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Attention deficit hyperactivity disorder's incidence in children and adolescents worldwide: A comprehensive review of meta-analyses

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***Abstract*---**Background: According to newly available epidemiological data, hundreds of primary research as well as dozens of systematic evaluations and meta-analyses have looked into the prevalence of ADHD in kids and teenagers. A thorough synthesis of the data from these systematic reviews and meta-analyses is what this umbrella review aims to provide. Objective: To comprehensively synthesize and evaluate existing evidence from systematic reviews and meta-analyses on the global prevalence of Attention Deficit Hyperactivity Disorder (ADHD) in children and adolescents, using an umbrella review approach. Methods: We conducted a thorough search of PubMed, Web

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of Science, PsychINFO, and Scopus to locate relevant research. PROSPERO had the study preregistered. Using a Measurement Tool to Assess Systematic Reviews (AMSTAR), the studies' quality was evaluated. Using an invariance variance weighted random-effect meta-analysis, the prevalence estimates from the included studies were combined. Result: 3,277,590 participants from 13 meta-analytic systematic reviews (588 primary investigations) were analyzed. The worldwide prevalence of ADHD in children and adolescents was 8.0% (95% CI 6.0–10%). Boys had a prevalence estimate twice as high (10%) as girls (5%). The inattentive type (ADHD-I) was the most prevalent subtype. Conclusion: Boys are twice as likely as girls to suffer from ADHD, making it a very common illness in children and adolescents. Our findings support early detection and treatment of ADHD in this population.

***Keywords*---**Children, Adolescents, Umbrella review, Meta-analysis, ADHD.

Introduction

People of all ages can be impacted by attention deficit hyperactivity disorder (ADHD), a complicated neurodevelopmental condition (APA, 2013; Ayano et al., 2020; Berger, 2011; Cortese et al., 2012). Widespread variation in its etiology, clinical manifestations, and therapeutic results is linked to it (APA, 2013; Ayano et al., 2021; Berger, 2011; Cortese et al., 2012). A broad and subtle change in gene expressions in several brain regions that impacts brain function is the primary cause of ADHD, which is characterized by developmentally inappropriate, persistent, and impaired levels of impulsivity, hyperactivity, and inattention (APA, 2013; Berger, 2011; Cortese et al., 2012). ADHD can affect people of any age, although it has been identified in school-age children the most frequently (Ayano et al., 2020; Montano, 2004). According to new research, ADHD is one of the major causes of the worldwide burden of disease in children and adolescents. Additionally, research indicates that raising children with ADHD is significantly more expensive than raising children without the disorder (Chan et al., 2002; Doshi et al., 2012). According to a 2019 study by Zhao and colleagues, for instance, raising children and adolescents with DAHD carries five times the financial burden compared to raising children without ADHD. The indirect costs of job loss or missed workdays are the main cause of this excess financial burden (Zhao et al., 2019). Children and adolescents with ADHD also experience severe effects on their physical and mental health, as well as their academic performance (Ayano et al., 2023; Ayano et al., 2022; Pang et al., 2021). There are widespread misconceptions and stigma surrounding ADHD, and the prevalence of the disorder in children and adolescents ranged from 5.9 to 14%, according to the World Federation of ADHD International Consensus Statement, which provided 208 evidence-based conclusions about the disorder (Faraone et al., 2021).

The prevalence of ADHD in children and adolescents has been examined in a number of published systematic reviews and meta-analyses (C´ enat et al., 2022; Polanczyk et al., 2007; Thomas et al., 2015; Vasileva et al., 2021). China, Spain,

