

Review Article

Attention Deficit Hyperactivity Disorder in Children: A Narrative Review

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Abstract

This is a narrative review of the recent literature on attention deficit hyperactivity disorder in children. The research suggests that prevalence rates have varied between 5% and 17%. This variability may relate to age range differences of the samples or to different measures of attention deficit hyperactivity disorder. The global prevalence has increased from 5% to 11% in this recent literature and the prevalence appears to be greater in western countries. Very few negative effects of attention deficit hyperactivity disorder have been addressed. They include negative effects on health, social behavior, cognitive/academic performance and sleep. Other disorders have been comorbid including depression, anxiety and conduct disorder. Predictors/risk factors have been the primary focus in this literature and have included parent variables of prenatal depression, pregnancy and secondhand smoke exposure. Effective interventions have been stimulant and non-stimulant medications and massage therapy. Potential underlying mechanisms for attention deficit hyperactivity disorder in children include heritability and prenatal depression. Although the data highlight the prevalence and severity of attention deficit hyperactivity disorder in children, they have been primarily based on parent-report surveys that have yielded mixed results across samples.

Keywords: Attention Deficit Hyperactivity Disorder; Children; Anxiety; Depression

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders in children. Based on the DSMV, it is characterized by inattention, impulsivity and hyperactivity. This narrative review is focused on ADHD in

children and summarizes 25 papers that were derived from a search on PubMed and PsycINFO using the terms attention deficit hyperactivity disorder in children and the years 2019-2024. Exclusion criteria included case studies and non-English language papers. The publications can be categorized as prevalence data, negative effects of ADHD, predictors/risk factors for ADHD, interventions and potential underlying biological mechanisms. This review is accordingly divided into sections that correspond to those categories. Although some papers can be grouped in more than one category, 7 papers are focused on prevalence, 5 on negative effects of ADHD, 9 on predictors/risk factors, 8 on Interventions and 4 on potential underlying biological mechanisms for ADHD in children.

Prevalence of Attention Deficit Hyperactivity Disorder in Children

The prevalence of ADHD has varied widely from 5% to 17% (Table 1). The 5% rate was cited by researchers who claimed that there were no significant differences between countries worldwide [1]. That rate was given for children and adolescents combined. The prevalence of ADHD ranged from 5-7% in studies addressing hereditary and prenatal risk factors and in a systematic review and meta-analysis on 61 cross-sectional studies on children 3-to-12-years-old (N=96,907), the prevalence based on DSMV criteria was 7.6% [2,3]. This rate was similar to the 7.5 rate noted in a systematic review and meta-analysis of 12 studies

on children and adolescents from Africa [4]. These researchers reported ADHD prevalence rates ranging from 2.2% to 17.8% in school-age children. They also reported a 2 to 1 ratio for prevalence of ADHD in boys versus girls (10.6% versus 5.3%). The predominant symptom they found in this sample was inattentiveness followed by hyperactivity/impulsivity. In a sample of 10-year-old children, a higher ratio of 3 to 1 was noted for boys to girls [5]. ADHD was reported for 11% of this sample.

An even higher prevalence of ADHD has been noted in data from the 2018 National Survey of Children's Health in the United States [6]. This rate of 12.9% was the average for that sample of 70,000 youth ranging in age from 5 to 17 years. Several areas of the country had even greater than 16% prevalence including West South Central, East South Central, New England and South Atlantic. The average rate was similar (15%) in the largest sample (N=166,047) that has appeared in this literature on ADHD in children [7].

As can be seen in Table 1, the global prevalence has increased from 5% in 2014 to 7% in 2015 to 8% in 2020 and 11% in 2022. Also, the limited prevalence data suggests that the rates are greater in more developed countries (U.S. and Quebec) at 13 to 16% than in Africa (7%). These observations are based on a very limited number of studies (7) of highly variable databases (surveys, meta-analyses and government census data). The increasing prevalence is clinically worrisome in addition to the observation that ADHD has continued into adulthood for 60% of those first diagnosed during childhood [7].

Prevalence	First Author
5% worldwide (2014)	Mechler
7% worldwide (2015)	Kian
8% global (2020)	Salan
11% worldwide (2022)	Rosenberg
3-16% United States	Zgodic
15% Quebec	Lemelin
7% Africa	Ayana

Table 1: Prevalence of attention deficit hyperactivity disorder (and first authors).

Negative Effects of Attention Deficit Hyperactivity Disorder

Surprisingly very few negative effects of ADHD have been reported in this literature, possibly because they were the focus of an earlier literature and the more recent studies are focused on risks/predictors and interventions. ADHD has had negative effects on health behaviors, social behavior, cognitive/academic performance and comorbidities.

