Prevalence of Attention-Deficit/ Hyperactivity Disorder: A Systematic Review and Meta-analysis

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abstract

BACKGROUND AND OBJECTIVE: Overdiagnosis and underdiagnosis of attention-deficit/hyperactivity disorder (ADHD) are widely debated, fueled by variations in prevalence estimates across countries, time, and broadening diagnostic criteria. We conducted a meta-analysis to: establish a benchmark pooled prevalence for ADHD; examine whether estimates have increased with publication of different editions of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM); and explore the effect of study features on prevalence.

METHODS: Medline, PsycINFO, CINAHL, Embase, and Web of Science were searched for studies with point prevalence estimates of ADHD. We included studies of children that used the diagnostic criteria from DSM-III, DSM-III-R and DSM-IV in any language. Data were extracted on sampling procedure, sample characteristics, assessors, measures, and whether full or partial criteria were met.

RESULTS: The 175 eligible studies included 179 ADHD prevalence estimates with an overall pooled estimate of 7.2% (95% confidence interval: 6.7 to 7.8), and no statistically significant difference between DSM editions. In multivariable analyses, prevalence estimates for ADHD were lower when using the revised third edition of the DSM compared with the fourth edition ($P = .03$) and when studies were conducted in Europe compared with North America ($P = .04$). Few studies used population sampling with random selection. Most were from single towns or regions, thus limiting generalizability.

CONCLUSIONS: Our review provides a benchmark prevalence estimate for ADHD. If population estimates of ADHD diagnoses exceed our estimate, then overdiagnosis may have occurred for some children. If fewer, then underdiagnosis may have occurred.

REVIEW ARTICLE

Considerable debate exists surrounding the diagnosis of attention-deficit/hyperactivity disorder (ADHD), with claims for the condition being both underdiagnosed[1] and overdiagnosed.[2,3] Prevalence estimates of ADHD within and between countries often vary widely,[4] and reports of increases in prevalence[5] further fuel the controversy. Prevalence estimates are important because high estimates are often widely reported and provide anchors for parents and diagnosing clinicians. Concern has also been expressed regarding the effect of widening diagnostic criteria with more recent editions of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM).[6,7] Given the controversy of whether ADHD is overdiagnosed or underdiagnosed and the true prevalence rate of the disorder, we conducted a systematic review to estimate the prevalence of ADHD and to examine factors that may explain the variations in prevalence.

Five editions of the DSM have been published, and reports of increases in ADHD prevalence have been made with each new edition since publication of the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition* (DSM-III).[7–9] Even when diagnoses are made by using the same DSM edition, variations in prevalence are reported. For example, the United States has conducted multiple nationwide studies that provide estimates of ADHD prevalence. When aggregated, these findings suggest statistically significant differences in prevalence estimates, both between states and within the overall national estimate.[10]

How different studies assess ADHD may affect reported prevalence estimates; for example, the person reporting symptoms for a diagnostic evaluation (parent, teacher, or child) and with what instrument[11,12] and when >1 informant is used, how the information is combined.[9,13] Estimates of ADHD prevalence also

vary when only some of the diagnostic criteria are fulfilled compared with full criteria being met.[14,15] Prevalence estimates for ADHD can be reduced by more than one-half when full criteria are used. For example, differences between DSM editions include the criterion of pervasiveness: the *Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition* (DSM-III-R), requires symptoms to manifest usually (but not necessarily) in >1 setting, whereas the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV), requires symptoms be present in ≥2 settings. DSM-IV includes a criterion of clinically significant impairment.

In the past decade, 5 systematic reviews have been conducted regarding prevalence estimates of ADHD: 3 descriptive reviews[16–18] and 2 meta-analyses.[9,13] However, the latter 2 studies are limited by the following factors: (1) studies were restricted to only 5 languages; (2) the method of measurement (eg, symptom only questionnaires compared with interviews) as potentially affecting prevalence was not considered; (3) prevalence studies using DSM-IV criteria only were included; and (4) the impact of study variables on prevalence estimates were not investigated. The present study is the first to statistically compare the prevalence estimates of ADHD over time between different editions of the DSM.