India, Africa, the United States, and other nations were among the many countries where these studies looked at the prevalence rates in children and adolescents (C´ enat et al., 2022; Chan et al., 2021; Polanczyk et al., 2007; Thomas et al., 2015; Vasileva et al., 2021; Wang et al., 2017; Yadegari et al., 2018). Furthermore, conflicting results between 3.4 and 14% were reported by the reviews (C´ enat et al., 2022; Polanczyk et al., 2007; Thomas et al., 2015; Vasileva et al., 2021). For instance, in 2015, Polanczyk and colleagues conducted a meta-analysis of 13 research involving 20,125 participants, and found that the prevalence of ADHD was 3% (Polanczyk et al., 2015). According to another meta-analysis, the prevalence of ADHD was 4.4% among 201,765 individuals in a comparatively small number of studies (n = 15) (Vasileva et al., 2021). On the other hand, a 2015 meta-analysis of 175 research with 1,023,071 children and adolescents found a prevalence of 7.2%, which was significantly higher than the studies mentioned above with fewer identified articles and participants (Thomas et al., 2015). Consistent results were observed by other comparable investigations (Ayano et al., 2020). According to a different meta-analysis conducted in the United States, 14% of American children and teenagers suffer from ADHD (C´ enat et al., 2021). Geographical differences in prevalence may be the primary causes of the discrepancy. The prevalence estimates of ADHD, for instance, were 15.9% among Black American children and adolescents, 16.6% among Whites, and 12.4% among Asians in two meta-analytic systematic reviews carried out in America by Cenat and colleagues (C´ enat et al., 2021; C´ enat et al., 2022). These figures are 1.5–2.5 times more than those found in research from other nations, including China, India, and Africa (Ayano et al., 2020; Catal´a-L´ opez et al., 2012; C´ enat et al., 2021; C´ enat et al., 2022; Chan et al., 2021; Chauhan et al., 2022; Polanczyk et al., 2007; Polanczyk et al., 2015; Thomas et al., 2015; Vasileva et al., 2021; Wang et al., 2017; Willcutt, 2012; Yadegari et al., 2018). The methodological variations across the research, the years the studies were carried out (from 2007 to 2021), and the scope of the meta-analysis are further potential explanations for the observed variations in prevalence rates. For instance, some evaluations calculated the prevalence rates across the continent, some globally, and some in a particular nation (Ayano et al., 2020; Catal´ a-L´ opez et al., 2012; C´ enat et al., 2021; C´ enat et al., 2022; Chan et al., 2021; Chauhan et al., 2022; Polanczyk et al., 2007; Polanczyk et al., 2015; Thomas et al., 2015; Vasileva et al., 2021; Wang et al., 2017; Willcutt, 2012; Yadegari et al., 2018).

By evaluating the caliber and methodological rigor of the studies and performing a thorough synthesis of the evidence reporting a wide range of conflicting findings, umbrella reviews—a methodical collection and assessment of multiple systematic reviews and meta-analyses conducted on a particular research topic—can overcome these limitations (Slim and Marquillier, 2022).

Thus, this umbrella review's goal is to present a solid synthesis of the data from these meta-analyses and systematic reviews. Our specific goals were to compile the following: (1) prevalence estimates for ADHD in children and adolescents worldwide; (2) prevalence estimates for boys and girls in particular; and (3) prevalence estimates for the three subtypes of ADHD. Our goal was to give doctors, researchers, and legislators solid information about the prevalence of ADHD in kids and teenagers around the world.

Methods

Research design and methods

We looked at the prevalence of ADHD in children and adolescents by doing an umbrella review of systematic reviews and meta-analyses of observational studies, adhering to the preferred reporting items for systematic review and meta-analysis guideline (Moher et al., 2009). CRD42023389704 is the International Prospective Register preregistration number for the protocol used for this evaluation.

Data source and searches

We used a structured search approach to discover relevant studies by methodically searching PubMed, Web of Science, PsychINFO, and Scopus. No limitations on language or date were imposed. In accordance with predetermined inclusion and exclusion criteria, two writers (GA and LT) independently selected and evaluated full-text articles. The following pertinent search phrases were used: (i) attention deficit hyperactivity disorder, or ADHD; (ii) prevalence, epidemiology, and rates; (iii) children, adolescents; and (iv) systematic review, meta-analyses, quantitative synthesis, and systematic literature review. Supplementary material (Supplementary material 1) contains the search strategy details. In order to find research that might not have been included in the three electronic databases mentioned above, we also manually searched the included article's references.

