:1
Subtype agreement	10 (16,205)[**]	4.0 % (3.0, 5.4)	2.6:1	0.8 % (0.6, 1.1)	3.5:1	0.6 % (0.1, 2.8)	2.0:1	1.8 % (1.4, 2.4)	2.0:1
Best estimate	20 (43,972)[††]	5.9 % (4.6, 7.5)	3.2:1	3.4 % (2.4, 4.9)	2.7:1	0.8 % (0.4, 1.5)[†]	3.5:1	1.8 % (1.1, 2.9)	1.8:1

Note: See Supplement Table 1 for a description of studies included in the meta-analysis, and Supplement Tables 2–9 for a list of the prevalence estimates that are included in the summary estimates in this table

ADHD = attention-deficit/hyperactivity disorder; attention-deficit/hyperactivity disorder-the combined type; ADHD-H = attention-deficit/hyperactivity disorder-hyperactive-impulsive type; ADHD-I = attention-deficit/hyperactivity disorder-inattentive type; CI = confidence interval; DSMV-IV = *Diagnostic and Statistical Manual of Mental Disorders, fourth edition*; Fem. = female

*Twenty-seven studies of subtypes, N=40,673. † The analyses summarized in the Supplemental Materials indicated possible evidence of mild publication bias. Controlling for potential bias did not change any prevalence estimate by more than 0.5 %. ‡ Eleven studies of subtypes, N=35,626. § Twenty-one studies of subtypes, N=53,645. ¶ N for subtypes=14,088. ‖ See text for description of these algorithms. **Six studies of subtypes, N=12,064. †† Eleven studies of subtypes, N=32,531

individual meets criteria for ADHD, their ratings frequently place the individual in different subtype groups.

Studies of the prevalence of the DSM-IV ADHD used several different algorithms to combine information from multiple raters. To examine the impact of these alternative procedures, separate prevalence estimates were calculated for each specific algorithm that was used by more than 1 study. The largest number of studies defined ADHD based on ratings by parents or teachers alone (57 studies), and 10 studies required an individual to meet symptom criteria based on both parent and teacher ratings. A smaller subset of studies used 1 of 2 specific algorithms to combine information from parents and teachers at the level of individual ADHD symptoms. The more inclusive algorithm was the "or rule" that was used in the DSM-IV field trials [6], which codes each symptom as positive if it is endorsed by either the parent or the teacher (i.e., in 3 studies). In contrast, the "and rule" codes a symptom as positive only if it is endorsed by both raters, making it the most stringent of all algorithms for the combination of parent and teacher ratings (i.e., in 2 studies). Finally, 20 studies used a best estimate diagnostic procedure in which a team of experienced clinicians evaluated all available clinical information to reach a consensus diagnosis.

Examination of the Impact of Specific DSM-IV Criteria on the Prevalence of ADHD

Although a handful of studies compared the prevalence of the DSM-IV ADHD based on symptom criteria only *versus* full diagnostic criteria, no published studies have directly tested the impact of the DSM-IV age-of-onset and cross-setting impairment criteria on the prevalence of ADHD, nor the final criterion that precludes a diagnosis of ADHD in children with a pervasive developmental disorder or psychotic disorder. Therefore, to supplement the results of the meta-analysis, additional analyses were conducted in a large community sample to assess the impact of each of the DSM-IV criterion on the overall prevalence of ADHD and the relative proportion of individuals with each of the subtypes of the DSM-IV ADHD.

The community sample was described in detail in previous articles [7]. Briefly, parents of a random sample of 13,300 children from 5 large school districts in Colorado

were invited to complete a screening questionnaire that included the DSM-IV Disruptive Behavior Rating Scale [8] and a battery of measures of social, academic, and global impairment [7]. Parents of 8,590 children agreed to participate (65 %), and parallel questionnaires were obtained from the teachers of 7,874 of the participants. Age of onset of ADHD symptoms was obtained as part of the parent ratings, and significant impairment was defined by a score below the 10th percentile of the total sample on composite measures of global, academic, and social functioning at home and at school [7].

Results

Estimated Prevalence Based Only on Symptom Criteria

Prevalence estimates based on symptom criteria alone overestimate the percentage of children who meet the full DSM-IV criteria for ADHD. However, because recent results challenge the validity of several specific DSM-IV criteria, the optimal approach to estimate the prevalence of the DSM-IV ADHD is not clear. Therefore, although prevalence estimates based on symptom criteria alone must be interpreted with caution, they provide a useful upper-bound estimate of the prevalence of DSM-IV ADHD and each diagnostic subtype.

