International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8, 2025
https://theaspd.com/index.php

Ameliorated Effects Of AI On Autism And ADHD

Hassan M. Rezk[1], Noha S. Farag[2], Mohammed Shaikhomer[3], Syed Fouzaan Albeez[4], Faisal Makki[4], Amjad Khan[4], Sanha Sideeque[4], Saleha Khan[4].
[1] Anatomy and Embryology Department, Faculty of Medicine, Mansoura University, Egypt
Department of Anatomy, Batterjee Medical College, Jeddah, Saudi Arabia.
[2] Department of Clinical Pathology, Batterjee Medical College, Jeddah, Saudi Arabia.
[3] Department of Internal Medicine, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia
Department of Internal Medicine, Batterjee Medical College, Jeddah, Saudi Arabia.
[4] General Medicine Practice Program, Batterjee Medical College, Jeddah, Saudi Arabia.

Abstract
This review studies the transformative impact of artificial intelligence (AI) on autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD). AI technologies, including machine learning algorithms, virtual reality (VR), and wearable devices, offer innovative solutions for early diagnosis, personalized treatment, and effective management of these neurodevelopmental disorders. For ASD, AI enhances social skills training, facilitates communication therapies, and provides real-time feedback through adaptive interventions. For ADHD, AI assists in precise diagnosis and continuous monitoring by studying behavioral patterns and utilizing adaptive learning tools. Integrating AI with neuroimaging and robotics supports targeted therapies, improving cognitive and motor functions. This review also addresses ethical considerations, emphasizing the need for responsible AI deployment to ensure fair access to quality care and to reassure the audience about the benefits of AI. By improving accessibility, cost-effectiveness, and personalization, AI represents a promising advancement in diagnosing, treating, and managing ASD and ADHD, making interventions more effective while maintaining the essential human element in healthcare.
Keywords: *Artificial Intelligence (AI), Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), Virtual Reality (VR), Robotic-Assisted Therapy.*

INTRODUCTION

Neurodevelopment disorders represent a significant proportion of the global disease burden due to premature deaths and long-lasting disability. More than 10% of the world's population is affected by at least one of these conditions [1]. Among the most common neurodevelopmental disorders are autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD), both of which present a range of cognitive, behavioral, and social challenges. ASD is characterized by repeated behaviours that impact social relationships and communication, whereas ADHD is primarily characterized by impulsivity, hyperactivity, and inattention. These conditions impact millions globally, creating significant clinical and social challenges that necessitate timely diagnosis and effective treatment. Recent studies estimate that ADHD affects between 5.5% and 7.6% of children and adolescents, while autism affects approximately 1.5% to 4.3% of this demographic [2].

Artificial intelligence (AI) has seen an emerging trend during the recent year in healthcare and precision medicine. AI is starting to show promising effects as a revolutionary tool for treating ASD and ADHD by creating personalized assistive technologies for these individuals. From a future perspective, it could be capable of conducting a precise assessment of individual needs enhancing the precision and effectiveness of treatment strategies [3,4]. Utilizing cutting-edge technology like artificial intelligence (AI), robots, deep learning, virtual reality (VR), and machine learning, these conditions may be continuously monitored, treated individually, and detected early. In order to fully comprehend these illnesses, AI algorithms examine behavioural patterns, genetic information, and neuroimaging results. Based on this analysis, the algorithms can provide customized therapies that significantly improve cognitive and social abilities, ultimately leading to better patient outcomes. The article examines how AI may be used to diagnose, treat, and manage ASD and ADHD, emphasizing the influence of technology improvements on patient outcomes. It also discusses

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8, 2025
https://theaspd.com/index.php

the moral issues surrounding the use of AI, highlighting the significance of striking a balance between technical advancement and the fundamentally human aspects of healthcare.

3. Epidemiology

3.1 Prevalence and incidence of ADHD & Autism:

ADHD is a childhood-onset neurodevelopmental disorder with a prevalence ranging from 1.4% to 3.0%, predominantly affecting boys more than girls. An analysis of 61 cross-sectional studies revealed that 7.6% of 96,907 children aged 3 to 12 years had ADHD (95% confidence interval: 6.1-9.4%), and 5.6% of teenagers aged 12 to 18 years had ADHD (95% confidence interval: 4.8-7%) [5]. The prevalence of ADHD in children and adolescents is higher when diagnosed according to DSM-V criteria compared to previous diagnostic criteria. In adults, the prevalence of persistent ADHD (with childhood-onset) was 2.58%, while symptomatic adult ADHD (regardless of childhood-onset) was 6.76%, affecting approximately 139.84 million and 366.33 million adults globally in 2020. The prevalence of ADHD decreases with advancing age [6].