Eligibility criteria

The following were requirements for eligibility: (1) meta-analytic systematic reviews; (2) reports on the prevalence of ADHD; (3) studies involving children and adolescents; and (4) English-language publication. Studies done on adults, narrative evaluations, commentaries, and qualitative system reviews were not included.

Data abstraction

Study quality

Two separate writers (GA and LT) used the Assessment of Multiple Systematic Reviews (AMSTAR) tool to evaluate the methodologic quality of the included publications (Shea et al., 2007). According to Shea et al. (2007), the tool's eleven elements are intended to assess the methodologic quality of meta-analyses. Our three standard scoring categories were low quality (scores 0–3), moderate quality (scored 4–7), and high quality (scored 8–11), in line with earlier umbrella reviews (Chesney et al., 2014).

Data synthesis and analysis

Meta-analyses were performed using Stata Version 16.1. Prevalence estimates from the included studies were combined using invariance variance weighted random-effect meta-analysis, taking into account the heterogeneity of the reported rates. The heterogeneity among the studies was assessed using the Cochrane's Q and I2 test (Borenstein et al., 2010). According to Higgins et al. (2003), the heterogeneity was divided into three categories: low (I2 values of 25), moderate (I2 values of 50), and high (I2 values of 75). A funnel plot was used to visually represent the possibility of publication bias, and Egger's test was used to statistically evaluate it (Egger et al., 1997). In addition to the subtypes of ADHD

(the inattentive type (ADHD-I), the hyperactive type (ADHD-HI), and the combined types (ADHD-C), subgroup analyses were performed by gender (boys and girls). For statistical significance, a p-value of less than 0.05 was used.

Results

3.1 Study selection

The research selection and inclusion procedure is depicted in the PRISMA flow diagram (Fig. 1). Our first electronic search turned up a total of 1148 studies. Two more papers were discovered via a manual search of other sources. 887 papers were evaluated at the title/abstract level following the removal of duplicates (263 citations). As a result, 19 papers that satisfied the eligibility requirements were saved for later reading. Lastly, this umbrella review contained 13 meta-analytic reviews (Ayano et al., 2020; Catal´ a-L´ opez et al., 2012; C´ enat et al., 2021; C´ enat et al., 2022; Chan et al., 2021; Chauhan et al., 2022; Polanczyk et al., 2007; Polanczyk et al., 2015; Thomas et al., 2015; Vasileva et al., 2021; Wang et al., 2017; Willcutt, 2012; Yadegari et al., 2018).