Overall ADHD

More than 60 studies of children and adolescents have estimated the prevalence of ADHD based on only symptom criteria (see Table 1 and Supplement Tables 2–7). The primary measure of ADHD symptoms in most of these studies was 1 of several widely used scales, which asks the parent or teacher to rate each symptom on a 4-point scale [8–11], and nearly all studies coded the top 2 categories on the scale as positive symptoms (on the majority of scales these anchor points were labeled "often" and "very often"). In studies that used this approach, 8.8 % of children and adolescents, based on parent reports, met the DSM-IV ADHD symptom criteria; 13.3 % of children and adolescents based on teacher ratings; and 8.5 % of adolescents only based on self-report ratings (Table 1). However, in the handful of studies that counted only the highest rating on the 4-point scale as a positive symptom, the proportion of individuals who met the DSM-IV symptom criteria for ADHD was significantly lower (4.9 % in 5 studies of teacher ratings and 1.9 % based on parent ratings in our community sample).

Prevalence estimates also varied widely when different algorithms were used to combine symptom ratings by parents and teachers. Whereas 12.9 % of children met symptom criteria for ADHD based on the "or-rule" algorithm (Table 1), less than half as many individuals met symptom criteria when raters were required to agree on the overall ADHD diagnosis (4.0 %) or each individual symptom (5.7 %). Overall, these results underscore the sensitivity of prevalence estimates to the specific method used to define symptoms of ADHD.

Subtypes

When subtypes were defined based only on symptom criteria, ADHD-I was the most common subtype based on parent ratings alone, teacher ratings alone, self-report ratings, and parent-teacher agreement (38–57 % of all individuals with ADHD) (Table 1). The relative frequencies of ADHD-C and ADHD-H varied by reporter; more individuals with ADHD met the criteria for ADHD-H than ADHD-C based on parent ratings (37 % vs 25 %) and self-report ratings (36 % vs 22 %), whereas a higher proportion met the criteria for ADHD-C than ADHD-H when ADHD was defined by teacher ratings or was in agreement between parents and teachers (24–30 % vs 19–20 %).

Full DSM-IV Criteria

Overall ADHD

Despite the important caveats regarding the validity of several specific DSM-IV criteria that are discussed in subsequent sections of this review, prevalence estimates based on full DSM-IV criteria provide a more appropriate estimate of the overall proportion of children who meet criteria for ADHD (Table 1). When full DSM-IV criteria were applied rather than symptom criteria alone, a smaller proportion of individuals met the criteria for ADHD based on parent ratings (6.1 %; 31 % reduction in prevalence) or teacher ratings (7.1 %; 47 % reduction), and these results were similar to the prevalence estimates reported by studies that used best estimate diagnoses (5.9 %).

Subtypes

ADHD-I remained the most common subtype when parent, teacher, or self-report ratings were used to define ADHD based on full DSM-IV criteria, but the rate of ADHD-C was higher than the rate of ADHD-I for best estimate diagnoses (Table 1). The estimated prevalence of ADHD-H was lower than ADHD-C or ADHD-I for all algorithms that applied to the full diagnostic criteria (i.e., 13–17 % of all individuals with ADHD), reflecting the lower rates of functional impairment in groups that met symptom criteria for ADHD-H versus ADHD-C or ADHD-I [3].

The Impact of Specific DSM-IV Criteria on Prevalence Estimates

Age-of-Onset by 7 Years of Age

Results in our community sample (Table 2) and others [12, 13] suggest that 10 to 25 % of children who meet the symptom criteria for ADHD have an age-of-onset after 7 years of age, and this occurs most frequently among children with ADHD-I. However, studies that have tested the validity of the DSM-IV age-of-onset criterion suggest that it specifies an artificial threshold that is not supported by empirical data [4, 14]. As an extension of this review, data from the community sample were used to examine the implications of this criterion for the prevalence and diagnostic validity of ADHD. Although some of the individuals who met the symptom criteria for ADHD did not meet the DSM-IV criterion, requiring onset of symptoms before 7 years of age, nearly all children who eventually met the criteria for ADHD exhibited symptoms and impairment by late childhood (e.g., 97–99 % by age 10) (Table 2). Most importantly, the rate of functional impairment was almost identical in the groups of children with ADHD with onset before and after age 7 (e.g., 80 % *vs* 82 % of cases in the 2 groups exhibited cross-setting impairment when ADHD symptoms were defined by best estimate procedures). Although our sample is not informative regarding the validity of late-onset cases of ADHD that emerge later in adolescence or adulthood, these results support the proposal that the age-of-onset criterion in the DSM-5 should at least be broadened to include onset of symptoms and impairment anytime during childhood [15].