Our aim was to answer 3 research questions: (1) What is the pooled prevalence estimate of ADHD in children according to DSM criteria? (2) Have prevalence estimates of ADHD increased over time when differing DSM diagnostic criteria have been used? (3) What is the effect of different sampling frames, informants, measurements, full versus partial criteria, and regions on prevalence estimates? We hypothesized that there would be significant increases in the prevalence

estimates of ADHD between DSM-III, DSM-III-R, and DSM-IV and that differences in study methods would account for significant variations in prevalence estimates.

METHODS

Inclusion and Exclusion Criteria

The searches were conducted for studies with point prevalence estimates of ADHD. Eligible studies were those that used the diagnostic criteria from DSM-III, DSM-III-R, or DSM-IV with samples from community or school populations, or using a whole population approach (eg, national surveys). We included studies of any language and with participants aged ≤18 years. Intervention or treatment studies were excluded.

Search Strategy

The databases of Medline, PsycINFO, CINAHL, Embase, and Web of Science were searched by using Medical Subject Headings terms and key words to identify potentially eligible studies (Supplemental Box 1). Key words included attention deficit, ADHD, hyperactivity, disorder, epidemiology, point estimate, child, adolescent, survey, and prevalence. No language, date, or publication restrictions were used.

Study Selection and Data Extraction

Our search yielded 5134 unique citations (Fig 1). All studies were screened against the eligibility criteria by 2 independent reviewers (R.T. and S.S.) by using screening software (DistillerSR, Evidence Partners, Ottawa, Ontario, Canada). Conflicts were resolved through discussion. Data were independently extracted by the same 2 reviewers regarding general publication information, DSM edition used for diagnosis, country, language of publication, sampling procedure (eg, random selection, cohort), year of sampling (or publication date if sampling year not reported),
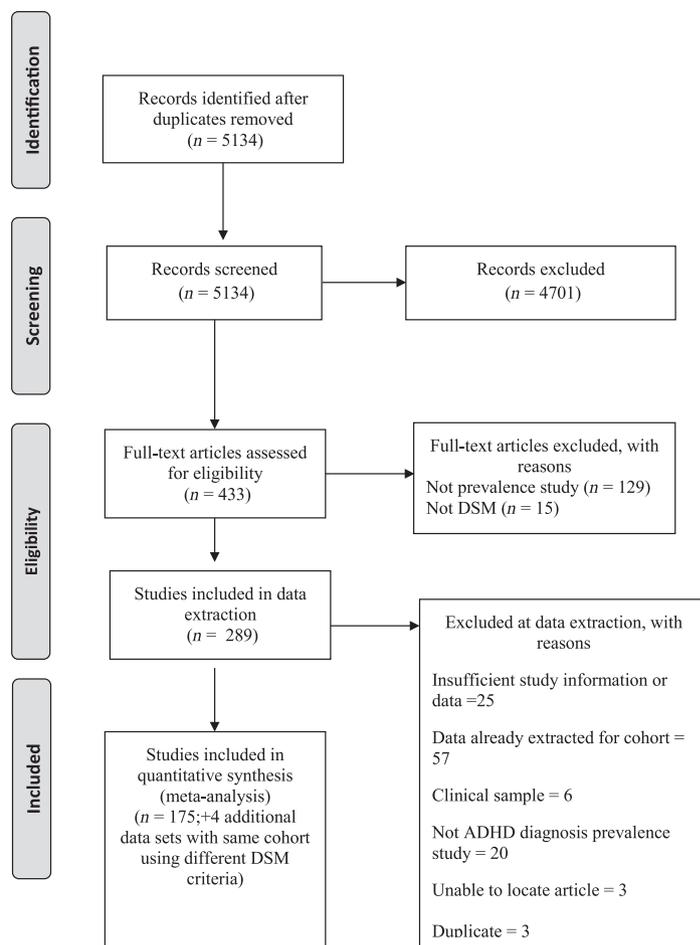
FIGURE 1
Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram.