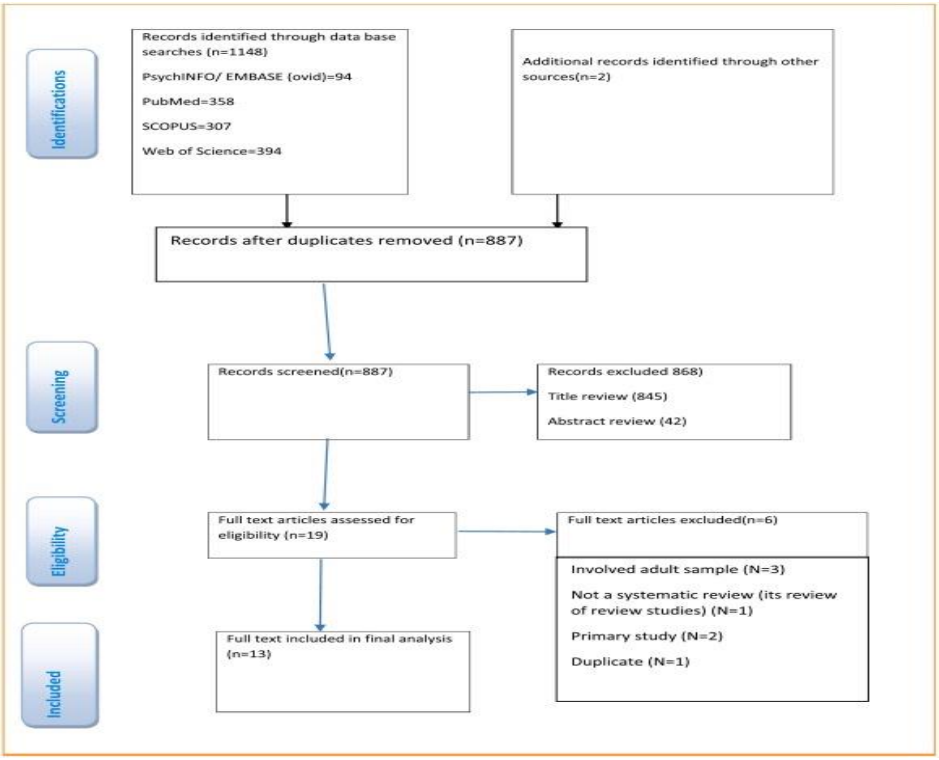

Fig. 1. PRISMA flowchart of review search.

3.2. Characteristics of included studies

Table 1 lists the features of the articles that were included. This research included 13 meta-analytic and systematic review investigations, which covered 478,146 ADHD cases and 588 primary studies. A selection of reviews were released from

2007 to 2022 (Polanczyk et al., 2007; Chauhan et al., 2022). The included reviews comprised an average of four databases, with a range of two to seven. PsychInfo (n = 7) and ERIC/Embase (via Ovid) (n = 6) were the next most popular information sources, after PubMed/Medline (n = 11). Compared to the median number of participants (43,972 0; range: 5499–1,613,780) and ADHD cases (2595; range: 527–221,088), the median number of studies included in meta-analyses was 21 (range: 5–175).

Three of the eleven studies offered prevalence rates for both male and female participants, and three of them provided distinct data for ADHD-I, ADHD-H, and ADHD-C. The prevalence of ADHD was assessed in six reviews, including three studies conducted in the United States, one in China, one in Spain, and one in Africa.

3.3. Quality assessment

The included systematic review and meta-analytic studies were evaluated for methodological quality using the AMSTAR program. According to Supplementary Material 2, 10 reviews (76.92%) had excellent quality, three reviews (23.08%) had medium quality, and none had bad quality. Interestingly, the predetermined study protocol was followed in only 1 out of 13 systematic reviews, and the great majority of the included systematic reviews did not search for grey literature (2 out of 13 systematic reviews did this).

3.4. Prevalence of ADHD

There was significant variation in the reported prevalence of ADHD, which varied from 3.4% to 14%. The pooled prevalence of ADHD was 8.0% (95% CI 6.0–10%), according to a random effect meta-analysis based on 588 original studies gathered from 13 meta-analyses. There was significant heterogeneity among the studies ($Q = 55{,}944.61$; $I2 = 99.98$; $p < 0.0001$) (Fig. 2). Publication bias is not supported ($\beta = 7.48$; $SE = 8.736$; $p = 0.3916$) (Fig. 3)