ASD shows considerable variability in prevalence, influenced by biological sex, sociodemographic status, ethnicity/race, and nativity. A review of 99 estimates from 71 studies since 2012 found a global autism prevalence with a median of 100/10,000 (range: 1.09/10,000 to 436.0/10,000) and a median male-to-female ratio of 4.2 [7]. Approximately 33.0% of autism cases have co-occurring intellectual disability.

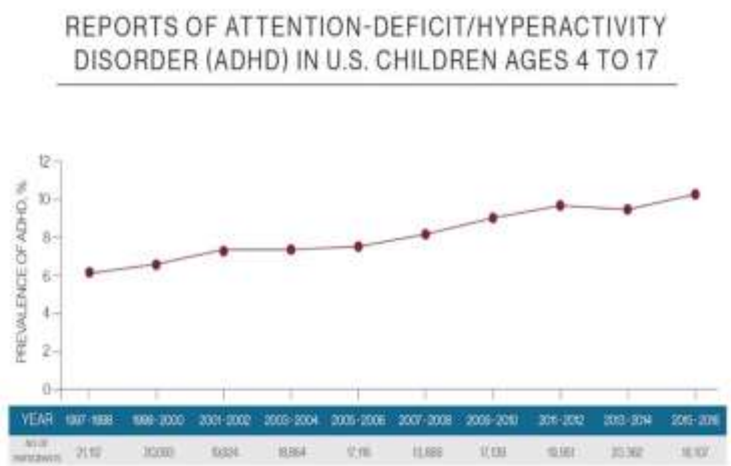

Figure 1:Data showing the increasing ADHD rates in the States (1997-2016)

In 2020, ASD prevalence among children aged eight years varied from 23.1 per 1,000 in Maryland to 44.9 per 1,000 in California, with an overall prevalence of 27.6 per 1,000 (one in 36). ASD was more prevalent among boys than girls (43.0 versus 11.4) and higher among non-Hispanic Black, Hispanic, and non-Hispanic Asian or Pacific Islander children compared to non-Hispanic White children. The median age of the earliest known ASD diagnosis was 49 months (approximately four years), with variations by state and earlier diagnosis among children with intellectual disabilities [8].

3.2 Epidemiological Studies on the Hereditary factors of ADHD & Autism:

Epidemiological data regarding marriage among individuals with autism spectrum disorder (ASD) reveals that offspring born to two individuals with ASD have an increased likelihood of inheriting ASD-related genetic characteristics due to shared genetic vulnerabilities. This heritability is influenced by complex interactions between multiple genetic loci and environmental factors, making it challenging to predict ASD expression in offspring. In marriages where only one partner has ASD, the risk of ASD transmission remains, albeit somewhat lower compared to couples where both partners have ASD. Genetic counselling is crucial in estimating transmission risk and informing family planning decisions. ASD is a neurodevelopmental condition characterized by social and language impairments, repetitive behaviours, and a male-to-female ratio of 4:1. Recent years have seen an increase in ASD diagnoses, with ratios reported as high as 1 in 68 children [9]. The disorder frequently coexists with intellectual disability, seizure disorders, and fragile-X syndrome. Genetic research has advanced significantly, uncovering novel genetic loci, risk factors, and submicroscopic chromosomal changes (copy number variations, CNVs) associated with ASD. Understanding these genetic mechanisms aids in providing tailored support and treatments to improve developmental outcomes for children affected by ASD and their families [10].

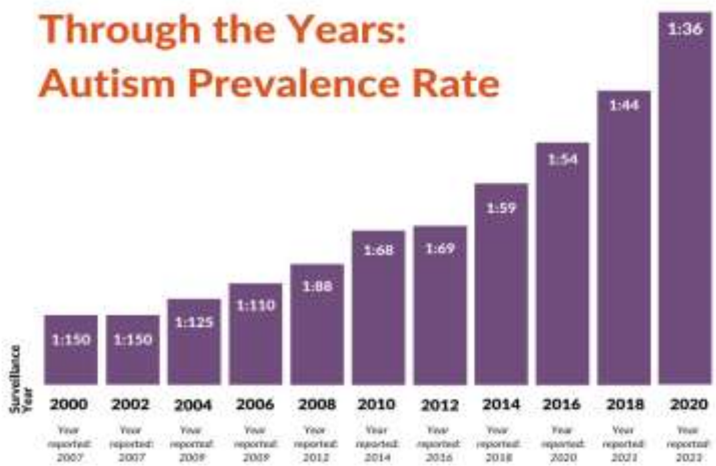

Figure 2: Data showing the increasing ASD rates in the States (2000-2020)

