

The Impact of Case Definition on Attention-Deficit/Hyperactivity Disorder Prevalence Estimates in Community-Based Samples of School-Aged Children

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Objective: To determine the impact of varying attention-deficit/hyperactivity disorder (ADHD) diagnostic criteria, including new *DSM-5* criteria, on prevalence estimates.

Method: Parent and teacher reports identified high- and low-screen children with ADHD from elementary schools in 2 states that produced a diverse overall sample. The parent interview stage included the Diagnostic Interview Schedule for Children-IV (DISC-IV), and up to 4 additional follow-up interviews. Weighted prevalence estimates, accounting for complex sampling, quantified the impact of varying ADHD criteria using baseline and the final follow-up interview data.

Results: At baseline 1,060 caregivers were interviewed; 656 had at least 1 follow-up interview. Teachers and parents reported 6 or more ADHD symptoms for 20.5% (95% CI = 18.1%–23.2%) and 29.8% (CI = 24.5%–35.6%) of children respectively, with criteria for impairment and onset by age 7 years (*DSM-IV*) reducing these proportions to 16.3% (CI = 14.7%–18.0%) and 17.5% (CI = 13.3%–22.8%); requiring at least 4 teacher-reported symptoms reduced the parent-reported prevalence to 8.9%

(CI = 7.4%–10.6%). Revising age of onset to 12 years per *DSM-5* increased the 8.9% estimate to 11.3% (CI = 9.5%–13.3%), with a similar increase seen at follow-up: 8.2% with age 7 onset (CI = 5.9%–11.2%) versus 13.0% (CI = 7.6%–21.4%) with onset by age 12. Reducing the number of symptoms required for those aged 17 and older increased the overall estimate to 13.1% (CI = 7.7%–21.5%).

Conclusion: These findings quantify the impact on prevalence estimates of varying case definition criteria for ADHD. Further research of impairment ratings and data from multiple informants is required to better inform clinicians conducting diagnostic assessments. *DSM-5* changes in age of onset and number of symptoms required for older adolescents appear to increase prevalence estimates, although the full impact is uncertain due to the age of our sample.

Key Words: ADHD, diagnostic criteria, *DSM-5*, impairment, age of onset

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Attention-deficit/hyperactivity disorder (ADHD) is described as the most common neurodevelopmental disorder of childhood^{1,2}; however, prevalence estimates vary, given their sensitivity to factors such as the period of study,³ country or region of the country,^{3,6} and research methods,^{7,8} although a recent meta-analysis has disputed the variability for studies using standardized procedures over time.⁹ In the United States, rates are higher in the South and Midwest³; however, even where prevalence estimates vary across regions, trends may be similar. Different study settings result in varying estimates, with clinic-based studies differing from community-based studies in both prevalence and case mix. The direction of differences depends on the denominator used for clinical studies, but clinic-based studies tend to reflect more severe cases with greater comorbidity.^{10–13} In addition, studies using different methods and case definitions, such as those that use administrative data and parent surveys, report different point estimates yet similar upward trends in the prevalence of ADHD^{14,15}; however, once sample selection parameters are made comparable, estimates may become similar.¹⁶

ADHD terminology and criteria have undergone substantial revision over time, starting with “hyperkinetic

reaction of childhood” in the *DSM-II*, then “attention deficit disorder with or without hyperactivity” in the *DSM-III*.¹⁷ In the *DSM-III-R*, subtypes were removed, and the diagnosis was ADHD without further specification.¹⁸ Three subtypes were created in the *DSM-IV* (inattentive, hyperactive/impulsive, and combined), reframed as presentation specifiers in the *DSM-5*.^{1,19,20}

Alongside changing terminology, diagnostic criteria have changed over the *DSM*’s 4 revisions, with direct impact on diagnosis and estimates of prevalence. The most marked changes occurred with the more clearly described disorder of inattentiveness with or without hyperactivity in the *DSM-III*,¹⁷ followed by delineated subtypes in the *DSM-IV*.¹⁹ The impact of modifications to the ADHD criteria in the *DSM-5*¹ has yet to be realized, particularly with regard to age of onset and criteria for older adolescents and adults, although a recent study examined the change in age of onset in a cross-sectional national sample and concluded that increased case finding with comparable clinical significance validated the change.²¹ Because of the variability in prevalence across study types and settings noted above, investigation of the impact of case definition on prevalence estimates is important.