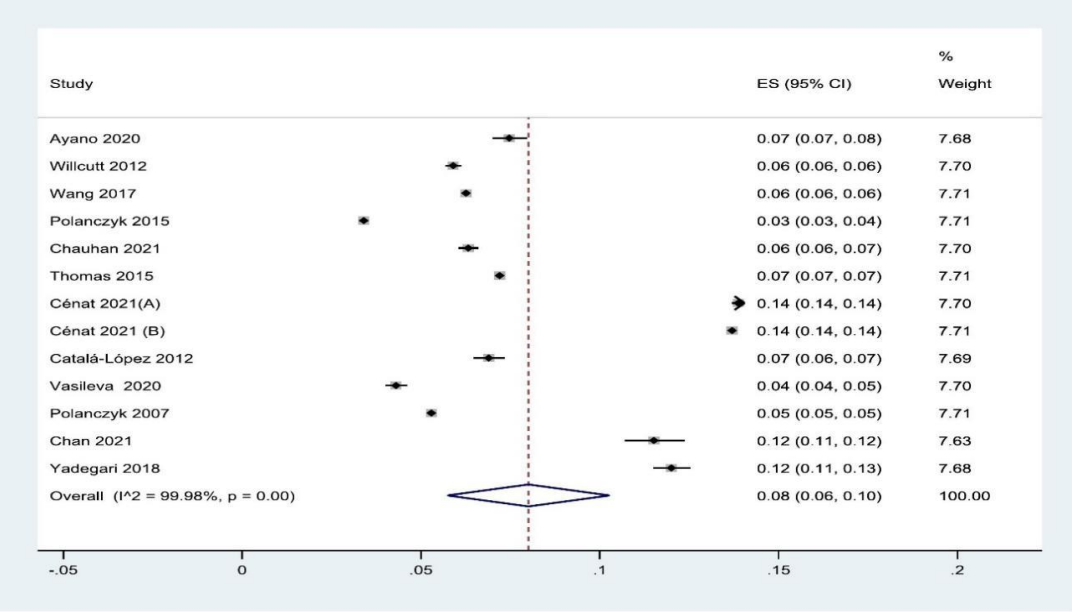

Fig. 2. A forest plot showing the estimated frequency of ADHD in kids and teenagers

We condensed the data from the included research into a single image for this forest area. Estimates, represented by the symbol ES, show prevalence rates and proportions together with their 95% CI. On a forest plot, each horizontal line denotes a separate research, with the 95% confidence interval of the result shown as the line and the result plotted as a box (prevalence estimates). The outcome of combining and averaging all of the separate experiments is displayed by the diamond at the bottom of the forest plot. The diamond's horizontal points represent the 95% CI limits, and they can be interpreted similarly to any other of the plot's individual studies.

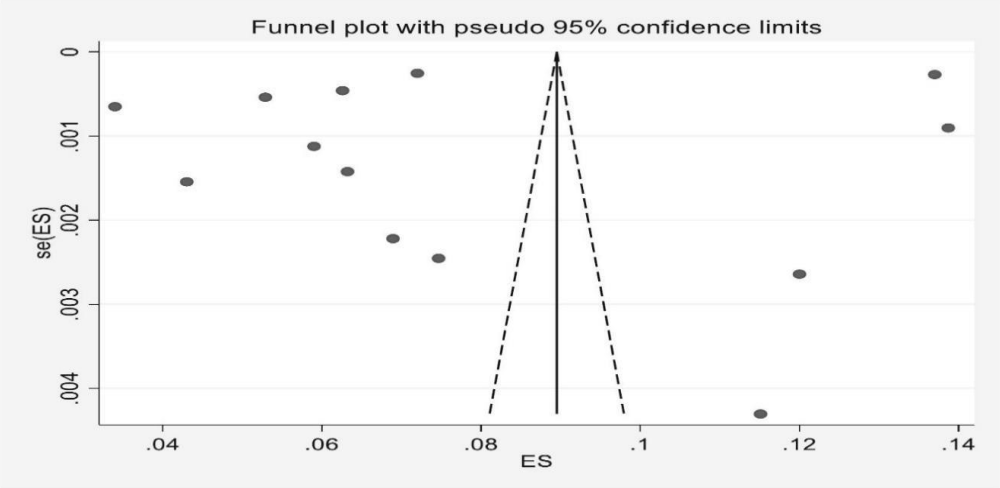

Fig. 3. Funnel plot for the prevalence of in children and adolescents.

