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Review article

Understanding Attention Deficit Hyperactivity Disorder: Prevalence, Etiology, Diagnosis, and Therapeutic Approaches

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Abstract

Background: Attention deficit hyperactivity disorder (ADHD) is classified using neoclassical systems such as the Diagnostic Statistical Manual of Mental Disorders-5 and the International Classification of Disease-10. There is significant evidence that pharmaceutical treatment, particularly stimulants, can reduce symptoms in the short term. ***Objective***: To explore the comprehensive landscape of childhood to adulthood ADHD within the literature, which involves delving into its prevalence, etiology, risk factors, diagnosis, and treatment modalities. ***Methods***: A literature search was conducted across articles published in English between 2011 and 2023; the literature extensively explored the prevalence, etiology, risk factors and diagnosis of the subject, with limited attention given to treatment between 2003 and 2023, utilizing electronic search engines such as Google Scholar, PubMed, IndMED, and MedIND, Scopus, and Web of Science. The search terms included "ADHD," "Attention Deficit and Hyperactivity Disorder," "Hyperactivity," "Child Psychiatry," "Hyperkinetic Disorder," "Attention Deficit Disorder," and "Worldwide." ***Results***: Out of the 400 papers evaluated, only 52 met the criteria encompassing prevalence, etiology, diagnosis, and treatment. ***Conclusions***: ADHD is a prevalent neurodevelopmental disorder impacting individuals from childhood to adulthood, with varying prevalence rates globally. Methodological differences influence prevalence estimates, highlighting the need for standardized study designs. Both genetic and environmental factors contribute to its development. Management typically involves a combination of psychotherapy, lifestyle adjustments, and medication. However, refined diagnostic criteria and tailored treatment guidelines for children and adults are necessary. Continuous evaluation of interventions is crucial for optimizing care and enhancing the well-being of individuals with ADHD.

Keywords: ADHD, Diagnosis, Etiology, Prevalence, Stimulants and non-stimulant.

فهم اضطراب نقص الانتباه وفرط النشاط: الانتشار والمسببات والتشخيص والأساليب العلاجية

الخلاصة

الخلفية: يتم تصنيف اضطراب نقص الانتباه وفرط النشاط (ADHD) باستخدام الأنظمة الكلاسيكية الجديدة مثل الدليل الإحصائي التشخيصي للاضطرابات العقلية -5 والتصنيف الدولي للأمراض -10. هناك أدلة مهمة على أن العلاج الدوائي، وخاصة المنشطات، يمكن أن يقلل من الأعراض على المدى القصير. **الهدف**: استكشاف المشهد الشامل لاضطراب فرط الحركة ونقص الانتباه من الطفولة إلى مرحلة البلوغ في الأدبيات، والذي يتضمن الخوض في انتشاره، والمسببات، وعوامل الخطر، والتشخيص، وطرق العلاج. **الطريقة**: تم إجراء بحث في الأدبيات عبر المقالات المنشورة باللغة الإنجليزية بين عامي 2011 و 2023. استكشفت الأدبيات على نطاق واسع انتشار الموضوع ومسبباته وعوامل الخطر وتشخيصه ، مع إيلاء اهتمام محدود للعلاج بين عامي 2003 و 2023، باستخدام محركات البحث الإلكترونية مثل Google Scholar و PubMed و IndMED و MedIND و Scopus و Web of Science. تضمنت مصطلحات البحث "اضطراب فرط الحركة ونقص الانتباه" و "اضطراب نقص الانتباه وفرط النشاط" و "فرط النشاط" و "الطب النفسي للأطفال" و "اضطراب فرط الحركة" و "اضطراب نقص الانتباه" و "في جميع أنحاء العالم". **النتائج**: من بين 400 ورقة تم تقييمها، استوفت 52 فقط المعايير التي تشمل الانتشار والمسببات والتشخيص والعلاج. **الاستنتاجات**: اضطراب فرط الحركة ونقص الانتباه هو اضطراب نمو عصبي سائد يؤثر على الأفراد من الطفولة إلى مرحلة البلوغ ، مع معدلات انتشار متفاوتة على مستوى العالم. تؤثر الاختلافات المنهجية على تقديرات الانتشار، مما يبرز الحاجة إلى تصاميم موحدة للدراسة. تساهم كل من العوامل الوراثية والبيئية في تطورها. تتضمن الإدارة عادة مزيجا من العلاج النفسي وتعديلات نمط الحياة والأدوية. ومع ذلك، من الضروري وجود معايير تشخيصية محسنة وإرشادات علاجية مخصصة للأطفال والبالغين. التقييم المستمر للتدخلات أمر بالغ الأهمية لتحسين الرعاية وتعزيز رفاهية الأفراد المصابين باضطراب فرط الحركة ونقص الانتباه.