In the *DSM-IV* and *DSM-5*, ADHD diagnosis requires meeting symptom count criteria and exhibiting impaired functioning in at least 2 settings. The *DSM-IV*¹⁹ stated there must be “some impairment” related to the symptoms in 2 or more settings and that there must be “clear evidence of clinically significant impairment” (p. 84). The *DSM-IV* noted that clinicians should obtain information from multiple sources. The *DSM-5* requires that several symptoms²² be present before age 12 years, that they be evident in more than 1 setting, and that they impair functioning. The *DSM-5* asserts that reliably ascertaining symptoms and impairment in multiple settings would be difficult without multiple informants, but both editions stop short of explicitly requiring multiple informants. The challenges of collecting data from multiple informants include the difficulty of obtaining information from teachers while respecting privacy concerns, regulations, and time constraints, as well as the difficulty of resolving disagreement between informants,^{23,24} raising concerns about the value of investing resources in obtaining data from other informants. Depending on how information is combined, diagnostic rates and prevalence estimates could increase or be attenuated. Barkley²⁵ pointed out that the *DSM-IV* criteria “confound settings with sources of information” (p. 91), and that impairment is the important clinical issue to be ascertained, rather than agreement among informants.

Furthermore, standard research instruments do not couch impairment classification in the terms used in the *DSM-IV* criteria, namely, “clinically significant impairment,” instead using terms such as “moderate” and “severe,” as in the *DSM-5*. Translating the level of impairment reported in research data to comparable thresholds for *DSM* classification has been a challenge. Just as there is no standard for assessing the level of impairment for research diagnostic classification, neither is there a standard metric for clinicians to use in determining level of impairment, especially with the deletion of the Global Assessment of Functioning from the *DSM-5*, which previously served as a common measure of functional impairment.

Another major change in the *DSM-5* was the increase in the age of onset criterion, which was raised from age 7 to 12 years. The age of onset requirement has been questioned for some time, especially because the inattentive symptoms may be delayed in presentation or more difficult to identify, particularly among females.^{10,26-28} Understanding the impact of the change in the age of onset criterion is critical for understanding trends in reported ADHD prevalence over the next generation of studies.²¹

The *DSM-5* also provides more guidance on diagnosis of ADHD among teens and adults 17 years of age and older, including reducing the number of symptoms required from 6 to 5 for that group. If prevalence estimates in adults change, the challenge will be to disentangle (a) age effects (i.e., adolescents newly meeting or no longer meeting criteria as a result of development or treatment) from (b) period effects (i.e., the expanded guidance for adult diagnosis in the *DSM-5*) and from (c) cohort effects (i.e., children and adolescents from later cohorts with higher prevalence rates aging into adulthood).

These issues of variability in prevalence estimates are important because they affect research methodology and clinical practice with regard to diagnosis and treatment. Furthermore, continued wide variability in research reports and in clinical diagnosis can undermine public confidence in reports of ADHD research, delaying their impact or reducing their utility for informing policy and programs.

In light of the foregoing, the objective of this paper is to quantify the impact of varying case definition criteria on prevalence estimates, with a focus on symptom and impairment criteria, reliance on 2 informants for multiple settings, and age of onset. Our primary hypothesis is that each successive additional requirement will result in a clinically meaningful decrease in the proportion of individuals classified as having probable ADHD. A secondary objective is to estimate the impact on prevalence estimates of the *DSM-5* criterion regarding age of onset for impairing symptoms and reduced number of required symptoms for those aged 17 years and older. Our secondary hypothesis is that higher age of onset and lower symptom count for older adolescents and adults will result in more participants meeting diagnostic criteria, thus increasing the prevalence of diagnosed ADHD. We examined these issues using data from the longitudinal Project to Learn about ADHD in Youth.²⁹

METHOD

Population

The Project to Learn about ADHD in Youth (PLAY) is a community-based epidemiological study to characterize the prevalence and impact of ADHD in school-aged children. Methods and demographic characteristics of the districts and screened sample by site have been previously described.²⁹ Briefly, study participants were selected from public elementary schools in school districts in South Carolina (SC) and Oklahoma (OK) using a stratified, 2-stage sampling design to maximize case-finding and to recruit comparable ratios of boys to girls within high- and low-screen groups. The first stage involved parent and teacher screening in mainstream classrooms (SC $n = 4,606$; OK $n = 12,626$). Parents were asked if their child had ever been diagnosed with ADHD/attention deficit disorder (ADD) and if their child was on medication for ADHD/ADD. For each child, teachers completed the Vanderbilt ADHD Diagnostic Teacher Rating Scale (VADTRS)³⁰ in all 6 school districts, and the Strengths and Difficulties Questionnaire (SDQ)³¹ in 4 districts. Teachers were also asked 2 questions about diagnosis and treatment for each child, comparable to those asked of parents. Screening excluded students in self-contained special education classrooms and included kindergarten through fifth grade, with a small number of prekindergarten students ($n = 21$ in SC and $n = 37$ in OK).