The figure's X-axis, or horizontal axis, displays the mean result (mean prevalence estimates indicated by ES), while the Y-axis displays the sample size or a precision index. The prevalence estimate of 4% (0.04) and 14% (0.14) is the same distance from the summary effect estimate (average), which is represented by the solid vertical line. The summary estimate of the treatment effect was obtained from the random-effect meta-analysis (8.0%; 95%CI 6.0-10%). A roughly funnel-shaped distribution is produced by the funnel plot, which posits that studies with high accuracy will be plotted close to the average and studies with low precision will be uniformly distributed on both sides of the average. A departure from this form may be a sign of bias in publications. Significant publication bias is not evident (β=7.48; SE=8.736; p = 0.3916). This indicates that the observed deviation is not considerable and that the stated prevalence values are not significantly affected by any missed investigations.

According to a gender-stratified meta-analysis, boys had double the prevalence of ADHD (10%; 95% CI 8–11%) compared to girls (5%; 95% CI 4–7). According to our subgroup analysis by type of ADHD, the most prevalent type was inattentive (ADHD-I) [3% (95%CI 2.0–4%), followed by hyperactive (ADHD-HI) [2.95% (95%CI 1.8–4%). as well as the mixed form (ADHD-C) [2.44%, 95% CI: 1.5–3.5%).

When compared to other ADHD subtypes, such as ADHD-C (3.63 %; 95 % CI 2.87–5.87 %) in males and 1.52%; 95 % CI 1.11–2.08 %) in females, and ADHD-HI (3.61 %; 95 % CI 1.88–6.82 %) in males and 1.50%; 95 % CI 0.78–2.87 %) in females, it was discovered that ADHD-I was the most prevalent subtype of ADHD in both males and females (4.05 %; 95 % CI 3.11–5.27 % in males and 2.21 %; 95 % CI 1.61–3.03 %) in females).

A stratified analysis by study setting revealed that, although the difference was not statistically significant (p-value = 0.439), the epidemiological prevalence of ADHD in children and adolescents was marginally higher in the clinical setting (8.74 percent; 95% CI 5.66–13.27 percent) than in the community setting (7.19 percent; 95% CI 5.59–9.19 percent).

Furthermore, Polanczyk and colleagues discovered that the prevalence estimate of ADHD was 2.3 times higher in children aged 6–11 years (7%) compared to adolescents aged 12–18 years (3%) ($p < 0.001$) based on analysis stratified by age (Polanczyk et al., 2007).

Discussion

To the best of our knowledge, this comprehensive review is the first quantitative meta-synthesis on the prevalence of ADHD in kids and teens worldwide. The review combined data from 13 meta-analytic and systematic review investigations, which included 3,277,590 individuals, 478,146 ADHD cases, and 588 primary research. Samples from various countries throughout the world, including the USA, China, Spain, India, Iran, and other established and developing nations, were chosen for the included investigations. The prevalence of ADHD in children and adolescents was calculated by the review, along with the prevalence of each of the specific subtypes and the prevalence of ADHD in males and girls.

There were four main conclusions overall: First, the prevalence of ADHD in children and adolescents is high worldwide (8%) and comparatively comparable worldwide, with the exception of Asian, Black, and White Americans, as well as those in India and the Middle East. For instance, consistent results ranging from 6.5% to 7.5% were reported by meta-analytic evaluations carried out in Africa, China, Spain, and another study that combined the prevalence of ADHD worldwide (;). However, according to two recent meta-analytic reviews by Cenat and colleagues that looked at the prevalence of ADHD in America, the prevalence was 1.5 to 2.5 times higher among Asians, 16.6% among Whites, and 15.9% among Black children and adolescents (; Cénat et al., 2022). When compared to other nations, the precise causes of the higher frequency of ADHD in American children and adolescents were not fully understood. According to Alvidrez (1999), Ayano et al. (2023), Ayano et al. (2021), and Ayano et al. (2019a), the inclusion of children and adolescents at risk for ADHD (i.e., comorbid medical disorders, low socioeconomic status, and higher rates of parental mental health and drug use) may be the cause of the discrepancy. The effects of trauma and racial discrimination might be additional causes (Ayano et al., 2019b; Kirkinis et al., 2021; Meng et al., 2018; Wei et al., 2010). It is necessary to look into the precise causes of the significantly greater incidence of ADHD among Asian Americans, White Americans, and Black Americans.