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INTRODUCTION

Genetic differences in gene expression in several brain function areas, such as attention deficit hyperactivity disorder (ADHD), are characterized by long-term inattention, hyperactivity, and impulsivity [1,2]. ADHD is a common yet complex neurological disorder. Early diagnosis is common, and some people with ADHD may never recover completely as adults. This condition manifests in three primary subtypes: predominantly inattentive (ADHD-I), hyperactive/impulsive (ADHD-HI), or a combination of both (ADHD-C) [3,4]. Symptoms typically manifest early in life and often encompass inattentiveness, lack of focus, disorganization, forgetfulness, and trouble completing tasks. To meet the criteria for ADHD, these symptoms must emerge before the age of 12, persist for at least six months, and significantly disrupt daily activities. Furthermore, they should be observable in multiple environments, such as home, school, or extracurricular activities. ADHD can lead to various challenges, including impaired social interactions, heightened risk-taking behaviors, occupational instability, and academic underachievement [5]. Understanding ADHD in childhood and adolescence requires a comprehensive approach that considers multiple factors, such as genetics, neuropsychology, cognition, and psychosocial dynamics. The developmental trajectory of ADHD encompasses not only its early manifestations but also its persistent features, which extend into adulthood [6]. Identifying risk and resilience factors is crucial for understanding how individuals with ADHD adapt and thrive. It's encouraging to see that strategies like coaching, tutoring, therapeutic support, and parental involvement can significantly enhance executive functions in ADHD children. These interventions improve academic performance and cultivate crucial skills like planning, self-monitoring, and memory. Additionally, teaching children to utilize tools like lists, reminders, and day planners can empower them to develop compensatory strategies, fostering independence and self-management. They build compensatory skills through lists, reminders, and day planners [7]. They are present at high levels, either alone or in combination, and they cause significant psychological, social, educational, or vocational impairment. The severity of ADHD is determined by the extent of impairment, prevalence, individual variables, familial and societal context, and other factors [8].

Significance of the study

While significant progress has been made in understanding prevalence and treating ADHD, there remains a need for further research to deepen our understanding of its underlying mechanisms, refine diagnostic criteria and assessment tools, and develop more targeted and individualized treatment approaches. Addressing these gaps will ultimately lead to improved outcomes from childhood to adulthood with ADHD. A literature search was conducted across articles published in English between 2011 and 2023; the literature extensively explored the subject's causes, prevalence, etiology, and diagnosis, with limited articles published on ADHD patients given treatment between 2003 and 2023.

METHODS

We utilized various online resources, including Web of Science, Embase, Scopus, Google Scholar, PubMed, IndMED, and MedIND, by searching for terms such as "hyperkinetic disorder," "attention deficit disorder," "ADHD," "attention deficit and hyperactivity disorder," "hyperactivity," and "impulsivity." From 2011 to 2024, we evaluated the prevalence, etiology, and diagnosis literature, with limited attention given to treatment between 2003 and 2023.

Inclusion and exclusion criteria

We refined our search criteria to encompass both children and adults, focusing on longitudinal, observational, and cross-sectional studies related to ADHD. Our investigation covers a broad spectrum, including the general population, patients, educational institutions, and colleges, and emphasizes the standardized prevalence, etiology, screening, therapy, and diagnostic criteria employed in ADHD research. We specifically opted for original research and meticulously assessed the literature. This comprehensive review was conducted exclusively in English. We excluded the thesis papers from the search.

Data extraction

The inclusion and exclusion rules correctly guided the review of the studies. A flowchart was used to collect the data after this comprehensive assessment of prevalence, risk factors, diagnosis, and treatments. Subsequently, the extracted data was systematically categorized into distinct themes, encompassing crucial aspects such as prevalence and five key risk factors. These themes included pharmacological and non-pharmacological interventions, as well as exploring adherence, the care pathway, and treatment seeking. Furthermore, the data analysis also delved into the knowledge and attitude surrounding ADHD, shedding light on important aspects of this complex condition.

Research Gap

The review can identify existing research articles on ADHD, addressing the data gaps on ADHD prevalence, etiology, risk factors, screening, diagnosis, and treatment.

RESULTS

Out of 400 studies, 52 were eligible for prevalence, risk factors, diagnosis, and treatment in the review. Figure 1 displays the study flowchart. The primary findings from the studies categorized by prevalence, as outlined in Table 1, Table 2, etiology and Table 3, identify five key risk factors.

Prevalence

In 2020, the global prevalence of ADHD was expected to be 7.2% in children [9], persistent adult ADHD was 2.58%, and symptomatic adult ADHD was at 6.76% [10]. Various epidemiological studies may have either inflated

or underestimated the prevalence of ADHD, attributed to the wide array of measurement methods and assessment tools employed by researchers.