Students with positive responses to the diagnosis and treatment questions from either parent or teacher or whose teachers endorsed at least 6 inattentive or 6 hyperactive/impulsive descriptors on the VADTRS and were rated as having at least some impairment on the SDQ or VADTRS were classified as high screen. SDQ data were used where present to determine teacher-reported impairment. For the 2 OK districts that did not administer the SDQ, VADTRS performance items were used due to good agreement of impairment classification between the SDQ and the VADTRS (based on 86.5% of the sample who had both: $\kappa = 0.68$). A low-screen group was randomly selected from the remaining screened students, with proportions by gender

TABLE 1 Frequencies and Weighted Percentages of Project to Learn About Attention-Deficit/Hyperactivity Disorder (ADHD) in Youth Sample Demographics

Characteristic	Baseline		Each Participant's Final Follow-Up	
	Frequency	% (95% CI)	Frequency	% (95% CI)
Total	1,060	100.00	656	100.00
Sex				
Male	737	51.5 (47.8–55.1)	440	47.9 (41.7–54.2)
Female	323	48.5 (44.9–52.2)	216	52.1 (45.8–58.3)
Age, y				
4–7	285	28.8 (23.5–34.8)	3	1.4 (0.2–8.0)
8–10	477	46.1 (39.9–52.4)	44	12.8 (7.4–21.5)
11–13	293	24.7 (19.9–30.2)	205	35.8 (28.3–44.2)
14–16	5	0.5 (0.1–1.7)	295	36.2 (29.7–43.2)
17–19	0	0.0	109	13.8 (8.8–21.0)
Race				
White	623	51.6 (45.6–57.5)	393	52.8 (44.6–60.9)
Black	263	28.6 (23.5–34.3)	191	37.2 (29.7–45.4)
Other	174	19.8 (15.5–25.0)	72	10.0 (6.5–14.9)
Ethnicity				
Hispanic	74	10.5 (7.2–15.1)	28	3.6 (1.6–7.8)
Not Hispanic	986	89.5 (85.0–92.8)	628	96.4 (92.2–98.4)
Poverty Status: 2004 FPL				
<200% FPL	590	54.5 (48.0–60.8)	440	47.9 (41.7–54.2)
≥200% FPL	470	45.5 (39.2–52.0)	216	52.1 (45.8–58.3)
Past-Year Parent-Reported ADHD Medication Use				
Among those meeting criteria				
SC	57/99	57.2 (46.9–66.9)	41/68	50.6 (36.3–64.8)
OK	33/116	21.4 (13.7–31.7)	42/82	24.4 (9.4–50.1)
Pooled	90/215	39.5 (31.1–48.6)	83/150	32.3 (16.6–53.5)
Among those not meeting criteria				
SC	84/382	10.3 (7.6–13.8)	62/305	12.2 (8.6–17.0)
OK	114/463	9.2 (6.8–12.3)	39/201	7.0 (4.2–11.3)
Pooled	198/845	9.6 (7.3–11.9)	101/506	9.4 (7.0–12.5)
Entire sample				
SC	141/481	14.4 (11.6–17.7)	103/373	15.6 (12.0–20.1)
OK	147/579	9.8 (7.5–12.7)	81/283	9.8 (6.8–13.9)
Pooled	288/1060	11.2 (9.3–13.4)	184/656	12.4 (9.9–15.4)

Note: FPL = federal poverty level; OK = Oklahoma; SC = South Carolina.

equal to proportions in the high-screen group. These students constituted the pool eligible for in-depth interviews.

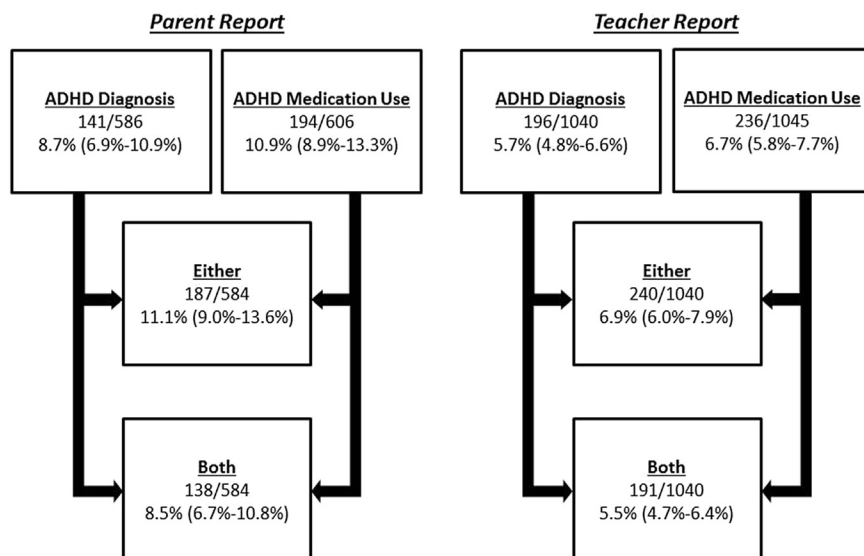
For most children, the participating interviewee was the child's mother (94% in SC, 86% in OK). Data from child interviews were not considered for this report. Interviews included selected modules from the Diagnostic Interview Schedule for Children, Version IV (DISC-IV).³² DISC-IV computer algorithms for probable diagnosis were supplemented by additional criteria in initial estimates of ADHD prevalence.²⁹ The case definition required at least 2 moderate ratings or 1 severe rating of impairment across 6 domains. In addition, to meet our ADHD case definition, low-screen students had to exhibit at least 4 teacher-reported symptoms of hyperactivity/impulsivity or inattention as confirmation symptoms that were present and problematic in the school setting. Studies at both sites were approved by their respective institutional review boards.