sampling frame, demographic variables of sample, informant, measures used to make diagnosis (ie, symptom only checklists, reports of diagnosis by others, interviews that were not necessarily conducted by clinicians), and whether the diagnosis met the full DSM criteria for each edition (ie, age of onset and duration for DSM-III; age of onset, duration, and symptoms manifest in at least 1 setting for DSM-III-R; age of onset, duration, symptoms manifest in ≥2 settings, and clinically significant impairment for DSM-IV). The number of children/adolescents identified as having ADHD was extracted, and prevalence was calculated by dividing this number by the total sample size.

Only 1 prevalence estimate for each DSM edition was extracted for each

study. The most conservative diagnosis was used in those studies reporting >1 estimate. Several studies reported lower prevalence of ADHD when children were the informant compared with parent,[13,16] parent compared with teacher,[11,13] and clinicians were reported to estimate the lowest prevalence compared with any other informant.[9,13] Therefore, if a study reported prevalence estimates from different informants, we chose child over parent or teacher, a parent over teacher, and a clinician over any other informant. If the study was longitudinal with multiple prevalence estimates over time in the same sample, the first prevalence estimate was chosen. If a study reported different prevalence estimates for different ages, the combined

prevalence estimate was extracted. Finally, if a study reported several prevalence estimates for ADHD based on full or partial criteria, data were extracted by using the most comprehensive criteria available (eg, we extracted full criteria instead of partial, severe instead of moderate ADHD, and clinical instead of subthreshold).

Prevalence studies often used >1 informant (eg, parent, teacher, child) to identify children or adolescents with ADHD symptoms. The most conservative estimate was again used: the "and rule" (positive if endorsed by ≥2 informants [usually the parent or the teacher]). We also coded whether the study used an "or rule" (positive if endorsed by either informant). The informant was coded as "clinician" if the final stage of screening required a diagnostic interpretation of a clinical interview.

Risk of bias was assessed by using a modified tool developed by Hoy et al[19] for assessing this variable in prevalence studies. One risk of bias item from Hoy et al[19] required studies use an acceptable case definition. As we used studies that reported DSM criteria, we considered this item irrelevant to our review and it was not included. We also limited response options to a forced choice of "low risk" or "high risk." Risk of bias criteria included items regarding the representativeness of sample, sampling frame, random selection, nonresponse bias, informant, and measurement reliability and validity. The more criteria were met, the lower the risk of bias. If the text was unclear, a high risk of bias was then recorded. A study was considered to have a high overall risk of bias if ≤3 criteria were met, moderate risk of bias if 4 or 5 criteria were met, and low risk of bias if studies met 6 to 8 criteria.

Statistical Analyses

Data were analyzed by using Stata version 11.1 (Stata Corp, College

Station, TX). Because there were many small studies with low prevalence estimates, SEs of the prevalence estimates from each study were calculated based on the exact binomial likelihood.[20] Summary effect estimates of prevalence were calculated by using a meta-analysis with a random effects model. Studies were grouped according to DSM editions, and the estimates were then pooled. We used z tests of 2 proportions to examine differences in prevalence estimates of studies by using different DSM criteria. The study factors were investigated that might be related to prevalence estimate by using meta-regression analyses. Study factors included sample size, sampling frame, informant, measurement (symptom only, report of diagnosis, interview, or unclear), study region, and full versus partial criteria. Three studies compared prevalence estimates by using different DSM criteria: DSM-III with DSM-III-R, DSM-III with DSM-III-R and DSM-IV, and DSM-III-R with DSM-IV. These studies were included in analyses for each DSM prevalence estimate, but only 1 estimate (based on the earliest published DSM edition) was included

in the overall pooled result and the meta-regression analysis.