Significant Impairment Across Multiple Settings

There is virtually no debate regarding the essential value of DSM-IV criterion D, which requires clear evidence that ADHD symptoms lead to clinically significant impairment in social, academic, or occupational functioning. DSM-IV criterion C for ADHD specifies that current symptoms must lead to functional impairment that is present in multiple settings. This criterion was included to ensure that individuals who received a diagnosis of ADHD were experiencing pervasive difficulties, and to minimize the chance that ADHD would be overdiagnosed due to inflated ratings by a single distressed rater. However, ADHD is the only DSM-IV disorder that requires impairment to be documented in multiple settings, and only a handful of studies have tested the validity of this criterion [5].

Table 2 summarizes the results of analyses that were conducted in our community sample to test the specific impact of the cross-setting impairment criterion on the prevalence of ADHD. Nearly all children who met symptom criteria for ADHD exhibited impairment in at least 1 setting (91–100 %), although the proportion of individuals without significant impairment was significantly higher in the group with ADHD-H (mean=22 %) than in groups with ADHD-I (4 %) or ADHD-C (2 %). Of note, however, a subgroup of cases had significant impairment that was restricted to a single setting (5–30 %), and this occurred significantly more frequently among individuals who met symptom criteria for ADHD-I (mean=20 %) or ADHD-H (mean=33 %) than children with ADHD-C. Therefore, the cross-setting impairment criterion has the most pronounced impact on the prevalence of ADHD-I and ADHD-H.

The absence of significant impairment across settings at a single point in time may sometimes occur due to measurement constraints or other practical reasons. For example, the documentation of impairment in multiple settings is typically based on ratings from 2 different adults. Because correlations between raters are low-to-medium in magnitude for most behavioral ratings [16], a lack of agreement between ratings of impairment may simply reflect measurement error or other rater effects, and not necessarily a true absence of impairment across settings. Furthermore, some children do not attend school (i.e., preschool or home-schooled children), limiting their opportunity to exhibit impairment in multiple settings, and others may display impairment in only 1 setting at 1 point in time, but multiple settings later in development when they are confronted with more challenging academic and social demands.

Nonetheless, it remains likely that some children who meet symptom criteria for ADHD may exhibit significant impairment that is truly restricted to 1 setting. This pattern may be especially common in groups with ADHD-I and ADHD-H because ADHD-I is associated most strongly with difficulties in academic domains that may be most evident at school, whereas the behavioral impairments that are most strongly associated with ADHD-H may be more evident at home. Although the reduction of false-positive diagnoses is a laudable goal, it is not clear why help would not be provided to a child who meets all other criteria for ADHD but has serious impairment in only 1 setting. In combination with the previous literature [5], the current results suggest that the validity of the cross-setting impairment criterion should be systematically evaluated in future studies to clarify the costs and benefits of its inclusion as a diagnostic criterion in the DSM-5 or other future diagnostic systems.

Exclusion of Individuals with a Pervasive Developmental or Psychotic Disorder

Results from our community sample suggest that the exclusion of individuals with a pervasive developmental disorder or psychotic disorder reduces the prevalence of ADHD by <0.5 % (Table 2). Therefore, although this exclusion

Table 2 Impact of Each Specific DSM-IV Diagnostic Criterion on the Prevalence of DSM-IV ADHD