Participants with baseline interviews were eligible for up to 4 follow-up interview waves in SC and up to 2 waves in OK beginning approximately 4 years after the baseline interview wave. Follow-up interviews included the parent and child DISC-IV and Vanderbilt

ADHD Diagnostic Parent Rating Scale (VADPRS) and SDQ, as well as additional assessments. Among respondents 78% in SC (n = 373) and 49% in OK (n = 283) completed at least 1 follow-up interview. The median time between baseline interview and last follow-up interview was 6.2 years in SC (interquartile range = 5.6–6.6) and 4.2 years in OK (3.1–5.0). The last follow-up interview for each child is used in these analyses to examine the impact of changes to DSM criteria in an older cohort of children (OK median age = 13 years, range = 7–18 years; SC median age = 15 years, range 7–19 years; overall median age = 14 years).

Weights were developed at each wave that reflected initial participation in the screening, stratified sampling, and nonresponse over time.²⁹ Analyses were conducted in SAS 9.2 (SAS Institute, Inc., Cary, NC) and SAS-callable SUDAAN 11.0 (RTI International, Research Triangle Park, NC) to account for the sampling design and weighting. The weighted population reflected the composition of the school districts with respect to race, gender, distribution across schools, and screening status at the time of the baseline interview. For a longitudinal analysis of

FIGURE 1 Number and unweighted percentage (95% CI) of the screened Project to Learn about Attention-Deficit/Hyperactivity Disorder (ADHD) in Youth sample with a parent- or teacher-reported ADHD diagnosis or medication use. Note: Denominators reported show the number of parents and teachers who responded to whether a child had been diagnosed with ADHD or used medication. Likely explanations for more teacher-reported data include that teachers received incentives, they were directly requested to complete reports by school administrators, and they were able to complete classroom-sized batches of instruments.



symptom persistence and factors associated with elevated symptom counts, see Holbrook *et al.*³³

Variations in Case Definition

The project case definition was based on the DISC algorithms, with additional requirements reflecting our interpretation of the *DSM-IV* criteria. Those criteria were formulated a priori and previously reported.²⁹ For this report, data from initial teacher and parent screens concerning diagnosis and treatment, teacher report of symptoms and impairment, and parent DISC-IV interviews were used to evaluate the impact on ADHD prevalence estimates of different case definition criteria that might be used in clinical practice or research studies. The evaluation of varying diagnostic criteria relies primarily on baseline data to which different case definition criteria were applied in succession to explore the impact of each additional criterion. Teacher evaluations were not available for follow-up assessments.

Symptom Count Criteria. In the first step, to parallel research studies that rely only on teacher-reported symptom counts, estimates reflect rates of (a) teacher report of 6 or more symptoms, as well as estimates based on (b) the report of at least some impairment due to symptoms, then (c) the effect of requiring both a minimum symptom count and at least some impairment.

Report of Diagnosis or Treatment. The second step parallels surveys that rely solely on reported diagnosis and treatment and reflects parent and teacher reports of ADHD diagnosis or treatment, separately and combined.

DSM-Based Estimates. The third step is patterned after *DSM-IV* criteria and successively reports proportions in the following order, each conditioned on meeting the prior criterion: 6 or more parent-reported DISC-IV symptoms; problem onset before age 7 years; at least 2 moderate or 1 severe rating of impairment; and a second informant (teacher) report of at least 4 symptoms.

At each stage results are reported as unweighted numbers with weighted percentages and 95% CIs for proportions representing the

school population, and unweighted percentages for within-sample comparisons.

Applying *DSM-5* Criteria

Age of onset and symptom count data from each participant's last follow-up interview were used to estimate changes in prevalence due to the *DSM-5*'s revised criteria. Consistent with the *DSM-5* specification of symptoms as mild, moderate, or severe, we used DISC-IV parent-reported severity of impairment associated with symptoms to determine the impact of requiring at least 2 moderate or at least 1 severe rating of impairment across 6 domains.