Epidemiological data regarding attention deficit hyperactivity disorder (ADHD) highlights genetic comorbidities with other major psychiatric disorders, assessed through genome-wide single nucleotide polymorphisms (SNPs). The analysis shows low genetic comorbidity between ADHD and autism spectrum disorder (ASD) at 2.5%, contrasting with higher rates between ADHD and schizophrenia (46%), major depressive disorder (18% to 22%), and major depressive disorder and ADHD (10%). The genetic determination of ADHD and other psychiatric disorders, estimated from genome-wide SNPs, is lower compared to traditional quantitative genetic methodologies, with ADHD estimated at 23%. This suggests that behavioural traits associated with ADHD, such as hyperactivity and impulsivity, may have had high adaptive value in early human evolution but are now associated with frequently diagnosed major psychiatric disorders [10].

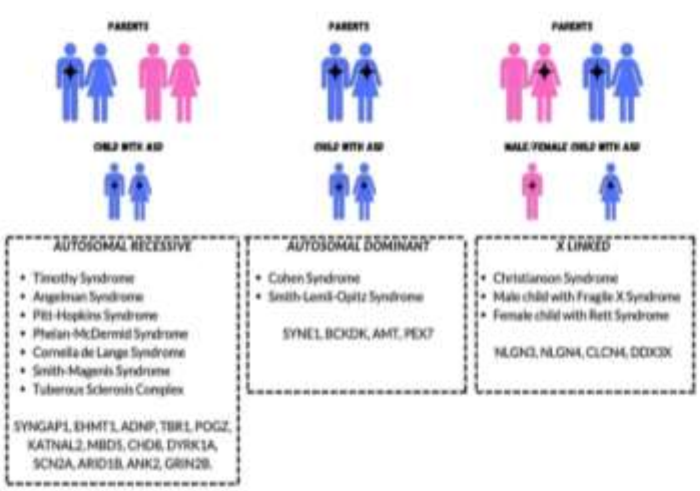

Figure 3: The inheritance patterns of high-risk genes and syndromes associated with ASD involve various genetic models, including autosomal recessive, autosomal dominant, and X-linked inheritance. The stars represent causal allele.

Epidemiological data regarding ADHD and autism spectrum disorder (ASD) highlight a significant genetic component, with both disorders associated with genes involved in brain development, neurotransmitter regulation, and synaptic connectivity, such as DRD4 and NRXN1. Shared genetic vulnerabilities contribute to overlapping symptoms and co-occurrence. Despite this overlap, no significant differences in allele frequency were found for several single nucleotide polymorphisms (SNPs) in SHANK2/SHANK3 among clinical groups with ADHD, ASD, or both [11]. The MAP1A gene, crucial for nerve cell structure development, is identified as highly affected in individuals with ADHD or autism, along with KDM6B, recognized as a risk gene for neurodevelopmental disorders. This epidemiological understanding aids in identifying shared genetic factors influencing the development and manifestation of ADHD and ASD, providing insights into their complex genetic interplay as seen in figure 4 [12].