Second, boys were twice as likely to have ADHD (10%) as girls (5%). There are a number of reasons why boys are diagnosed with ADHD at a higher rate than girls. First, according to Mahone and Wodka (2008), girls are shielded from the onset of ADHD. Second, research indicates that because of the presenting symptoms, girls with ADHD are more prone than boys to be overlooked (Berry et al., 1985).

The third subtype of ADHD was found to be the inattentive type (ADHD-I) at 3%, followed by the hyperactive type (ADHD-HI) at 2.95 % and the combined type (ADHD-C) at 2.44 %, according to the review. The persistent character of ADHD-I may be one of the factors contributing to its higher prevalence rates when compared to other subtypes (Weyandt et al., 2003). Emerging epidemiological evidence supports this, indicating that while hyperactive-impulsive symptoms, such as inattentive symptoms, are developmentally sensitive and tend to decrease over time (although restlessness may persist), inattentive symptoms of ADHD appear to be relatively constant over time (Weyandt et al., 2003).

Fourth, based on other comparable studies, a few of the included evaluations found a limited number of studies in comparison to the available data. Interestingly, compared to studies that included a larger number of primary studies, the prevalence of ADHD was comparatively low in those that included fewer primary studies. For instance, the prevalence of ADHD was 3% in a meta-analysis conducted in 2015 by Polynzyx and colleagues, which included 13 research with a total of 125 participants (Polanczyk et al., 2015). According to a different meta-analysis, the prevalence of ADHD was 4.4% among 20 1765 individuals in a comparatively small number of studies (n = 15). In contrast, the prevalence was 7.2% in 2015 meta-analytic research that included 175 studies with 1,023,071 children and adolescents. This was much higher than the prevalence in the studies mentioned above that only had a small number of recognized articles and participants (Thomas et al., 2015). compatible findings

were found by other comparable studies (Ayano et al., 2020), which is also compatible with the prevalence of 8.0% in the current meta-analytic view. Methodological differences (i.e., search strategy, search terms/keywords, and databases searched) may be the primary cause of the minimal number of studies found in some systematic reviews and meta-analyses. For example, ADHD was evaluated under the general heading of mental illnesses in the two meta-analytic reviews mentioned above, which included a limited number of participants. The search method used in these reviews was not especially tailored to find research on ADHD in children and adolescents (Polanczyk et al., 2015).

This umbrella review has a number of advantages: (1) This umbrella review's strength is that it is the first to quantitatively combine data on the prevalence of ADHD in children and adolescents worldwide using meta-analytic reviews. (2) It evaluated the methodological quality of the included studies using robust techniques and closely adhered to the PRISMA guideline; (3) It calculated the prevalence of ADHD for both boys and girls and for each of its subtypes. (4) For most of the included studies, the quality of the studies was good. Only three studies received a medium quality rating because they failed to register their protocol and/or provide the specifics of their methodology for the review, while no study received a low quality rating. It is important to note, nevertheless, that the evaluation was partially subjective and was thus greatly influenced by the way the evaluations were reported rather than just the article's actual methodological excellence.

There are certain restrictions on this general review. First, it estimated the prevalence of ADHD in children and adolescents worldwide using data from the included systematic review and meta-analysis studies. As a result, other published and unpublished studies can be overlooked. Second, we discovered notable variation amongst research, as anticipated.

Conclusion

According to data from our cumulative umbrella study, boys are twice as likely as girls to suffer from ADHD, indicating that the illness is very common in children and adolescents. The most prevalent of the three subtypes of ADHD was determined to be ADHD-I, which was followed by ADHD-H and ADHD-C. Our findings support the idea that preventing, diagnosing, and treating ADHD in kids and teenagers should be a top focus.

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