Children with ADHD are twice as likely to have more negative health behaviors even after correcting for several covariates [8]. In this study on 7-to-10 year-old children (N=184 with ADHD and 100 without ADHD), the health behaviors that were negatively affected included water intake, sweet beverages, vitamins, reading, screen time, physical activity and sleep.

Social behaviors have also been negatively affected by ADHD [8]. In this paper entitled "Evaluation and management of ADHD in children and adolescents", there was an increased risk for behavioral and academic issues, including substance abuse and legal problems.

Neuro-cognitive performance has also been negatively affected by ADHD [9]. In this sample (N= 138) children with ADHD were significantly more impulsive and had processing speed difficulties as well as concentration and accuracy problems.

Psychiatric comorbidities have frequently accompanied ADHD. For example, in a sample from Izmir, Turkey (N=320 children and adolescents age 8-to-15-years-old), the prevalence of comorbidities was 60 to 80% based on the DSMIV [10]. Disruptive behavior occurred in 29% of the youth, depressive disorder in 13%, obsessive-compulsive disorder in 10% and anxiety in 6%. ADHD subtypes were characterized by different comorbidities. The ADHD combined subtype (inattentive and impulsive/hyperactive) was accompanied by oppositional defiance disorder and conduct disorder. Anxiety was a comorbidity for the ADHD inattentive subtype. Those children with the ADHD combined subtype, as would be expected, experienced greater

severity, a more delayed treatment response and a more negative prognosis (Table 2).

Video game addiction may contribute to these cognitive difficulties [11]. In this sample of 12-year-old children with ADHD (N=393) from Saudi Arabia, 63% were engaging in video games every day for more than five hours per day.

Behaviors Negatively Affected	First Author
Health behavior	Holton
Social behavior	Krieger
Cognitive behavior	Krieger
Video game addiction	Alrahili
Psychiatric comorbidities	iPCi

Table 2: Behaviors negatively affected by attention deficit hyperactivity disorder (and first authors).

Risk Factors /Predictor Variables for Attention Deficit Hyperactivity Disorder

Risk factors/predictor variables for ADHD have been the focus of many studies in this recent literature. A few of the studies have focused on genetic or heritability factors. Others have explored prenatal effects and pregnancy Inflammation. Only a couple research groups explored multiple variables. Other studies not reviewed here have ruled out potential risk factors including diet, polyunsaturated fats, pollutants and parasites. For example, in a study on the knowledge of Danish teachers about ADHD in children (N=528), most knew about ADHD symptoms in children (79 to 96%) and interventions (75 to 98%), but only 56% and 17% correctly guessed that diet wasn't the cause or an intervention for ADHD [12].

In a study on prenatal medication effects entitled "Maternal ADHD medication use during pregnancy and the risk of ADHD in children", 15% of the sample (N=166,047) were diagnosed with ADHD [13]. The data suggested that ADHD in the children resulted from genetic and/or environmental factors but not in utero exposure to ADHD or to prenatal medications. In contrast, another research group concluded that both hereditary disease and prenatal effects contributed to ADHD [2]. The title of their paper called "Prenatal risk factors and genetic causes of ADHD in children" reflected their results.

A similar conclusion was drawn by another research group in a paper entitled "The heritability of ADHD in children of ADHD parents: A post-hoc analysis of longitudinal data" [13]. A combination of three longitudinal databases in this study suggested that offspring of ADHD parents are at greater risk of ADHD and its associated psychiatric, cognitive and educational impairments.

Prenatal stress was again implicated in a systematic review and meta-analysis of 58 articles [14]. The authors concluded that maternal stress and anxiety, prenatal stress, maternal depression, maternal postpartum depression and perinatal anti-depressants as well as paternal depression were factors that contributed to ADHD in children.

Prenatal inflammation has also been associated with risk of ADHD in children in a very recent study (N=604 children at age 10) [5]. C-reactive protein (as a measure of inflammation) was assayed at 24 weeks gestation. Longitude data suggested that the C-reactive protein measured during pregnancy predicted to an increased ADHD symptom load in children.

In another systematic review and meta-analysis, family environment risk factors were suggested to predict ADHD in children [15]. The negative factors across 59 studies included intrusiveness and negative/harsh discipline, maltreatment, parental relationships (divorce, single parenting), parental incarceration and child media exposure. Positive factors included sensitivity, warmth and parent-child interaction quality.

Surprisingly, only a couple studies could be found in this recent literature on environmental risk for ADHD. In a systematic review and meta-analysis, exposure to secondhand smoke was noted to increase the risk for ADHD in children [16]. In a study entitled "The impact of family dynamics, lifestyle and food intolerance on ADHD children" (N=240 children), food intolerance was a significant risk factor for ADHD in children [17].