RESULTS

A total of 175 unique studies were included that contributed 179 estimates of prevalence in 1 023 071 subjects over 36 years (Fig 1). Study characteristics are depicted in Fig 2, and characteristics of all included studies are provided in Supplemental Table 2. Overall, there was a broad geographical distribution of studies, although the greatest proportion of studies were conducted in Europe (31%). A majority of studies were conducted within school populations (74%), and few used a whole population approach (10%). The methods used in the studies varied over time, with the use of clinicians falling from 55% in DSM-III studies to 28% in studies using DSM-IV criteria. Parents were used as informants in more than twice as many studies using DSM-IV compared with DSM-III-R criteria (29% and 12%, respectively) and >3 times compared with DSM-III criteria (9%). There was a general decrease in the use of interviews as a measurement tool from DSM-III to DSM-III-R to DSM-IV

(82%, 62%, and 39%) and a corresponding increase in a reliance on symptom only criteria (9%, 33%, and 42%). There was also a decrease in the use of full criteria compared with partial criteria from DSM-III to DSM-III-R to DSM-IV (82%, 62%, and 37%).

Although most studies (75%) were at moderate or low risk of bias, no studies met all 8 criteria, and only 17% were at low risk of bias (Fig 3). The majority of studies rated poorly for likelihood of nonresponse bias (88%) and representativeness of sample (84%), and most studies did not collect ADHD diagnostic information directly from children or adolescents (68%). Summary statistics for risk of bias for studies included in each DSM edition are provided in Supplemental Figs 5, 6, and 7.

Overall Prevalence of ADHD

The overall, pooled prevalence of ADHD including all editions of the DSM was 7.2% (95% confidence interval [CI]: 6.7 to 7.8]). Within the univariable models, prevalence estimates of ADHD were, on average, 3% lower when diagnoses were made with DSM-III-R criteria than with either DSM-III or DSM-IV criteria
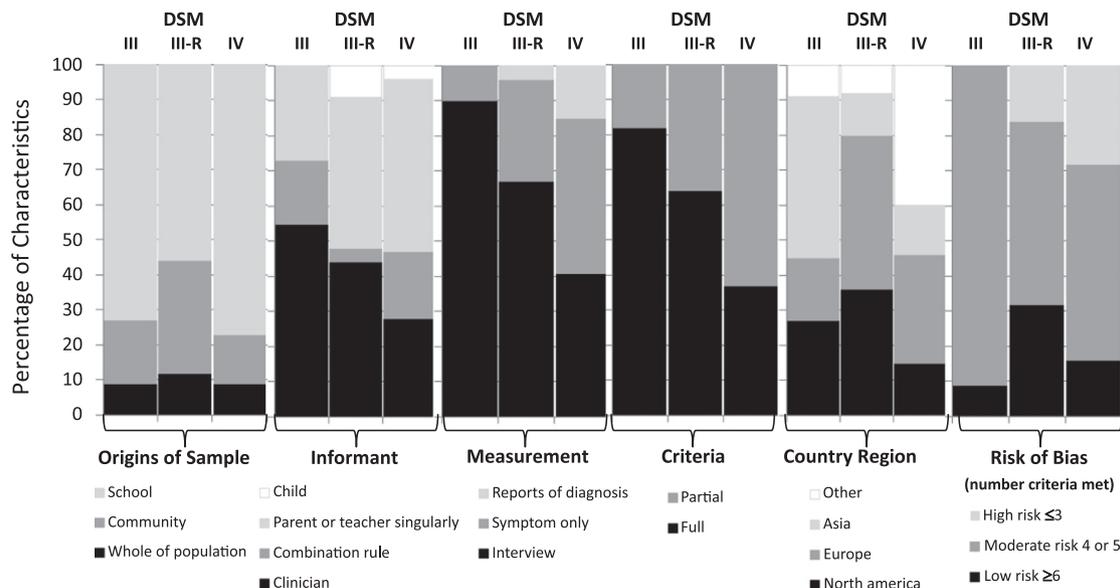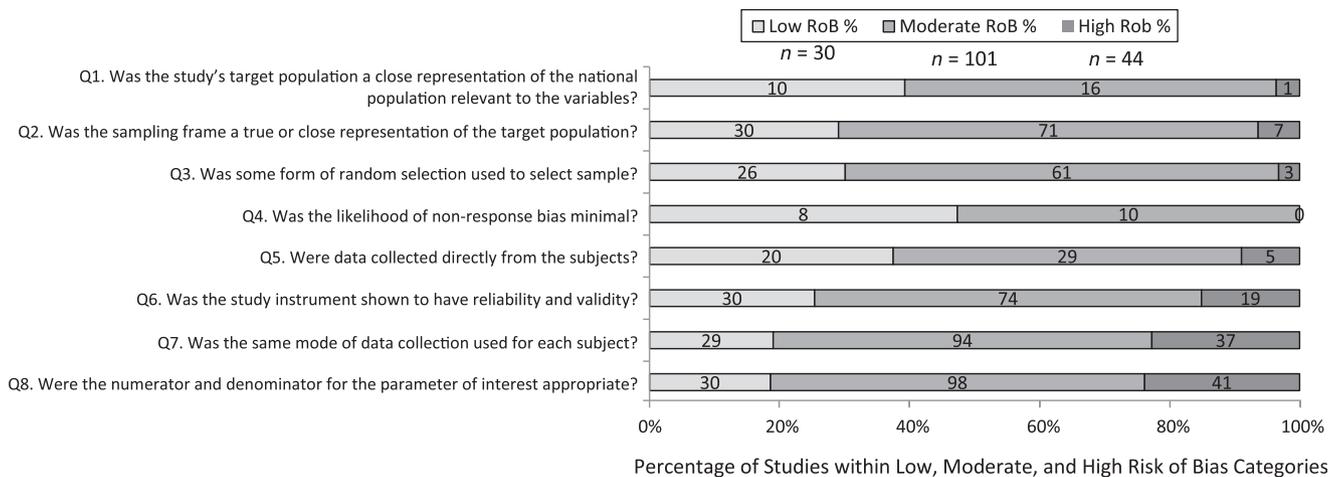