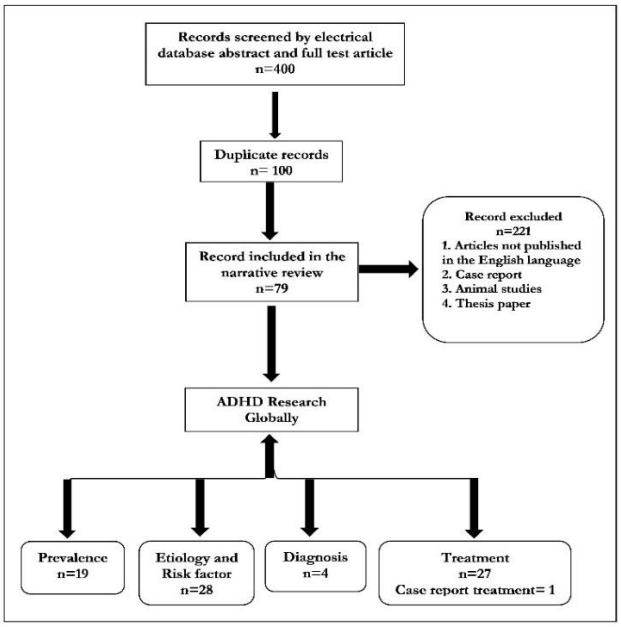

Figure 1: Flowchart outlining the search and selection strategy.

Additionally, geographical location emerged as a critical determinant influencing ADHD prevalence across different age groups—children, adolescents, and adults. The analysis encompassed globally reviewed research articles, investigating prevalence rates across multiple nations such as the United States, China, Spain, India, and various African countries [9,11–16]. According to the reviewed literature, the World Federation of ADHD International Consensus Statement (2008) provides evidence-based conclusions on the disorder, which primarily affects boys and girls and has a global prevalence of 5.9% of young people and 2.8% of adults, reducing misconceptions and stigma [6]. Polanczyk and colleagues conducted a meta-analysis in 2015 that comprised 41 studies from 27 countries, revealing a 3.4% prevalence of ADHD. This study emphasizes the necessity for a more thorough information analysis. According to the systematic and meta-analysis reviews, they had a lower frequency of ADHD than those with more primary studies. The estimates exhibited significant diversity, with the diagnostic interview, sample representativeness, and sample framing playing essential roles [13]. Another systematic review analyzed 175 relevant research articles, estimating an overall ADHD prevalence of 7.2%. Different editions of the Diagnostic and Statistical Manual of Mental Disorders showed no significant variations. Notably, only a few studies utilized random population samples for their analysis [9]. An analysis of 13 studies indicated that the global incidence of ADHD in children and adolescents is 8.0%, with boys having twice the rate as girls. ADHD-inattentive is the most prevalent subtype, followed by hyperactive and mixed kinds. The prevalence ranged from 3.4% to 14%, with significant variations across studies [11]. Other comparable experiments yielded similar results and outcomes [12]. Recent meta-analytic assessments of 27 articles spanning from 2001 to 2016, encompassing 15,124 students aged six to fourteen, indicate a prevailing ADHD prevalence of 8.0%. Within these studies, ADHD prevalence rates among boys were notably higher than among girls, at 12%, 15.6%, and 17.2%, compared to 7.9% and 5.5%, respectively [17]. Researchers may have overestimated or underestimated the prevalence of ADHD with substance use disorder (SUD) among this population in various epidemiological studies because they used different measurement scales and instruments to investigate the phenomenon globally, including alcohol dependence, opioid dependence, and high-risk and low-risk alcohol use, all of which impact the quality of life for ADHD patients. Furthermore, the study's geographical location significantly influenced the prevalence of ADHD among children, adolescents, and adults, as well as the association of ADHD with SUDs among adults. According to the studies conducted in India, there is a strong link between adult ADHD and substance use disorders (SUDs) [18–25]. In 2018, the highest prevalence rate was found in Karnataka state, Bengaluru, with a rate of 62% [24] in 2022, while the prevalence rate in Bhubaneswar, Odisha, was 58.8% [26] in Eastern India. A similar method was used to estimate the global prevalence of ADHD with SUDs in this group globally [27,28]. This study assesses the research on treating adults and adolescents who have co-occurring drug use disorders and ADHD. According to the data, stabilizing addiction will only lead to moderate improvements in ADHD and no discernible improvement in SUD [29]. Controlled trials have found no significant advantage in treating ADHD in people who also have SUD. More studies are needed to determine the long-term efficacy of therapy. According to the narrative review, the global prevalence of ADHD and SUD is increasing as diagnostic criteria and awareness improve. Stimulant-assisted treatment can potentially enhance long-term outcomes and avoid the onset of SUD [30]. We have thoroughly examined and categorized the prevalence of ADHD methodologies based on the included studies, incorporating systematic reviews, review articles, and original research papers into the comprehensive summary presented in Table 1.

Etiology and risk factors

Several kinds of literature, encompassing genotype and environmental analyses alongside systematic analyses, have prenatal and perinatal environmental elements that elevate the risk of ADHD (Table 2). However, none of these factors are exclusive to the disorder. Conditions such as maternal distress during pregnancy, premature birth, low birth weight, socioeconomic deprivation, and moderate exposure to lead and other environmental toxins are among the potential contributors necessitating deeper causal and mechanistic exploration [31]. Consequently, many of these findings stem from observational studies, which could potentially overlook unmeasured variables like genetic predisposition [32–41]. This literature conducted with 79 children diagnosed with ADHD and their parents revealed a noteworthy occurrence of ADHD symptoms among the parents. Specifically, 41.3% of mothers and 51.0% of fathers fulfilled the criteria for ADHD. Despite parents reporting relatively mild symptoms, a significant portion experienced symptoms of moderate severity.