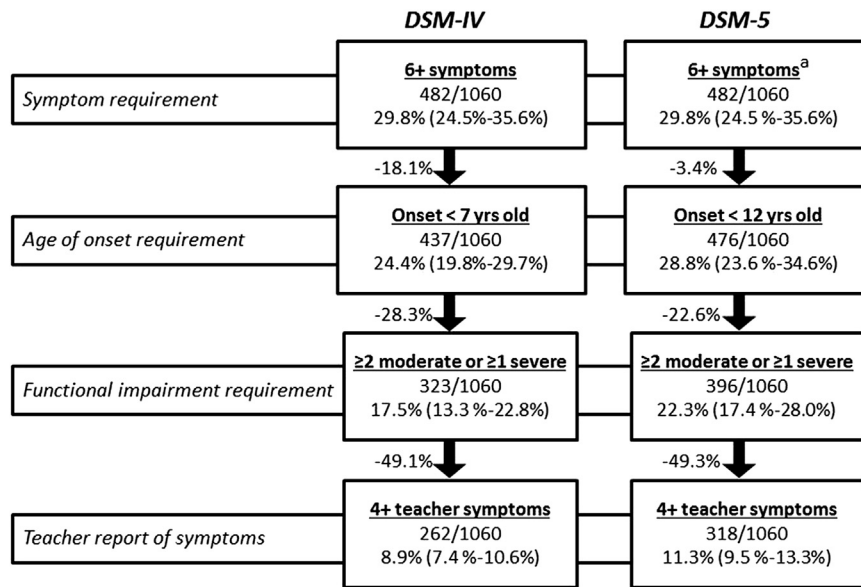
RESULTS

Case Definition Parameters

Teacher screeners and baseline parent interviews were obtained for 481 children in South Carolina and 579 children in Oklahoma. Demographic characteristics are shown in Table 1. Because relative changes in estimates when applying different case definition criteria resulted in similar patterns at both sites, combined results are presented here. The SC sample had a higher proportion of black students, and the OK sample had more Hispanic and American Indian students, although both samples were racially diverse. The most significant difference between the 2 samples was in the proportion of students from families whose income was less than 200% of the 2004 federal poverty line (<200% FPL: 67.8% in OK versus 29.5% in SC).

For the screener questions on ADHD diagnosis and medication history, there were 584 parent reports (11 parent-only) and 1,040 teacher reports (467 teacher-only). Teacher-reported proportions were lower than parent-reported results (Figure 1). Of the subset of children for whom both

FIGURE 2 Depreciation in the number and percent (95% CI) of the baseline Project to Learn about Attention-Deficit/Hyperactivity Disorder (ADHD) in Youth sample who met each level of ADHD diagnostic criteria. ^aNo participants at baseline were 17 years or older, so the required symptom count remains 6 or more.



parent and teacher screening data were available ($n = 573$), agreement between parent and teacher report of either a diagnosis or medication use was good to excellent (SC: $\kappa = 0.88$, 95% CI = 0.84–0.92; OK: $\kappa = 0.67$, 95% CI = 0.58–0.70; combined $\kappa = 0.78$, 95% CI = 0.69–0.87), with 7.7% of children having either diagnosis or medication usage reported by both parent and teacher, and 11.6% of children having diagnosis or medication usage reported by at least 1 informant. Of those with parent-reported diagnosis, 67.5% were reported by teachers as having a diagnosis. When parents reported medication, 78.5% of teachers also reported medication; 91.3% of parents reported a diagnosis when the teacher also reported a diagnosis; and 90.2% of parents reported medication when the teacher reported medication.

Teachers reported 20.5% of children had at least 6 ADHD inattentive or hyperactive/impulsive symptoms, and 33.6% of children had at least some impairment based on the SDQ or VADTRS. When symptom count and impairment criteria were combined, the proportion of children who met both criteria dropped to 16.3%.

Baseline parent interview data reflected that 29.8% of children had at least 6 ADHD symptoms (Figure 2), 81.9% of whom had symptom onset by age 7 years. Varying impairment criteria resulted in prevalence estimates ranging from 11.5% to 17.5%. Only 3 children had a severe rating in 1 domain with no other moderate or severe ratings, thus requiring at least 2 moderate ratings capture 99.1% (320 of 323) of those meeting the impairment component of our study case definition and 98.8% (249 of 252) of those with at least 1 severe rating.

Finally, we added the requirement of teacher report of at least 4 symptoms in those children meeting DISC-based parent-reported criteria but who were low-screen. With that additional requirement, the prevalence estimates

decrease by approximately half, from 17.5% to 8.9% in the pathway corresponding to our case definition, quantifying the impact of the inclusion of information from multiple informants.