FIGURE 2
Characteristics of included studies.

FIGURE 3
Number and percentage of included studies addressing risk of bias (RoB) questions (N = 178).

(P = .008), 2% higher when symptom only checklists were used rather than clinical interviews (P = .02), and 4% higher when children were diagnosed in the Middle East compared with North America (P = .002) (Table 1). No other variables were statistically significant. After entering all statistically significant variables into a multivariable meta-regression, only DSM edition and region remained significant. After adjusting for measurement and region, prevalence estimates for ADHD were, on average, 2% lower when using DSM-III-R compared with DSM-IV criteria (P = .03) and 2% lower in studies conducted in Europe compared with North America after adjusting for DSM edition and measurement (P = .04).

Changes in Prevalence Using Different DSMs

There was a wide range of prevalence estimates for each DSM. DSM-III prevalence ranged from 1% to 12% and had a pooled prevalence of 5.6% (95% CI: 3.7 to 7.5). DSM-III-R estimates ranged from 0.3% to 11% with a pooled prevalence of 4.7% (95% CI: 3.3 to 6.0). DSM-IV had the widest prevalence range (between 0.2% and 34%) with a pooled prevalence of 7.7% (95% CI: 7.1 to 8.4). There was significant heterogeneity across all studies in each DSM edition (I^2 ranged between

96.9% and 99.3%). Despite the different prevalence estimates, the pooled prevalence was not statistically significantly different between editions of the DSM (DSM-III to DSM-III-R, P = .9; DSM-III-R to DSM-IV, P = .6; DSM-III to DSM-IV, P = .8).

Impact of Study Variables on Prevalence Estimates for Different DSMs

In univariable meta-regressions for studies conducted with DSM-III criteria, there was a significant increase in prevalence estimates when the informants were parents compared with clinicians (parents' estimates were, on average, 8% higher, P = .03). However, no other study variables were significant. In studies establishing the prevalence of ADHD by using DSM-III-R criteria, no study variables helped explain heterogeneity. When using DSM-IV criteria, only the region in which the study was conducted was significant; the Middle East had, on average, 3% higher prevalence estimates of ADHD than North America (P = .02).