DSM-IV diagnostic criterion applied	Cases based on symptom criteria that meets each specific DSM-IV diagnostic criterion for ADHD*					
	Parent Ratings[†] (Total N=746)	Teacher Ratings[†] (Total N=884)	Or Rule (Total N=1,229)	Best Estimate (Total N=934)	And Rule (Total N=292)	Parent/teacher Agreement[‡] (Total N=369)
Age of onset	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Onset by 7 years of age	684 (91.7 %)	779 (88.1 %)	1,098 (89.3 %)	840 (89.9 %)	270 (92.5 %)	338 (91.6 %)
Onset by 10 years of age	736 (98.7 %)	865 (97.9 %)	1,210 (98.5 %)	922 (98.7 %)	287 (98.3 %)	358 (97.0 %)
Impairment across settings						
Impaired at home	636 (85.3 %)	720 (81.4 %)	963 (78.4 %)	808 (86.5 %)	280 (95.9 %)	344 (93.2 %)
Impaired at school	614 (82.3 %)	794 (89.8 %)	1,008 (82.0 %)	840 (89.9 %)	290 (99.3 %)	360 (97.6 %)
Impaired at home or school	690 (92.5 %)	826 (93.4 %)	1,107 (90.1 %)	895 (95.8 %)	290 (99.3 %)	364 (98.6 %)
Impaired at both home and school	560 (75.1 %)	688 (77.8 %)	864 (70.3 %)	753 (80.6 %)	278 (95.2 %)	339 (91.9 %)
Exclusion criteria						
Not explained by PDD or psychosis	706 (94.6 %)	833 (94.1 %)	1,166 (94.3 %)	881 (94.3 %)	279 (95.5 %)	352 (95.4 %)
All diagnostic criteria						
N cases based on full cjriteria[§]	495 (66.3 %)	568 (64.2 %)	824 (67.0 %)	630 (67.4 %)	265 (90.7 %)	312 (84.5 %)

ADHD = attention-deficit/hyperactivity disorder; DSMV-IV = *Diagnostic and Statistical Manual of Mental Disorders, fourth edition*; PDD = pervasive developmental disorder

*See text for a full description of each algorithm. [†] ADHD status defined by parent or teacher ratings only, with ratings by the other observer free to vary. [‡] Agreement between parent and teacher ratings for overall ADHD diagnosis, but not necessarily specific subtype. [§] Because some cases failed to meet multiple criteria, the total is not the sum of the N that meets each criterion

criterion is controversial and may be reworded or eliminated in the DSM-5, if it is retained, it is likely to have a relatively minor effect on the prevalence of ADHD.

Potential Moderators of Prevalence

After the primary meta-analysis was completed to estimate the overall prevalence of ADHD, a series of secondary analyses were conducted to test if the prevalence of ADHD varied as a function of moderators, such as age, gender, SES, or country or region of the world.

Developmental Changes in the Prevalence of ADHD

Longitudinal studies of unselected samples [17] and children with ADHD [18, 19] suggest that levels of hyperactivity-impulsivity symptoms decline significantly from early childhood through adolescence, whereas inattention symptoms decline minimally with age. Because no longitudinal studies of population-based samples have tested for developmental changes in the prevalence of the nominal subtypes, secondary analyses were conducted after subdividing the studies in the meta-analysis into 4 age groups: 1) 3- to 5-year-olds, 2) 6- to 12-year-olds, 3) 13- to 18-year-olds, and 4) 19-year-olds or older. Although these analyses are cross-sectional rather than longitudinal, they provide useful preliminary information regarding the

potential impact of the different developmental trajectories of inattention and hyperactivity-impulsivity symptoms on the prevalence of the overall diagnosis of ADHD and the distribution of the DSM-IV subtypes.

Overall ADHD

Results were similar when parent and teacher ratings were analyzed separately, so that findings were collapsed across raters to simplify interpretation (Table 3). The overall prevalence of ADHD was highest in preschool (10.5 %) and elementary school samples (11.4 %), which then declined in samples of adolescents (8.0 %). The results of 11 studies of samples from those older than 18 years of age suggest that the prevalence of ADHD may decline further in adulthood (5.0 %), at least when the DSM-IV symptom thresholds are used to define ADHD. However, most studies of adults defined ADHD by self-report ratings rather than the parent and teacher ratings used in studies of children and adolescents, suggesting that these comparisons should be interpreted with caution.