Table 1: Summary in Prevalence of ADHD globally

No	Author	Type of Study	Sample Characteristics	Study Setting	Age Group	Assessment	Prevalence
1	Thomas *et al.* (2015) [9]	Systematic review and meta-analysis	175 eligible studies 179 ADHD affected	Europe compared with North America	Not mention age	Diagnostic criteria from DSM-III, DSM-III-R and DSM-IV	7.2%
2	Song *et al.* (2021) [10]	Systematic review and meta-analysis	139.84 million and 366.33 million affected adults in 2020 globally.	Adult ADHD globally	Not mention age	The diagnostic criteria from and DSM-5	Persistent adult ADHD was 2.58%, and symptomatic adult ADHD was 6.76%
3	Ayano *et al.* (2023) [11]	Meta-analysis	588 primary studies	Children and adolescents globally	Not mention age	Measurement Tool to Assess Systematic Reviews (AMSTAR)	8.0 %
4	Ayano *et al.* (2020) [12]	Systematic review and meta-analysis	7452 articles	Children and adolescents Africa	Not mention age	Cochran's Q- and the I^2-test	7.47%
5	Polanczyk (2015) [13]	Systematic review and meta-analysis	41studies conducted in 27 countries	Children and adolescents	Not mention age	DSM or ICD	3.4%
6.	Cénat *et al.* (2022) [14]	Systematic review and meta-analysis	155 articles	Black, White, Latino and Asian children and adolescents.	Not mention age	DSM-5	15.9% among Black children and adolescents, 16.6% among Whites, 10.1% among Latinos and 12.4% among Asians
7	Vasileva *et al.* (2021) [15]	Systematic review and meta-analysis	18,282 children ,8 countries	Children younger than 7 years	Meta-analysis, Not mention age	Not mentioned	4.3%
8	Wang *et al.* (2017) [16]	Systematic review and meta-analysis	67 studies, 275,502 children and adolescent	Children and adolescents in China	Meta-analysis, Not mention age	CCMD (Chinese Classification of Mental Disorders), DSM(III, III-R, IV, or ICD(9-10)	6.26%
9	Yadegari *et al.* (2018) [17]	Meta-Analysis	27 articles, 15124 students	Parents and teachers	Meta-analysis, Not mention age	DSM-IV	12%
10	Ganesh *et al.* (2017) [18]	Cross-sectional study	240 patients, 135 cases	Patients	Before 25 years	Adult Attention Deficit Hyperactivity Disorder self-reporting scale	56.25%
12	Lohit *et al.* (2019) [20]	Cross-sectional study	100 inpatients	Patients	18 and 60 years	Adult ADHD Self Report Scale, DSM-5	19%
13	Gupta *et al.* (2020) [21]	Cross-sectional study	132 inpatients	Patients	<18 years	Adult Attention-Deficit Hyperactivity Disorder Self-Report Scale	18.2%
14	Ganesan *et al.* (2021) [22]	Cross-sectional study	711 engineering students	Student, college	17-25 years	Adult ADHD self-report scale, Symptom Checklist (ASRS-v1.1) and impulsivity by the Barratt Impulsiveness Scale (BIS-11)	40.9%
15	Kumar *et al.* (2021) [24]	Cross-sectional study	82 patients	Patients	Below 25 years	The WHO ASRS was used to screen adult ADHD.	25.60%
16	Dhagudu *et al.* (2021) [23]	Cross-sectional study	200	People	<18 years of age	Adult ADHD Rating Scale	18%
17	Samal *et al.* (2022) [25]	Cross-sectional study	226	Patients	18 and 65 years	Adult ADHD Self-Report Scale (v1.1) DSM-5	24.3%
18	Rohner *et al.* (2023) [26]	Meta Analysis	31 studies 12,524 participant	Participant	Meta-analysis	Adult ADHD self-report scale v1.1, DSM-5	21.5%
19	van Emmerik-van Oortmerssen *et al.* (2012) [27]	Meta-regression analyses	59 articles	Articles	meta-regression analyses	DSM-criteria	23.1%
20	van de Glind *et al.* (2014) [29]	Cross-sectional study in 10 countries	3558patients	International, multi-center patients	18–65 years	DSM-IV and DSM-5, ASRS	5.4%
21	Srichawla *et al.* (2022) [30]	A narrative review	49 articles globally	Adolescent	less than 17 years	WHO Adult ADHD Self-Report Scale (ASRS)	2%-7%

Aberration: Diagnostic and Statistical Manual 3rd edition(DSM-III), Diagnostic and Statistical Manual 3rd edition revision (DSM-III-R) and Diagnostic and Statistical Manual 4th edition (DSM-IV)