Changes in Prevalence Over Time

Figure 4 plots the prevalence estimates of ADHD between 1977 and 2013 according to year of study publication. Also shown are the year of DSM publication, the year of US Food and Drug Administration

approval dates of significant ADHD medications, and the year direct-to-consumer advertising commenced in the United States. When a new DSM edition was published, it was followed by an increased publication of studies with prevalence estimates of ADHD with a publication lag time. Most studies with a prevalence estimate of ADHD >10% occurred using the diagnostic criteria of DSM-IV.

Sensitivity Analysis and Potential Bias

Sensitivity analyses were conducted with the 32 studies (contributing 33 prevalence estimates) that were at the lowest risk of bias. The prevalence estimate of ADHD in these studies was slightly higher at 7.8% (95% CI: 6.6 to 9) but not statistically different from the overall pooled prevalence (P = .95). Prevalence estimates of low risk of bias studies ranged between 1% and 20%. Heterogeneity remained significant (I^2 = 99.5%), and there were no statistically significant differences between prevalence estimates according to the various DSM editions.

Prevalence estimates were compared with study sample size (Supplemental Fig 8), similar to a funnel plot, to detect publication or methodologic bias. Almost all of the studies with smaller samples (between 100 and

TABLE 1 Association Between Study Variables and ADHD Prevalence Estimates

Study Variable	Univariate Analyses			Multivariate Analyses With Significant Predictors		
	Coefficient	95% CI	P	Coefficient	95% CI	P
DSM edition (RC: DSM-IV)						
DSM-III-R	−3%	−0.05 to −0.01	.008	−2%	−0.05 to 0.00	.03
DSM-III	−2%	−0.05 to 0.01	.18	−1%	−0.04 to 0.02	.60
Sample size	0%	−0.00 to 0.00	.17	—	—	—
Origins of sample (RC: population)						
Community	−1%	−0.04 to 0.03	.72	—	—	—
School	2%	−0.01 to 0.04	.17	—	—	—
Informant (RC: clinician)						
AND rule	0%	−0.03 to 0.03	.85	—	—	—
OR rule	0%	−0.04 to 0.03	.79	—	—	—
Parent	0%	−0.02 to 0.02	.79	—	—	—
Teacher	1%	−0.01 to 0.04	.19	—	—	—
Child	−2%	−0.06 to 0.02	.24	—	—	—
Unclear/not reported	−1%	−0.05 to 0.07	.71	—	—	—
Measurement (RC: interview)						
Symptom only	2%	0.00 to 0.04	.02	1%	−0.00 to 0.03	.11
Reports of diagnosis	−1%	0.03 to 0.02	.59	−1%	−0.04 to 0.01	.36
Unclear/ not reported	0%	−0.04 to 0.04	.82	0%	−0.04 to 0.04	.92
Criteria						
Partial versus full	1%	−0.01 to 0.02	.32	—	—	—
Country region (RC: North America)						
Europe	−1%	−0.04 to 0.01	.15	−2%	−0.05 to 0.00	.04
Asia	−2%	−0.05 to 0.01	.12	−2%	−0.05 to 0.00	.08
South America	2%	0.00 to 0.05	.10	1%	−0.02 to 0.04	.55
Oceania	−3%	−0.07 to 0.01	.13	−3%	−0.07 to 0.01	.12
Middle East	4%	0.02 to 0.06	.002	2%	−0.00 to 0.05	.09
Africa	−1%	−0.05 to 0.03	.70	−3%	−0.07 to 0.02	.21
South Asia	−1%	−0.05 to 0.03	.65	−2%	−0.06 to 0.03	.39

RC, reference category; —, variable not included in multivariable analyses.