DSM-IV Subtypes

As seen in Table 3, the estimated prevalence of ADHD-H was highest in preschool children (4.9 %; 52 % of all children with ADHD), then declined steadily in samples collected in elementary school (2.9 %; 26 % of children

Table 3 Developmental Differences in the Prevalence of DSM-IV ADHD and the Distribution of ADHD Subtypes

Age range	Samples (total N)	Total ADHD		ADHD-C		ADHD-H		ADHD-I	
		Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.	Prevalence (95 % CI)	Male: Fem.
3–5-years-old	12 (9,339)	10.5 % (8.9, 12.5)	1.8:1	2.4 % (1.7, 3.4)	2.5:1	4.9 % (4.5, 5.4)	1.9:1	2.2 % (1.4, 3.3)	1.0:1
6–12 years-old	24 (56,088)*	11.4 % (9.8, 13.3)	2.3:1	3.3 % (2.7, 4.0)	3.6:1	2.9 % (2.3, 3.5)	2.3:1	5.1 % (4.3, 6.2)	2.2:1
13–18-years-old	6 (5,010)	8.0 % (4.4, 14.3)	2.4:1	1.1 % (0.5, 2.5)	5.6 : 1	1.1 % (0.5, 2.3)	5.5:1	5.7 % (3.2, 10.1)	2.0:1
19+ years old	11 (14,081)[†]	5.0 % (4.1, 6.2)	1.6:1	1.1 % (0.9, 1.4)	2.0:1	1.6 % (1.1, 2.4)	1.4:1	2.4 % (1.7, 3.3)	1.7:1

ADHD = attention-deficit/hyperactivity disorder; attention-deficit/hyperactivity disorder-the combined type; ADHD-H = attention-deficit/hyperactivity disorder-hyperactive-impulsive type; ADHD-I = attention-deficit/hyperactivity disorder-inattentive type; CI = confidence interval; DSMV-IV = *Diagnostic and Statistical Manual of Mental Disorders, fourth edition*; Fem. = female

*Twenty-two studies of subtypes (total N=52,622). [†] Ten studies of subtypes (total N=10,882).

with ADHD) and adolescence (1.1 %; 14 % of children with ADHD). The prevalence of ADHD-C increased slightly between preschool (2.4 %; 25 % of children with ADHD) and elementary school (3.3 %; 29 % of children with ADHD), and then also declined in samples of adolescents and adults. In contrast, the prevalence of ADHD-I increased from preschool (2.2 %; 23 % of children with ADHD) to elementary school (5.1 %, 45 % of children with ADHD), and then remained high in adolescence (5.7 %; 72 % of all individuals with ADHD), and was the most common subtype in adults (47 % of cases).

This overall pattern of results is consistent with the findings of longitudinal studies of DSM-IV ADHD subtypes in children and adolescents [14, 19, 20]. These studies indicate that the overall ADHD diagnosis has reasonable stability for periods of 5 to 9 years, but nominal DSM-IV subtype classifications are unstable for the same period of time. In addition to unpredictable shifts between subtypes due to random fluctuations in levels of symptoms and measurement error, a subset of individuals with ADHD appear to shift systematically between subtypes across the development in a pattern that is consistent with the different developmental trajectories of the symptom dimensions [3]. Specifically, individuals who meet criteria for ADHD-H in preschool may shift to ADHD-C early in elementary school, as increased attentional demands in school make their symptoms of inattention more noticeable and impairing, leading to an increase in the prevalence of ADHD-C and a decrease in the prevalence of ADHD-H. Then, because DSM-IV inattention symptoms remain relatively stable across development, whereas DSM-IV hyperactivity-impulsivity symptoms decline with age, individuals who initially meet criteria for ADHD-C in early childhood may shift to ADHD-I as they get older and their hyperactivity-impulsivity symptoms decline below the diagnostic threshold. Future longitudinal studies in population-based samples will provide a more definitive test of this possibility.

Gender Differences

Results for all diagnostic algorithms indicated that males were more likely than females to meet criteria for an overall diagnosis of ADHD and for each of the DSM-IV subtypes (Table 1). Among all individuals who met symptom criteria for any subtype of ADHD, a significantly larger proportion of females than males met criteria for ADHD-I in samples of children (42 % of females *vs* 36 % of males based on parent report; 57 % *vs* 47 % based on teacher ratings) and adults (55 % *vs* 49 %). In contrast, males with ADHD were more likely than females with ADHD to meet criteria for ADHD-C (28 % *vs* 22 % based on parent ratings; 27 % *vs* 17 % based on teacher ratings; and 26 % *vs* 18 % in studies of adults).

Demographic Factors

Comparisons Between Countries

Consistent with the results reported in the previous meta-analysis of the prevalence of ADHD [1], moderator analyses indicated no significant differences in the prevalence of overall ADHD or any of the DSM-IV subtypes when results were stratified by country or region of the world.