Surprisingly, the study did not find a significant correlation between parental ADHD diagnoses and those of their children.However, it raised concerns about how parental ADHD might impact family dynamics, parenting approaches, and the efficacy of parent-focused interventions and therapies. In this study, we emphasize the importance of taking parental ADHD into account when comprehensively addressing ADHD [42]. In this article, sibling relationships can intensify the risk of ADHD, doubling it compared to those without siblings. Researchers have explored various factors like viral infections, maternal smoking during pregnancy, inadequate nutrition, and fetal alcohol exposure as potential triggers for the disorder. Despite extensive research, brain imaging studies of ADHD patients have yielded inconsistent findings. Furthermore, changes in dopaminergic receptor levels, particularly reduced levels in the frontal lobes, have been linked to the disorder's onset [43,44]. ADHD is an inherited condition, which is the primary cause and constitutes 70% of ADHD cases. Though environmental factors influence the development of ADHD children, without being active, children can inherit ADHD genes [45]. The prevalence of ADHD among mothers and fathers was 41.3% and 51.0%, respectively, with mixed and hyperactive-impulsive subtypes.

Table 2: Etiology of ADHD

Genetics	ADHD tends to run in families, with individuals who have a parent or sibling with the condition being at a higher risk of having it themselves. Additionally, twins are more likely to be diagnosed with ADHD compared to non-twin siblings
Birth factors	Being born prematurely or with very low birth weight elevates the risk for ADHD. These conditions may increase the probability of developing ADHD, although they aren't direct causes. Premature birth and low birth weight often correlate with changes in brain development, especially in regions governing attention, impulse control, and executive functions—areas closely linked with ADHD.
Factors for the expectant mother include	1. Drug or alcohol use 2. Use of certain drugs (corticosteroids and antidepressants) 3. Mental problems 4. High blood pressure 5. Hyperthyroidism 6. Smoking 7. Exposure to certain environmental toxins (lead).

Symptoms were classified as low, medium, or severe, and there was no significant relationship between parental diagnosis and diagnosis [46]. These studies discovered that pregnant women who smoke have a much higher risk of giving birth to babies with ADHD; similarly, pregnant women who drink alcohol or use drugs increase their child's risk of having the disorder. Older children born before their due date are more likely to develop ADHD [47,48] A 2018 pediatrics study discovered that smoking during pregnancy dramatically increases a child's risk of having ADHD. The offspring of heavy smokers are more likely to develop ADHD. The study identified a relationship but was unable to determine whether smoking caused ADHD [49,50]. A 2019 study discovered that consuming four or more beers at once or frequent low- to moderate-alcohol consumption was associated with a significant increase in the risk that a child would later develop ADHD [51]. Females are more likely to acquire ADHD, with middle childhood being the riskiest time of development. Researchers have linked obesity in men to increased oppositional behaviors, poor sleep, motor coordination issues, and methylphenidate abuse [52]. Although ADHD is substantially heritable, environmental factors account for 10–40% of its variance. The prenatal environment may influence the development of ADHD. Despite the lack of proven causation, previous epidemiological studies and data linkage research have shed light on this association. Developing a new standard for ADHD research requires an examination of prospective data gathering as well as other genetic and family characteristics [53]. Several studies have consistently found genetic and environmental review articles that link ADHD to alcoholism as an adult, the same literature on an emotional problem as a child, and DNA variants in the brain-derived neurotrophic increase the risk of ADHD [45,54–58]. Despite the DSM-5 acknowledging the clinical variability within ADHD through its three subtype presentations, the limitations of the symptom checklist diagnosis method underscore a broader issue. The polygenic nature of ADHD suggests a diverse genetic landscape, complicating efforts to identify an etiology or universally applicable processes. Moreover, studies indicate that the relevant neurobiological factors for ADHD vary among individuals and are multifaceted, contributing to the challenge of understanding its underlying mechanisms. Notably, even among those with abnormal brain structures, a minority of ADHD patients exhibit deviations from the typical anatomical profile of the disorder [59–64]. Describing and refining phenotypic heterogeneity is critical to understanding the etiology and mechanisms of ADHD.

Screening and diagnosis

To establish diagnostic validity, most studies used a variety of standardized techniques for evaluation and diagnosis. The International Classification of Diseases (ICD) and the Diagnostic and Statistical Manual (DSM) are tools for determining prevalence, etiology, and treatment. Assessments have included questionnaires graded by teachers, parents, physicians, and students. The Diagnostic and Statistical Manual, Fourth Edition Text Revision Criteria and DSM-5, the Conner's Parent Rating Scale (CPRS), the Conner's Teachers Rating Scale (CTRS), and the Vanderbilt Assessment Scale (VAS) were the most commonly used measures, along with the adult ADHD self-report scale (ASRS v1.1) and other ASRS evaluations. Xu et al. (2018) conducted a nationwide study to assess the prevalence of ADHD among children and adolescents in the United States from 1997 to 2016, using data representative of the nation [60]. They discovered that the prevalence of ADHD was 6.1% during the study period, with a notable increase to 10.2% in 2015–2016. Moreover, they identified significant ethnic disparities in ADHD diagnosis rates. Importantly, the prevalence of ADHD increased significantly across all demographic categories throughout the study period [65]. This systematic review of the literature suggests that screening for ADHD should begin at the age of six or upon the child's initial diagnosis. Moreover, it emphasizes the importance of ongoing screening and reassessment following any alterations in antiepileptic medication (AED). The review also stresses how important it is for medical professionals with advanced knowledge in ADHD (Level U) to be involved in the diagnosis process [66]. According to the research, school staff should use behavior rating scales, school histories, vision and hearing tests, and classroom observations to learn more about kids who are having trouble learning and behaving. It emphasizes the importance of multimodal treatments, such as pharmaceutical trials, psychological assessments, and academic endeavors. It also recommends keeping in touch with parents and schools during changes, such as pharmaceutical and psychological trials [67]. Our literature review assessed the diagnostic accuracy of various techniques across different types of samples and reporters, including population-based, clinical, and high-risk groups. The findings remained consistent across these diverse populations. It is crucial to note that, due to