5000 participants) and with prevalence estimates >10% used DSM-IV diagnostic criteria. Of the 75 studies with <1000 participants, 23 studies reported prevalence estimates of >10%. Of these, all but 2 (91%) were studies that used DSM-IV criteria for ADHD diagnosis. Similarly, of the 80 studies with sample sizes between 1001 and 5000, 18 studies reported a prevalence estimate of >10%; of these, 17 (94%) were studies that used DSM-IV criteria. A post hoc χ^2 analysis indicated that studies with prevalence estimates >10% were more likely to be from studies that used the DSM-IV criteria compared with DSM-III or DSM-III-R criteria (χ^2 = 6.99, P = .03).

DISCUSSION

We conducted the first meta-analysis investigating if there has been

a change in the prevalence of ADHD over time and after publication of new DSM editions. Anecdotally, and using data from physician outpatient registries,[21] the number of children diagnosed with ADHD seems to have increased. However, contrary to our hypothesis, the estimates of prevalence did not statistically significantly increase over time nor were they statistically significantly different between the various DSM editions.

Our pooled estimate of 7.1% for all studies exceeds the 5.3% estimate reported by Polanczyk et al,[9] but the difference may be explained by the language restriction in that sample and by the increased number of studies included in our review. We included 83 studies published since the review of Polanczyk et al was published, and we had no language restriction for included studies.

Willcutt[13] also conducted meta-analyses for prevalence estimates of ADHD. The author categorized the prevalence estimates according to informant, with the lowest prevalence estimate reported for clinicians (5.9% "best estimate") and the highest for teachers using measurements that assessed symptoms only (13.3%). Our estimate is within this range.

Although pooled estimates were not statistically significantly different between DSM editions, prevalence estimates were smaller when studies used the DSM-III-R criteria for diagnosis of ADHD. It is possible that the inclusion of subtypes in both DSM-III and DSM-IV criteria allow for a broader group of children to be diagnosed with the disorder that our study has not had the power to detect. When different DSM criteria were considered simultaneously in a univariable and multivariable analysis, studies using the criteria of DSM-III-R had significantly lower ADHD prevalence than studies using either DSM-III or DSM-IV criteria.

The only other study characteristic that contributed to the variation in prevalence estimates was region. Estimates of ADHD prevalence were greater in the Middle East compared with North America in univariable analyses; multivariable analysis studies conducted with participants from Europe had lower prevalence estimates of ADHD compared with North America. Unexpectedly, sample size, sampling frame, informant, and measurement did not account for differences in prevalence estimates.

Our study has several strengths. It is the first to quantify changes to ADHD prevalence estimates over time. The included studies span 36 years and report on prevalence estimates of ADHD for >1 million children. We included all languages, and most regions of the world were represented. We used the most conservative estimates of prevalence by analyzing data in a manner that reflected best practice (eg, full criteria
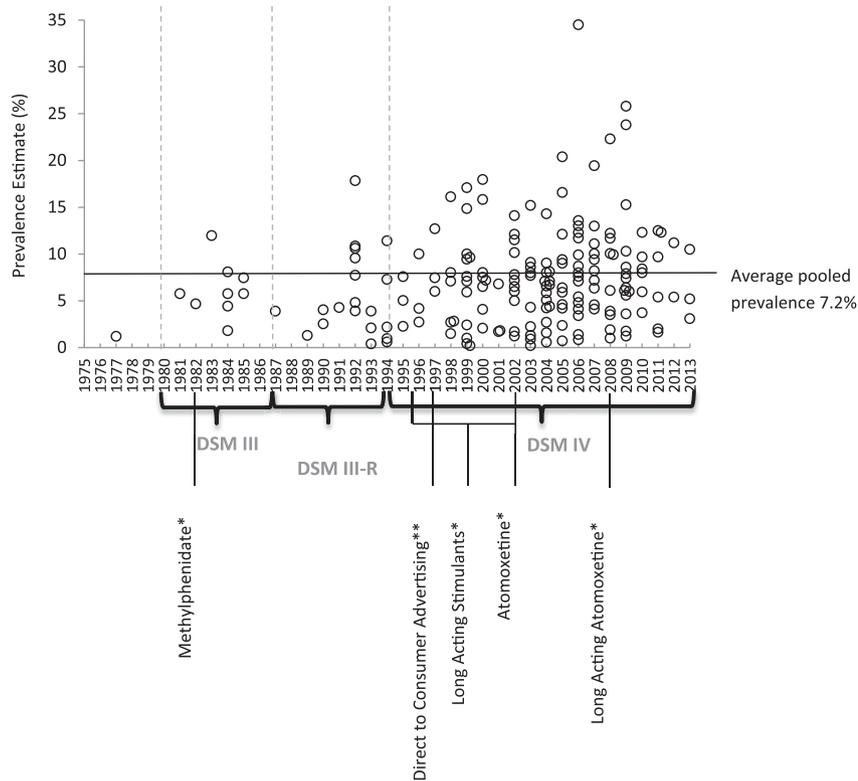
* US Food and Drug Administration approval year
** Direct to Consumer Advertising to the US