Socioeconomic Status

Only a handful of studies in the meta-analysis stratified their results by SES. Studies in Colombia [21], Germany [22], Iran [23], Australia [24], and the United States [25, 26] indicated that individuals from low SES environments were 1.5–4 times more likely to meet criteria for ADHD than individuals from families with high SES. However, other studies did not find a significant relation between SES and prevalence of ADHD [12, 27–29] suggest that additional research is needed to test more conclusively whether low SES may be a risk factor for ADHD in at least some populations.

Race/Ethnicity

Initial studies in the United States that defined ADHD, based on parent and teacher ratings suggested that African American children exhibited more symptoms of ADHD than non-Hispanic White or Hispanic children [28, 30, 31]. Similarly, a later study that measured ADHD with a structured interview in a sample of 4-year-old children reported higher rates of ADHD in African American and Hispanic children than White, non-Hispanic children, but these differences were no longer significant after differences in socioeconomic status were controlled [32]. In contrast, 2 other studies in the United States used structured interviews to diagnose ADHD based on full DSM-IV criteria, and found no difference in the overall prevalence of DSM-IV ADHD in samples of African American and non-Hispanic White children [26, 33]. In fact, in 1 of these studies [26] and in a study of adult ADHD based on retrospective ratings [34], it was found that non-Hispanic-White individuals were more likely to meet criteria for ADHD than Hispanic individuals.

Few studies outside the United States have been conducted to test for differences in the prevalence of ADHD as a function of race or ethnicity. One study in the Netherlands reported initial ethnic differences in prevalence when ADHD was defined only by symptom criteria, but these differences were not significant when full DSM-IV criteria were applied [29]. Overall, these results suggest that race or ethnic differences in prevalence may be most likely to emerge when ADHD is defined by rating scales and by symptom criteria only, but the small number of available studies underscores the critical need for additional research in this area.

Limitations and Directions for Future Research

Limitations of the Literature Review

Due to the extensive published literature on the prevalence of the DSM-IV ADHD, unpublished studies were not included in the current review. As summarized in the Supplemental Materials, statistical tests for publication, and other selection biases suggest that the exclusion of unpublished studies, and the unintentional omission of any published studies that were not identified by the search procedures had minimal impact on the overall pattern of results. Nonetheless, the results of the review should be interpreted in the context of this potential limitation.

Statistical Power

Despite the immense literature synthesized in this report, perhaps the most important limitation of the current review is the limited number of studies that addressed several key questions.

For example, these results provide strong evidence that males are more likely to meet criteria for overall ADHD and all 3 DSM-IV subtypes. In contrast, there were no significant differences in prevalence between countries or regions of the world, but this finding is based on a small number of studies in several regions. Similarly, mixed results were reported by studies that tested for prevalence differences as a function of ethnicity or SES, but power to detect the effects of these potential moderators was limited because few studies reported results stratified on these variables. Taken together, these results suggest that additional research is needed to test the etiology of the robust gender difference in the prevalence of ADHD, and to test more definitively whether the prevalence of ADHD differs as a function of ethnicity, SES, or region of the world.

Diagnostic Procedures

The overall point estimates of the prevalence of ADHD ranged from 4.0 to 13.3 % in the meta-analysis depending on the specific procedures that were used to combine information from multiple raters and measure functional impairment. These results clearly illustrate the sensitivity of prevalence estimates to methodological differences, and suggest several important directions for future research.

Measurement of Impairment

Whereas DSM-IV provided detailed operational definitions of the 9 symptoms of inattention and hyperactivity-impulsivity, little guidance was provided regarding the measurement of functional impairment. As a result, the studies included in the meta-analysis used a wide range of different approaches to assess this key diagnostic criterion. Often, these procedures were not described in detail, and the psychometric characteristics of many of the impairment measures that were used are weak or unknown. Unreliable measures of impairment unavoidably constrain the validity of the overall diagnosis, and could easily lead to overdiagnosis or underdiagnosis of ADHD when full DSM-IV criteria are applied. Systematic research is needed to develop and validate psychometrically sound measures of different aspects of functional impairment, ideally with adequate normative data to facilitate their use in clinical practice.