limited scientific research in this area, our study exclusively focused on papers originating from a specific geographic region. The literature reviewed used the ICD-10 and various versions of the DSM, including the DSM-IV, DSM-IV TR, and DSM-5, as tools for screening and diagnosing ADHD patients [68].

Treatment

Therapies are part of a multimodal approach to treating ADHD. The Food and Drug Administration (FDA) has approved ADHD treatment stimulants such as methylphenidate, dexmethylphenidate, dextroamphetamine, mixed amphetamine salts, dextromethamphetamine, and lisdexamphetamine [69], as well as non-drugs such as atomoxetine, alpha-2a adrenergic receptor agonists such as clonidine and guanfacine, modafinil, bupropion, and antidepressants [70].

Stimulants

A systematic review, narrative review, and original literature were used to evaluate the immediate-released (IR) methylphenidate as a placebo; the study discovered extremely low-certainty evidence that it may reduce ADHD symptoms. The data require a higher level of confidence. However, IR methylphenidate showed only a mild effect on ADHD symptoms. Furthermore, there is very little conclusive evidence that IR methylphenidate may reduce the clinical perception of the severity of ADHD symptoms [71,72]. The meta-analyses revealed that the study found strong evidence in the childhood and adolescent literature to support the hypothesis that methylphenidate helps treat adult ADHD. MPH effect sizes were associated with higher dosages and physician outcome evaluations. Clinicians now have greater confidence in the effective use of the ADHD diagnosis in adults, thanks to a one-day trial [73,74]. Further research has shown that the most often used ADHD medicine is methylphenidate, which acts on dopamine and norepinephrine transporters, increasing norepinephrine levels in the prefrontal brain cortex [75]. All sustained-release formulations of methylphenidate have a once-daily dose, although their pharmacodynamic effects differ. Current long-acting formulations include Concerta®, Focalin XR®, Metadate® CD, and Ritalin® LA. Intermediate-acting medications like Ritalin® SR, Metadate® ER, and Methylin® ER may require twice-daily administration or immediate-release pharmaceuticals in the middle of the day. When considering a once-daily dose, practitioners must consider symptoms and the duration of action. Peak concentration time and total "coverage" vary significantly between products. Ritalin® LA and Focalin® XR use a spheroidal oral drug absorption system (SODAS). It produces two concentration maxima that are identical to those observed in twice-daily immediate-release formulations [76].

Dexmethylphenidate

An effective isomer of MPH known as dexmethylphenidate was commercially available to treat ADHD; it has a 1% to 2% longer half-life and requires a lower dose. According to a meta-analysis of randomized controlled trials, d-MPH may be effective in treating ADHD in early children and adolescents. The basic psychometric properties of the Swanson Kotkin, Agler, M-Flynn, and Pelham Scale (SKAMP), which measures functional impairment related to ADHD, are significantly better in the laboratory. Parents and instructors reported comparable results. According to the NNT of three, d-MPH treatment will benefit one in every three ADHD patients [77].

Dextroamphetamine and combined amphetamine salts

Stein et al. [73] did a study that showed that as doses went up, the effects of extended-release dexmethylphenidate (ER d-MPH) and extended-release mixed amphetamine salts (ER MAS) on ADHD symptoms got much weaker. Both stimulants relieved symptoms of ADHD and hyperactivity/impulsivity, but they also caused reduced appetite and tiredness. 43 percent selected only one medicine.

Dextromethamphetamine with lisdexamfetamine

The 2016 review paper found that lisdexamfetamine dimesylate, a long-lasting prodrug of d-amphetamine, can treat adults, adolescents, and children with ADHD when used in conjunction with active amphetamine exposure and efficacy duration. A lower Cmax, a longer latency to Cmax, and reduced variability within and across people distinguish its pharmacokinetic profile. Following a dose, LDX's therapeutic effects persist for at least 14 hours in adults and 13 hours in children [78]. After five randomized controlled studies and multiple open-label investigations, Health Canada approved it for children aged six to twelve. It has similar side effects to other long-acting amphetamine formulations [79]. A laboratory school did a literature analysis and discovered that pupils with ADHD who took LDX had much fewer symptoms than those who got a placebo. During the crossover treatment, we observed effectiveness at post-dose periods of 1.5 hours and up to 13.0 hours. It indicates that LDX may help children with ADHD manage their symptoms during the day, especially during family time and after-school activities [80]. In a case study [81], a 33-year-old ADHD patient was treated with lisdexamfetamine (30 mg), which was then increased to 40 mg. Serenity, quiet, focus, and reduced procrastination were essential benefits for the patient. He had fewer amphetamine cravings and no desire to use illicit substances again.