FIGURE 4
Prevalence of ADHD over time. [a]US Food and Drug Administration approval year. [b]Conducted in the United States.

rather than partial criteria).[14] This study is also the first to rate risk of bias of prevalence studies for ADHD.

The major limitation of our review is the sampling frames of the primary studies. Few studies used a whole population approach with random selection. Most were from single towns or regions, thereby limiting generalizability. The majority did not discuss the potential of nonresponse bias. We also did not contact authors to find unpublished studies; given the range of prevalence estimates over the 3 DSM editions, however, we do not consider this omission likely to have affected our outcomes.

To ensure that the study data were as homogeneous as possible, we extracted prevalence estimates from each by using the study's most conservative diagnosis. This method may also be a limitation of our review.

There are no agreed standards regarding accuracy or reliability of different informants, and studies vary in their informant source. Using the most conservative estimates based on informant and full criteria rather than partial criteria may have affected prevalence. Finally, only 55 studies reported clinician involvement in the diagnosis of ADHD, and studies using these informants decreased over time; the impact of this outcome is unclear.

There is significant community[22] and professional[23] concern that ADHD is overdiagnosed. Some researchers[24] have argued that to determine if overdiagnosis of ADHD has occurred, a comparison of actual diagnoses with the prevalence estimate of a large-scale, well-conducted, national representative study would be suitable. We contend that our estimates provide a suitable

benchmark. Over time and editions of the DSM, the high-quality estimates of prevalence are relatively consistent. If diagnoses from national or state population surveys exceed our estimate, then prima facie overdiagnosis of ADHD may be occurring for some children. If fewer, then underdiagnosis may be occurring.

Prevalence estimates matter because they have an anchoring effect. If a condition is considered rare, a clinician does not often consider it as a primary diagnosis. Conversely, if deemed common, the condition is often considered one of the most likely diagnoses. ADHD is a well-known, "common" childhood diagnosis, and publications of high estimates receive widespread media coverage. We have established a benchmark prevalence estimate for ADHD by systematically extracting the most robust and conservative estimates from 36 years of published research.

There was a wide variation in prevalence estimates between studies, and few factors in our meta-regression explain this variation. It is possible that how the diagnostic criteria were applied may explain some of the variation. For example, although 2 studies may consider the extent to which ADHD symptoms clinically affect an individual, the subjective interpretation of "clinically significant" can vary. This qualification was added to DSM-IV criteria and has been criticized for its subjectivity.[25,26] It has been changed in the *Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders* to symptoms must "interfere with, or reduce the quality of" functioning.[6] How this change affects the prevalence of ADHD is unknown.

CONCLUSIONS

Given the range of prevalence estimates in published studies and that these estimates matter to

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professionals and the public alike, it is clear that how the criteria of the DSM are applied must be standard and systematic. Media reports of high rates of diagnosis may cause suspicion regarding the diagnosis overall and can lead to stigma for those diagnosed with the condition. Extensive media coverage of prevalence estimates that exceed expectations subject the diagnosis of ADHD to ridicule and incredulity, and harms those with severe problems the most. An accurate diagnosis is arguably the single most important thing a clinician can do for a patient, and our estimates may help to better establish population-based benchmarks for clinicians to consider.

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