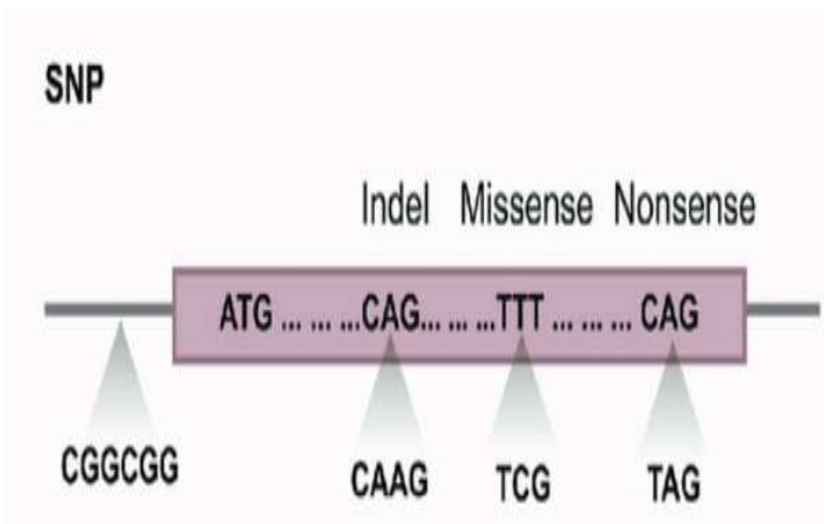

Figure 4: The shown types of genetic variation including SNP and CNVs

4. AI in Epidemiology of ADHD & Autism

I has significantly transformed the rehabilitation of ADHD, starting with physical rehabilitation, and progressing to address cognitive and behavioural challenges by the early 2000s. Today, AI-driven tools enable early detection through machine learning algorithms analyzing behavioural patterns and cognitive markers. These tools create personalized therapy plans that adapt in real time based on individual progress and feedback. AI-enhanced virtual reality (VR) and augmented reality (AR) platforms provide immersive environments for therapeutic exercises, boosting engagement and improving attentional control and self-regulation skills. Wearable devices with AI algorithms monitor physiological and behavioural metrics, allowing continuous feedback to optimize treatment plans and track intervention effectiveness over time. Future outcomes include advancements in neuroimaging and robotics, enabling targeted neurofeedback and robotic-assisted therapies to enhance motor skills and behavioural outcomes. Addressing ethical considerations and data privacy is crucial for responsible AI deployment, ensuring equitable access to quality care for individuals with ADHD [13,14].

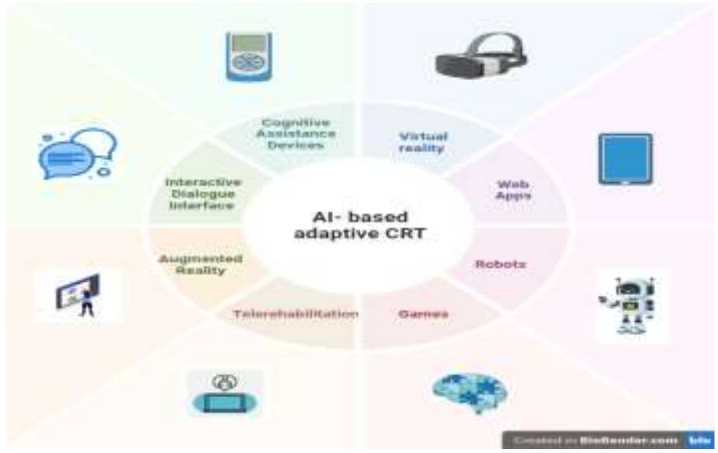

Figure 5: AI-based adaptive cognitive rehabilitation therapy interventions

AI has revolutionized rehabilitation approaches for autism spectrum disorder (ASD), addressing cognitive and behavioural challenges through sophisticated tools. Initially focused on physical rehabilitation, AI evolved to support cognitive impairments and behavioural challenges by the early 2000s. AI algorithms now analyze brain activity patterns to develop targeted neurofeedback protocols that enhance self-regulation and attentional control in individuals with ASD. Integrating AI with robotics has enabled robotic-assisted therapies that provide interactive experiences to improve motor skills, social interaction, and communication abilities. AI-enhanced VR and AR platforms offer immersive environments for therapeutic exercises, enhancing engagement and skill development. Wearable devices with AI algorithms monitor a more comprehensive range of physiological and behavioural metrics, facilitating personalized interventions and optimizing treatment outcomes. Future neuroimaging and personalized medicine advancements are expected to enhance ASD rehabilitation by improving self-regulation and social-emotional skills. Ethical considerations, data privacy, and algorithmic transparency are crucial for the responsible deployment of AI, ensuring its full potential for individuals with ASD [13,14].

5. Pathophysiology:

Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) are two common and prevalent neurodevelopmental disorders, giving rise to differing and distinct behavioral and cognitive profiles. An understanding of general pathophysiology is required for intervention at an optimum time, which will help in specific therapies and thereby ameliorate the condition of the patient. This paper elaborates the fructuous effects of AI and pathophysiological aspects in ADHD and autism including risk factors, predisposing factors, embryological changes, neuroanatomical features, and neurohistological features [18].

5.1Risk Factors

The history of the marriages and relationships among parents puts great effects and risks in the offspring to develop ADHD or Autism. Recent studies have revealed that inbred consanguineous marriages may be at more risk of giving genetic disorders to children, including neurodevelopmental disorders such as ADHD and Autism. The genes in such marriages become widely spread, thus a high probability of recessive genetic disorders to be manifested in its offspring [19, 20, 21].

In addition, parental age at conception, pregnancy-related maternal health, and socio-economic factors also plays a crucial role. Advanced paternal age has long been understood to be one of the risk factors for Autism, a condition most likely arising from genetic mutations among spermatozoa. Similarly, maternal stress, nutrition, and exposure to environmental toxins during pregnancy are important factors that can predispose children to these disorders [19].