DSM-5–Based Case Definition Comparison

Although 45 of 482 sample children with 6 or more *DSM-IV* ADHD symptoms did not meet the age of onset criterion of 7 years, all but 6 of the children meeting symptom count criteria met the new age of onset criterion of 12 years (Figure 2). Adding the impairment criterion resulted in a greater reduction in the prevalence estimate when using the earlier age of onset: 28.3% reduction versus 22.6% for the later age of onset. Alternatively, 323 of 437 with earlier symptom onset met the impairment criterion, whereas 396 of the 476 with onset by age 12 years met that additional requirement. When adding in the requirement of at least 4 teacher-reported symptoms, the weighted prevalence estimates were 8.9% based on the *DSM-IV* versus 11.3% of school-aged children based on the *DSM-5* (Figure 2).

Of the 1,060 participants at baseline, 656 had at least 1 follow-up interview. Demographic characteristics of participants at their final PLAY follow-up assessment (age range = 7–19) are listed in Table 1, and characteristics of the participant group under differing criteria are presented in Table 2; the effects of modifying diagnostic criteria on prevalence estimates are shown in Figure 3. At follow-up, the SC sample was slightly older than the OK sample because of additional follow-up interviews. In the final assessment sample, 8.2% ($n = 128$ of 656) met *DISC-IV* case criteria (95% CI = 5.9–11.2) with 54.7% classified with the inattentive subtype. When the age of onset criterion is modified for symptom onset to have occurred before age 12 years rather than age 7, the prevalence of ADHD increases to 13.0%

TABLE 2 Project to Learn About Attention-Deficit/Hyperactivity Disorder (ADHD) in Youth Follow-Up Data: Demographics and Sample Characteristics (Unweighted) of ADHD Cases Under Various Diagnostic Criteria Reflecting *DSM-IV* and *DSM-5*

Characteristic	<i>DSM-IV</i> Criteria		<i>DSM-IV</i> Criteria + Relaxing Age of Onset to <12 Years + Requiring Only 5+ Symptoms for ≥17-Year-Olds			
	Total % (n)		Additional cases % (n)		Total % (n)	
Total	100.0	(128)	100.0	(22)	100.0	(150)
Sex						
Male	71.1	(91)	77.3	(17)	72.0	(108)
Female	28.9	(37)	22.7	(5)	28.0	(42)
Race						
White	68.0	(87)	59.1	(13)	66.7	(100)
Black	14.8	(19)	36.4	(8)	18.0	(27)
Other	17.2	(22)	4.5	(1)	15.3	(23)
Ethnicity						
Hispanic	7.8	(10)	0.0	(0)	6.7	(10)
Not Hispanic	92.2	(118)	100.0	(22)	93.3	(140)
Subtype						
IA	54.7	(70)	81.8	(18)	58.0	(87)
HI	7.8	(10)	0.0	(0)	6.7	(10)
Combined	37.5	(48)	18.2	(4)	35.3	(53)
Ever Met Criteria for a Condition Other Than ADHD						
Yes	66.4	(85)	63.6	(14)	66.0	(99)
No	33.6	(43)	36.4	(8)	34.0	(51)
Ever Took ADHD Medication Treatment						
Yes	74.2	(95)	68.2	(15)	73.3	(110)
No	25.8	(33)	31.8	(7)	26.7	(40)
SDQ Total Difficulties Score						
Abnormal	53.6	(67)	55.0	(11)	53.8	(78)
Borderline	20.0	(25)	15.0	(3)	19.3	(28)
Normal	26.4	(33)	30.0	(6)	26.9	(39)
Missing	—	(3)	—	(2)	—	(5)

Note: This table includes only additional cases, although there was some shifting between subtypes of cases from baseline to last follow-up interview. After requiring only 5 or more symptoms for participants who were 17 years old or more, 1 participant with an ADHD-inattentive diagnosis became ADHD-combined. HI = hyperactive/impulsive; IA = inattentive; SDQ = Strengths and Difficulties Questionnaire.

(95% CI = 7.6–21.4), adding 20 cases, with 58.1% (16 additional) as inattentive subtype. The remaining 4 new cases were all combined subtype.

The final major change to the *DSM-5* criteria allows for a decrease from 6 to 5 in the number of symptoms needed to qualify for diagnosis among young adults. There were 109 participants aged 17 years or older in the last interview ($n = 656$), 23 (21.1%) who were considered cases, yielding a weighted prevalence among those aged 17 and older of 8.1% (95% CI = 4.1–15.6). The required symptom count reduction resulted in only 2 additional cases (both inattentive subtype), producing a weighted prevalence in older participants of 8.7% (95% CI = 4.4–16.3) and a slight increase in overall prevalence of ADHD, from 13.0% to 13.1% (95% CI = 7.7–21.5), in the full follow-up cohort.