Non-Stimulants

In their 2023 study, Radonjic *et al*. conducted a meta-analysis and systematic review focusing on non-stimulant therapies for ADHD, aiming to assess their acceptability, tolerability, and efficacy. Their comprehensive analysis incorporated one narrative synthesis along with 18 research papers. Findings indicated that atomoxetine, guanfacine, and viloxazine ER exhibited significantly higher effectiveness compared to the control group. Notably, in treating ADHD among adults, all non-stimulants under investigation outperformed placebos. However, it's noteworthy that the placebo was perceived

as more palatable and acceptable [82]. This research paper describes a study that employed a genetic model and pharmacological screening to find five potential non-stimulant therapies for ADHD [83]. The study identified three non-stimulant therapies that interrupted sleep and potentially reversed the hyperactive phenotype. Four drugs, namely moxonidine, doxazosin, amlodipine, and aceclofenac, have similar effects to atomoxetine. Moxonidine, which strongly binds to the imidazoline receptor, has been shown to improve cognitive function. The findings provide a novel tool for understanding the brain circuitry and causation of ADHD [84]. A literature review explored the impact of stimulant and non-stimulant medications on the autonomic nervous system (ANS) in individuals with ADHD. The analysis encompassed eleven studies examining blood pressure and heart rate, one study on pupillometry, and five studies on electrodermal activity. The findings revealed that both stimulants and non-stimulants elevate blood pressure, heart rate, and alertness in individuals with ADHD. However, to better anticipate or monitor these effects, further extensive research is necessary to elucidate the interplay between arousal, medication, and behavior in ADHD [85]. A research study conducted between 2005 and 2017, with a follow-up from 2011 to 2021, examined the impact of stimulant medication use for attention-deficit/hyperactivity disorder (ADHD) during adolescence on cocaine and methamphetamine use during young adulthood. The study focused on secondary students and investigated the associations between ADHD medication history and prescription stimulant misuse (PSM), as well as cocaine and methamphetamine use. According to the findings, teenagers who did not have a history of ADHD medication use had the lowest rates of past-year outcomes: 4.7% for PSM, 1.6% for cocaine, and 0.7% for methamphetamine. In contrast, those with a history of combined stimulant and non-stimulant therapy showed the highest rates: 22.3% for PSM, 10.4% for cocaine, and 7.8% for methamphetamine. Interestingly, there were no significant differences in rates between teenagers undergoing monotherapy; the rates remained moderate [86]. The findings suggest that youths taking ADHD medication should undergo regular monitoring for stimulant effects, particularly those who have previously undergone both stimulant and non-stimulant therapy [87,88]. A survey by ML Wolraich and colleagues has unveiled fresh insights into a specific condition's causes, symptoms, and treatment options. Managing symptoms and improving functioning through medication is beneficial, yet diagnosing and treating ADHD poses significant challenges. Raising awareness of ADHD among both medical practitioners and the public is crucial to ensuring appropriate treatment. Furthermore, advancing research is imperative for developing more effective medications and a deeper understanding of the complexities of ADHD [89]. It is impossible to overstate the importance of psychosocial therapies in the treatment of adults, children, and adolescents with ADHD. Therapists can manage ADHD flexibly and knowledgeably if they have access to adequate and reliable medications. Creating an overview of evidence-based interventions can provide patients with various treatment options that can supplement or replace psychostimulants, providing a comprehensive approach that considers their expectations about medical attention and treatment preferences [90]. We conducted a literature search and categorized the treatment approaches into stimulant and non-stimulant categories based on systematic and meta-analysis, review articles, case studies, and original publications included in the study. This study reveals disparities among the diagnostic criteria outlined in the DSM-IV, DSM-5, and ICD-10 for ADHD. While all three systems feature similar symptom lists, they diverge in their approaches to diagnosis, prevalence etiology, risk factors and treatments. The DSM-5 introduces two diagnostic dimensions, accommodating cases where only a few symptoms are present. Hyperactivity and impulsivity are key features considered across both adolescent and child dimensions. In contrast, the ICD-10 mandates fulfilling all criteria in multiple situational contexts for diagnosis. The DSM-5 emphasizes impairment across various situations as a diagnostic criterion. We employ a blend of these scales alongside other assessment modalities. Nonetheless, honing in on a child's symptoms or treatment trajectory may pose challenges amidst daily interactions. Despite these complexities, these scales serve as invaluable instruments in diagnosing and treating ADHD, offering a systematic approach to data collection and assessment involving children, parents, educators, and mentors alike [91]. Exploring ADHD comprehensively involves examining its prevalence, causes, diagnosis, and treatments. This includes understanding how ADHD affects different groups, such as from childhood to adulthood. It also entails uncovering the mix of genetic, environmental, and neurological factors that contribute to ADHD's development. Identifying prevalence and risk factors associated with ADHD onset is crucial, as is using reliable diagnostic criteria for accurate identification. Finally, it is crucial to implement a variety of therapeutic interventions to effectively manage symptoms and improve overall functioning.