In another multivariate study, a nomogram (a diagram representing the relations between 3 or more variable quantities) was calculated based on a logistic regression of predictor variables (N=141,356 children) [18]. Several variables entered the nomogram including behavior problems, learning disabilities, age, intellectual disabilities, anxiety, gender, premature birth, maternal age at childbirth and parent - child interaction patterns (Table 3).

Risk Factors/Predictor Variables	First Author
Heritability	Uchida
Hereditary disease and prenatal effects	Kian
Prenatal stress	Robinson
Prenatal inflammation	Rosenberg
Prenatal medication	Lemelin
Parental divorce	Claussen
Secondhand smoke	Huang
Food intolerance	Zhang
Multiple parent and child problems	Gao

Table 3: Risk factors/predictor variables for attention deficit hyperactivity disorder (and first authors).

Interventions for Attention Deficit Hyperactivity Disorder

Although as many as seven papers in this recent literature are focused on interventions for ADHD in children, they only include four types of interventions. These are herbal medication, psychotropic medication, neurofeedback and massage therapy. In a paper entitled "A national survey on the clinical practice patterns of Korean medicine doctors for ADHD", herbal medicine was the most popular as reported by 44% of the doctors [19]. It was also cited as the most effective by 54% of those surveyed.

Stimulants and non-stimulants have been pharmacological treatment options for ADHD [1]. The stimulants have included methylphenidate and amphetamines and the non-stimulants include atomoxetine, guanfacine and clonidine. They reportedly have had large positive effects, but in short-term trials. According to an insurance claim study, 23 to 25% of children with ADHD have been given psychotropic medication with stimulants. SSRIs have been used by 7 to 8%, atypical antipsychotics by 4 to 5% and guanfacine extended release by 5 to 7%.

In a systematic review of 312 studies, most did not compare alternative treatments [20]. However, the studies combined suggest that medications had the strongest evidence for decreasing disruptive behaviors and broadband measures. But they were also associated with adverse side effects.

In a study on a novel non-stimulant treatment, viloxazine extended-release capsules were assessed in four randomized, double-blind, placebo-controlled trials (N= 1354) (100 mg per day for one week). Based on the ADHD Rating Scale, symptoms and impairments were decreased. The scale assesses 18 symptoms of attention and hyperactivity/impulsivity. The ADHD revised scale added six domains of functional impairment, including family relationships, peer relationships, completing/returning homework, academic performance, controlling behavior at school and self-esteem.

In a paper entitled "Neurofeedback and ADHD in children: Rating evidence and proposed guidelines", two meta-analyses confirmed the efficacy of neurofeedback protocols with a medium affect size and sustained effects after 6 to 12 months [11]. The remission rates ranged from 32% to 47%.

Massage therapy has also been an effective treatment for children with ADHD. In a systematic review and meta-analysis of 8 randomized controlled trials on massage therapy for treating ADHD in children, massage therapy led to greater improvements than Ritalin for the conditions of anxious - passive and asocial behavior (Table 4) [14].

Intervention	First Author
Herbal medication	Lee
Stimulants and non-stimulants	Mechler
Psychotropic medication	Zhou, Peterson
Viloxazine	Nasser
Neurofeedback	Arms
Massage therapy	Chen

Table 4: Interventions for attention deficit hyperactivity disorder (and first authors).

Potential Underlying Biological Mechanisms for Attention Deficit Hyperactivity Disorder

Surprisingly, very few studies have addressed potential underlying biological mechanisms for attention deficit hyperactivity disorder. Potential underlying mechanisms have only derived from studies exploring risk factors/predictor variables. For example, in the study on pharmacological treatment options for ADHD, the authors concluded that the etiology was multifactorial although there was high heritability and high rates of comorbidities [1].

The primary biological mechanisms that have been mentioned in this literature include heritability/genetic and prenatal effects. As already mentioned, in the study on prenatal medication effects, 15% of the sample were diagnosed with ADHD [7]. The data suggested that ADHD in the children resulted from genetic and/or environmental factors but not from in utero exposure to ADHD or from prenatal medications. Other data from another research group, however, concluded that both hereditary disease and prenatal effects contributed to ADHD [2]. Similarly, the post-hoc analysis of longitudinal data from three longitudinal databases suggested that offspring of ADHD parents are at greater risk of ADHD and its associated psychiatric, cognitive and educational impairments, again implicating heritability as the risk factor [13].

Prenatal stress was also implicated in the systematic review and meta-analysis of 58 articles [14]. Those authors concluded that maternal stress and anxiety, prenatal stress, maternal depression, maternal postpartum depression and perinatal anti-depressants as well as paternal depression were factors that contributed to ADHD in children.