DISCUSSION

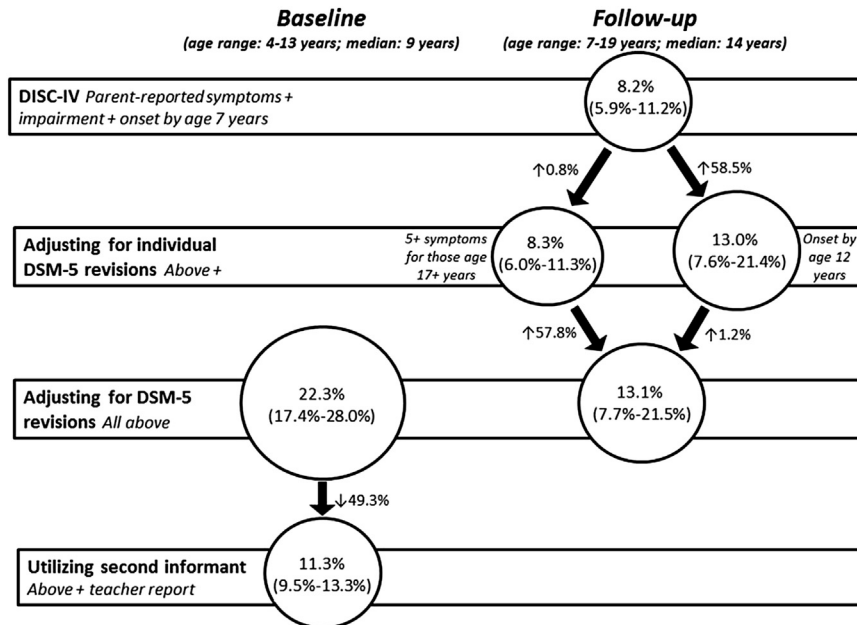
Despite widely varying published estimates of the prevalence of ADHD, there has been very little research on the

qualitative and quantitative impact of varying case definitions and criteria on prevalence estimates. Relying on data from a community-based cohort, we have examined the extent to which applying successively more rigorous criteria affects the resulting proportions of the study sample who meet a specific case definition. We have also examined the potential impact of new *DSM-5* criteria on prevalence estimates.

Consistent with the *DSM*, requiring at least some impairment decreases the estimated prevalence by 28.3% compared to reliance on symptom count and age of onset by 7 years. Even for research studies that rely only on teacher questionnaires that assess symptoms, requiring the full count of symptoms and a measure of impairment are important as an initial basis for classifying probable diagnosis or for obtaining reasonable estimates of prevalence.

In our DISC-IV parent interview data, the prevalence of suspected ADHD with onset by age 7 years dropped by about one-half when at least 1 severe rating of impairment was required, versus our original definition of 1 severe or 2

FIGURE 3 Change in attention-deficit/hyperactivity disorder (ADHD) prevalence (95% CI) after incorporating DSM-5 changes and inclusion of teacher report. Note: DISC-IV = Diagnostic Interview Schedule for Children-IV.



moderate ratings. This highlights the importance of clarity in the definition of impairment and the need for guidance for both clinical diagnosis and research classification. It also demonstrates that the definition of impairment, especially regarding the level of severity required, has a large impact on the classification of disorder. Degree of impairment is also the most salient clinical finding, as it has been shown that the presence of impairment, rather than symptoms, may drive who seeks treatment.³⁴ Further research on the measurement of impairment severity is crucial for both diagnosis and treatment of ADHD.

Because many survey-based estimates rely on parent reports of diagnosis and medication treatment, we examined the agreement between teacher and parent reports and the impact of combining rules for diagnosis or treatment for informants. There was moderate to strong agreement between parents and teachers on diagnosis and medication for ADHD, with parent-reported rates higher than those based on teacher report, although the difference between parents and teachers was greater for reported diagnosis (36%) than for medication use (19%). Teachers may be more aware of medication treatment than of diagnoses because of the marked change in behavior that is achieved with medication treatment, even with the emergence of extended-release formulations that may be administered exclusively at home. Our findings are consistent with this interpretation: teachers reported medication 78.5% of the time when parents reported medication, but teachers reported a diagnosis only two-thirds of the time when parents reported diagnosis. It should also be noted that parents are able to respond to the question of whether the child has ever been diagnosed with ADHD, but teachers may be able to respond only for the

period for which they have the child in class. As expected, when teachers reported diagnosis or medication, parents also reported more than 90% of the time. That is, teacher reports appear to have good specificity but less sensitivity, especially for “ever diagnosed” classifications.