Future directions

Future research could look into risk factors, treatments, and potential applications for various health disorders. More research is needed to determine how to medicate ADHD individuals based on age, gender, and geography. More research is required in order to better understand the sources of risk indicators and their long-term repercussions for ADHD patients worldwide. The definition of psychopathology is evolving from separate diseases to overlapping symptoms. Executive dysfunction and inattention are standard features of dysregulatory psychopathology, which includes ADHD. The review improves the use of neuropsychological testing for ADHD diagnosis; however, its particular contributions are unclear. People are increasingly asking psychologists and neurologists to explain the importance of their roles in healthcare. More studies are needed to evaluate the validity and unique utility of neuropsychological testing in ADHD diagnostic and treatment trials, as well as its potential role in the creation and execution of treatment plans.

Table 3: Summary of ADHD Risk Factors

Study	No of population	Study design	Risk factor	Main outcomes and measures
Haddad *et al*., (2022) [87]	7921 mothers	Population-based cohort study	Early-life exposures. Maternal ADHD PRS, ASD PRS, and SCZ PRS were calculated using discovery effect size estimates from the largest available genome-wide association study and a significance threshold.	Factors affecting pregnancy and childbirth can be broadly categorized into maternal lifestyle and behavior, maternal use of nutritional supplements and medications during pregnancy, maternal illnesses, and perinatal factors.
Havdahl *et al*., (2022) [88]	14 539 mothers	Cohort study	PGS for ADHD, autism, and schizophrenia, calculated (using discovery effect size estimates and threshold of P < .05) from the largest available genome-wide association studies	Self-reported measures pertaining to pregnancy that encompass lifestyle behaviors, metabolic health, infectious and autoimmune diseases, other physical health conditions, and medication usage.
Neugebauer *et al*., (2015) [89]	234	Cohort study	Increasing prenatal PCDD/F and PCB concentrations were significantly ($p < 0.05$) associated with a higher number of omission errors in the subtest Divided Attention.	Exposure to PCDD/F and PCB during the pre-and perinatal periods could subtly impact attention performance in healthy children, even at low environmental levels. Conversely, behavior changes may be adversely affected. Specifically, prenatal exposure to PCDD/F or PCB was found to have a negative association with ADHD-related behavior, such as a decrease of 10% (95% CI: 0.82–0.99) in the case of PCB exposure.
Abid *et al*., (2014) [90]	1,257	Cross-sectional survey	PAH exposure was measured by urinary metabolite concentrations.	Outcomes were defined by parental report of (1) ever doctor-diagnosed ADHD, (2) ever doctor- or school representative-identified LD, and (3) receipt of SE or early intervention services
Perera *et al*., (2018) [91]	351 children	Prospective cohort study	Prenatal Polycyclic aromatic hydrocarbons (PAH) exposure	These exposures might reduce the risk of ADHD problems, additional benefit to the developing fetus and young child would come from a multifaceted approach to reduce PAH exposure and alleviate material hardship.

Aberration: Autism spectrum disorder (ASD PRS), and schizophrenia (SCZ PRS), polygenic scores (PGS), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs)

Future studies on the treatment of dextromethamphetamine and lisdexamphetamine should include a randomized controlled trial with a more extended follow-up period to establish long-term clinical benefits.

Conclusion

ADHD is a widely recognized neurodevelopmental disorder with significant global prevalence, affecting individuals from childhood through adulthood. While prevalence rates vary across studies, ranging from 2.2% to 8.9% in two-setting analyses and generally falling between 4% and 10% across diverse populations, methodological disparities rather than inherent population differences likely account for observed variations. Moving forward, standardized study designs are crucial for establishing more precise prevalence estimates. Both genetic and environmental factors contribute to its development. Effective management of ADHD typically involves a multifaceted approach, including psychotherapy, lifestyle modifications, and pharmacotherapy. Both stimulant and non-stimulant medications have proven efficacy in symptom management. However, there remains a pressing need for refined diagnostic criteria that better capture the nuanced presentation of ADHD across the lifespan. Additionally, the development of formal treatment guidelines tailored to adult populations is warranted. As research progresses, it is imperative to systematically evaluate the utility and effectiveness of interventions, ensuring that individuals with ADHD receive optimal care throughout their developmental stages. By addressing these challenges and refining diagnostic and treatment strategies, we can better support individuals affected by ADHD and enhance their overall well-being and functioning.

Conflict of interests

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Supplementary data can be shared with the corresponding author upon reasonable request.

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