Algorithms to Combine Multiple Sources of Clinical Information

One of the primary initial goals of our community study was to identify the diagnostic algorithm for ADHD that optimized positive and negative predictive power when significant functional impairment was used as the external criterion to validate the diagnosis. However, the results summarized in Table 2 lead to a more nuanced interpretation that warrants brief discussion.

A total of 824 individuals in our sample met full criteria for the DSM-IV ADHD based on the "or-rule" from the DSM-IV field trials, the least restrictive diagnostic algorithm (Table 2). However, 405 additional cases met symptom criteria based on the "or-rule" but failed to meet other DSM-IV criteria, indicating that only 67 % of all children identified by the "or-rule" algorithm met full criteria for ADHD. In contrast, more than 91 % of the children who met symptom criteria based on the more restrictive "and-rule" algorithm met full DSM-IV criteria for ADHD, but the "and-rule" failed to identify nearly 70 % of the cases that met full diagnostic criteria based on at least 1 alternative algorithm.

These results illustrate that each diagnostic algorithm has important strengths and weaknesses. Due to its high sensitivity, an inclusive algorithm such as the "or-rule" may provide an ideal screening procedure if the overall goal is to identify all individuals who meet criteria for ADHD while minimizing the number of eligible cases that are missed. However, the use of an inclusive algorithm is constrained by its relatively low positive predictive power, leading to a higher number of false-positive diagnoses that must then be identified and excluded.

In contrast, more stringent diagnostic algorithms, such as the "and-rule", maximize the probability that each identified case will meet full criteria for ADHD. This high positive, predictive power may be especially critical for studies that involve a high cost for each participant, including studies that include clinical interventions, brain imaging, or genome-wide DNA analyses. On the other hand, the high rate of false-negatives indicates that stricter algorithms, such as the "and-rule" miss a large percentage of children who meet diagnostic criteria for ADHD based on other algorithms, making it more difficult to recruit a sample of sufficient size. In addition, the most stringent algorithms are likely to identify several affected samples that may not be representative of the overall population of individuals with ADHD to whom studies wish to generalize.

Overall, results from our sample and the meta-analysis suggest that there may be no single "correct" algorithm to combine multiple complex sources of clinical information. Instead, the optimal diagnostic algorithm may depend on the specific purpose for which it will be used. The sparse existing literature indicates the critical need for future studies that directly compare groups defined by different diagnostic algorithms across multiple levels of analysis.

Prevalence of ADHD Across the Lifespan

Of the 97 studies included in the meta-analysis, 80 reported results for samples between 6 and 18 years of age. Furthermore, the majority of the available studies of adults focused on samples that were <25 years of age. Therefore, the current results are most clearly generalizable to school-age children, adolescents, and young adults. Little is known about the manifestation of ADHD symptoms in very young children or individuals with ADHD later in adult life. The development of an adequate developmental model of ADHD across the lifespan is an important goal for future research on the definition and prevalence of ADHD.

Summary and Conclusions

This meta-analysis examined the prevalence of the DSM-IV ADHD in 86 studies of children and adolescents (N= 163,688 individuals) and 11 studies of adults (N=14,112 individuals). Although prevalence estimates reported by individual studies varied widely, results of the meta-analysis suggest that when full DSM-IV diagnostic criteria are applied, the overall prevalence of ADHD in children and adolescents is similar whether ADHD is defined by parent ratings, teacher ratings, or a best estimate diagnostic procedure (5.9–7.1 %). Furthermore, similar prevalence estimates were reported by initial studies of adults (5.0 %).

ADHD-I was the most common subtype in all samples, with the exception of preschool children. In contrast, samples ascertained through clinics typically include a higher proportion of individuals with ADHD-C than ADHD-I or ADHD-H [3]. This difference suggests that although more individuals in the population meet criteria for ADHD-I, individuals who meet criteria for ADHD-C may be more likely to be referred for clinical services.

Finally, consistent with the results of a previous meta-analysis of earlier studies [1], there were no significant prevalence differences between countries or regions of the world after controlling for differences in the diagnostic algorithms used to define ADHD. Although these results must be interpreted with caution due to the small number of studies that were completed in some regions, they indicate that ADHD is observed across a wide range of cultures. This pattern of results argues against the hypothesis that ADHD is a cultural construct that is uniquely associated with the United States or any particular culture [35], and provides important support for the diagnostic validity of ADHD.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

Conflict of interest The author of this work has no real or perceived conflict of interest.

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