Prenatal inflammation has also been associated with risk of ADHD in children in the study on C-reactive protein [5]. Those longitude data suggested that the C-reactive protein measured during pregnancy predicted to an increased ADHD symptom load in children.

Interestingly, although heritability has been implicated as a potential underlying biological mechanism, genetic studies did not appear in this recent literature. and although prenatal risk factors have also been suggested, only single prenatal risk factors have been measured, for example, C-reactive protein or in multivariate studies, the most predictive prenatal factor has not been identified.

Methodological Limitations and Future Research Directions

The recent literature on Attention Deficit Hyperactivity Disorder (ADHD) in children has several methodological limitations that relate to different age samples, measures and methods across studies. These limitations are highlighted by the authors of several systematic reviews and meta-analyses who concluded that they were limited due to several forms of variability and bias.

Most of the samples are children who have been diagnosed with ADHD. But many of the samples have lacked comparison or control groups of children without ADHD. and although three subtypes of ADHD have been identified including the attention, impulsivity/hyperactivity and the combined, children with those subtypes were only compared in one study. The use of different scales in different studies has also made it difficult to compare results across studies and the parent-report data are more subjective and less definitive than more objective physiological measures which did not appear in this literature.

Most of the studies were focused on risk/ predictor variables. These have typically measured one versus multiple variables. In the few multivariate studies, logistic regression analysis or structural equations models were not conducted to determine the

relative significance of the different variables contributing to ADHD. The significant mediating/moderating variables in some of the studies highlight the importance of assessing multiple variables in the same samples. Although parenting styles such as overprotectiveness and permissiveness have been risk factors for anxiety in children, they have not been the focus of intervention studies in this recent literature on ADHD.

The limited literature on the negative effects of ADHD and the infrequent consideration of comorbidities was surprising given that ADHD has been reputedly comorbid with depression, anxiety and conduct disorder and is frequently identified by teachers because of academic performance problems. The direction of effects, i.e. whether ADHD contributed to a comorbidity or the reverse, cannot be determined as most of the studies were cross-sectional. Longitudinal studies are needed to study the development of ADHD as it has been noted to increase in severity from childhood to adolescence. The absence of research on peer interaction effects is also surprising as social behaviors are compromised by ADHD.

Most of the recent intervention studies have focused on pharmacotherapy suggesting that although it has been effective, adverse side effects have been noted. Surprisingly, Cognitive Behavioral Therapy did not appear in this intervention literature as it has been one of the most popular therapies for other childhood disorders. and school interventions did not appear in this literature, although some of the greatest difficulties of children with ADHD appear in the school environment and teachers are those who often identify children with ADHD. The appearance of neurofeedback and massage therapy was promising. Other alternative therapies have been effective for reducing child disorders in general like yoga and exercise and tai chi was surprisingly effective for ADHD in an earlier literature [21-26]. This was surprising given the attention demands of tai chi.

The potential underlying biological mechanism literature has been missing, although several researchers who have focused on risk factors have implicated heritability/genetics and prenatal effects. But genetic studies were missing from this literature, possibly because there have been no recent findings that could inform causality. Even fMRI research is missing from this literature which is surprising given its frequent appearance in literature on the comorbidities of ADHD in children (anxiety and depression). Despite these methodological limitations, the literature has highlighted the prevalence of ADHD in children, with the possibility that the prevalence may have also increased as the overuse of social media has increased, although social media only appeared in one study in this literature. The prevalence of ADHD highlights the need for more intervention research. The data on predictor variables have helped identify children in need of therapy and the intervention data have informed clinicians on potential treatments for children with ADHD. Further research is needed to specify the relative significance of predictor variables for identifying children with ADHD and the specific intervention techniques that are effective in reducing ADHD in children.

Conclusion

The prevalence of Attention Deficit Hyperactivity Disorder (ADHD) has varied between 5% and 17%. This variability is related to age range differences of the different samples and to the use of different measures of ADHD. The global prevalence has increased from 5% to 11%. ADHD has negatively affected children's health, social behavior, academic performance and sleep. Comorbidities of ADHD include depression, anxiety, conduct and obsessive-compulsive disorder. Parent variables have been predictors/risk factors for ADHD in the children including prenatal depression, pregnancy inflammation and secondhand smoke exposure. The most effective stimulant and non-stimulant medications and massage therapy have been effective interventions. Potential underlying mechanisms for attention deficit hyperactivity disorder in children include heritability and prenatal depression. Although the data highlight the prevalence and severity of ADHD in children, they have been frequently derived from surveys of parents and have yielded mixed results across samples.

Conflict of Interest

The author has no conflict of interest to declare.

Financial Disclosers

The authors have no financial relationships relevant to this article to disclose.

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