The results also demonstrate the importance of multiple informants in determining the presence of symptoms and impairment in multiple settings. Adding the requirement of at least 4 teacher-reported symptoms to the DISC-IV case definition with full parent-reported symptoms and impairment reduced the prevalence estimate in our data by half. Our data support the conclusions of others that the use of a second informant is important to appropriate diagnosis and to valid estimates of prevalence.^{22,35}

It should be noted, however, that *DSM-5* is not explicit about the extent to which symptoms must be present in different settings. Although the multiple informant issue is distinct from the multiple settings issue, they are related in that additional informants provide information about the patient in other settings or relationships. These concerns are further complicated for older adolescents and adults, who may be the only informant at diagnosis. Attempts to feign symptoms to obtain special accommodations or prescriptions for stimulant medication have been documented^{36,37} and further reinforce the need for additional confirmatory reports from other informants. Thus, a clinical decision, rather than reliance on checklists from informants, may be most important, with multiple informants enriching the information available to the clinician for making diagnostic and treatment decisions. This is a significant issue, particularly with primary care evaluations, for which the time for assessment is limited in most practices.

We were able to assess the potential impact of the changes in diagnostic criteria in the *DSM-5* regarding age of onset and number of symptoms required for those aged 17 years and older. Comparable to a recent US study²¹ but in contrast to estimates from a British birth cohort,³⁸ older age of onset had a substantial impact, increasing the proportion with probable ADHD by 18% compared to estimates based only on symptomatology and by 27% after application of the impairment and second informant criteria. Given the baseline age of this elementary school sample, it was expected that the expanded age of onset criterion was not going to rule out many of the children because most of them were younger than 12 at baseline. However, at follow-up, when only 13.4% of the participants were under age 12, the extended age of onset added 20 cases, resulting in an increase in prevalence from 8.2% to 13.1%. It seems clear that the change in the age of onset criterion is likely to result in a substantial increase in ADHD diagnosis, the extent of which is also a function of how rigorously the *DSM-IV* criterion has been applied in practice in the past.

In our sample the reduction in symptom count from 6 to 5 for individuals aged 17 years and older resulted in the addition of only 2 cases, both of the inattentive type, in the final interview follow-up sample in which 16.6% ($n = 109$) were 17 years of age or older. Of 208 individuals with 5 or more inattentive symptoms, 183 (88%) had at least 6 symptoms, and of 94 individuals with 5 or more hyperactive-impulsive symptoms, 70 (74.5%) had at least 6 symptoms. This difference is consistent with our previous findings of greater persistence of inattentive versus hyperactive symptoms through adolescence.³³ It does not appear that this relaxation of criteria for individuals 17 years and older will have major impact on older adolescents, although we cannot draw any conclusions about the impact on adult populations with a broader age range.

This study exhibits some of the limitations common to community-based epidemiologic studies. Although the evaluations were conducted using validated systematic structured interviews (DISC-IV) with standardized algorithms and rigorous training of interviewers, there is potential for response bias, including social desirability and selective recall, especially in recalling age of onset for symptoms. The interviewed sample when weighted is diverse in race, ethnicity, and socioeconomic status, and is representative of the school districts from which it was drawn, but it is not representative of the US population as a whole. Response rates were typical of contemporary epidemiologic studies—of those who participated at baseline, 62% had at least 1 follow-up interview—so there is a possibility of bias due to attrition. Finally, we did not have access to physician or other provider records to verify treatment and diagnosis and relied only on parent and teacher reports of diagnosis, treatment, symptoms, impairment, and age of onset, although we believe parents to be the optimal informants for age of onset.

These findings quantify the impact of various *DSM*-based case definition criteria on research-based prevalence estimates but also have implications for clinical practice because they indicate the influence of various criteria on the probability of valid classification. Changes in diagnosis may have

an impact on patterns of comorbidity in research studies as well as in clinical settings, where treatment decisions may be affected. Furthermore, the new criteria are especially likely to have an impact on perceptions of developmental trajectories and considerations of the appropriateness of ADHD diagnosis in older adolescents and adults.

Assessment of impairment is a critical component of research and clinical diagnosis and is most useful for diagnosis, treatment, and research when it includes both specification of the level of severity and consideration of multiple domains. Similarly, our findings document the sensitivity of prevalence estimates to both symptoms and impairment across settings, further supporting the importance of including reports from multiple informants. The level of impairment remains a matter of clinical judgment rather than simple reliance on checklists from informants. Although time for assessment and access to additional informants in clinical settings is often limited, the determination of the extent and level of impairment is important even if derived from a single informant.

We were also able to assess the probable impact of new *DSM-5* criteria: that is, the likely increase in prevalence from raising the required age of onset, and a possible smaller increase in prevalence among older adolescents and young adults because of the reduction in symptom count required. These findings will contribute to evaluating trends in ADHD diagnosis by assisting clinicians and researchers in differentiating changes due to new criteria from secular changes caused by trends in prevalence already documented. Because of the age of our participants, we are less clear about how the new criteria will affect diagnosis and estimates of ADHD prevalence among adults older than those in our sample.

Finally, even though multi-axial assessment is no longer part of the *DSM-5*, it remains clinically important to consider environmental factors that may exacerbate symptoms and impairment in patients with late-onset ADHD. We hope to use our longitudinal data to shed light on this little-studied phenomenon. $\otimes$

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