5.2 Predisposing Factors

A. Genetic Ingredients

This means that ADHD and Autism are both highly genetic. Most of the studies have identified several genes that are related to these conditions. In the case of ADHD, some of the genes that have been found to relate to include the gene involved in the regulation of dopamine such as DAT1, DRD4, and DRD5. These genes are part of the dopaminergic that constitutes an important system for use in attention regulating and the executive system [19].

In contrast, Genetic Architecture stretches over more than 100 genes that have been associated with Autism. Many are involved in the normal functioning of synapses, development of neurons, and communication between different brain cells. The key genes include, but are not limited to, SHANK3, NRXN1, and CHD8. Disruptive synaptic connectivity and altered communication of neurons might be the cause of behavioral and cognitive characteristics in people with Autism, mainly due to genetic mutations in these important genes [20].

B. Radiation Exposure and Targeting of CNS by Heavy Metals

Environmental factors, mostly in the form of radiation and heavy metals, are of great importance to the pathophysiology of ADHD and Autism. Radiation exposure during gestation may be contributory to fetal abnormalities in development. Ionizing radiation is quite dangerous as it could have implications for DNA impairment, probably causing mutations and changes in normal cellular functioning [22].

Heavy metals, particularly lead, mercury, and cadmium, are established neurotoxins and can exert negative effects on CNS functions. Specifically, lead exposure is related to the loss of cognitive capacities and behavioral alterations. The metal can suppress the release of neurotransmitters and functionality of the blood-brain barrier, leading to neuroinflammation and neuronal injury. Mercury exposure, especially from fish and, to a lesser extent, air pollution sources, affects the division and migration of neuronal cells, which are important processes in normal brain development. The exposure of Cd evokes oxidative stress and apoptosis in neuronal cells [23].

5.3 Embrological Changes

Brain development takes place early in embryogenesis and goes on later into early life. Events during embryonic development include cell birth, migration, differentiation, and death. It is an alteration of these processes that later results in neurodevelopmental disorders [24].

The embryological changes in ADHD include an alteration in the timing of neural tube closure, which is associated with structural brain abnormalities: Further disturbances in the proliferation and migration of neuronal precursor cells result in abnormal cortical development [24].

In Autism, this is excessive and involves too many stages of development of the brain. In fact, early disturbances in neuronal development result in atypical brain size and connectivity. Generally, it has been demonstrated that increased head size or head circumference at birth suggests abnormal growth or development of the brain; thus, children with autism normally exhibit this characteristic. The equally important development in Autism is abnormalities of synaptogenesis and pruning in early childhood [25].

5.4 Neuroanatomical Features

Comparative neuroanatomical studies have revealed remarkable structural differences in the comparison of the individuals suffering from ADHD or Autism with the neurotypical. For instance, ADHD has been demonstrated with a decrease in the thickness of the cortex in the prefrontal lobes, which are responsible for executive functions and attention; this decrease is believed to cause the co-existing difficulties in attention regulation and impulse control. More recent studies have provided such evidence of changes in the gyri and sulci of the brain, a conclusion that the normal development of the cortex has been disrupted [26].

Reduced blood flow, or hypoperfusion, to specific sections of the brain is also yet another hallmark of ADHD. Neuroimaging studies using fMRI have shown decreased blood flow to the prefrontal cortex and basal ganglia, regions important for both restraining actions and optimal attention regulation [27].

In the case of Autism, the differences are more pronounced in terms of neuroanatomy in general. Increased brain volume and surface area, particularly in the frontal and temporal lobe, are the most typical. Such enlargement is generally the result of abnormal neuronal proliferation with reduced synaptic pruning in early development. Additionally, the thickness of the cortex is also variable in people with Autism: there are studies reporting increased cortical thickness in few regions, while in some other areas, there is a reduced thickness [27].

Autism demonstrates abnormal height of gyri and depth of sulci. Cases have even been reported with increased gyrification that is taken as a sign of excess neuronal proliferation and migration. Such structural abnormalities in the brain hence form the underlying cause of the social and cognitive deficits in autism.

Hypoperfusion in autism is noted in regions of the brain associated with the temporal lobes, which are critical in processing, among others, language and social matters. Reduced blood flow in these areas may contribute to the communication and social interaction difficulties characteristic of autism [27].

Neurohistological Features

Neurohistological works provide data on the microscopic structure of brain tissue and the cellular and molecular abnormalities accompanying ADHD and Autism. Histological studies, too, have shown abnormalities in the dopaminergic system and spaces of reduced density of the dopamine transporter and altered expression of dopamine receptors, which further added to support the role of dopamine in attention and executive function in ADHD. In fact, reduced synaptic density has also been seen in the prefrontal cortex and basal ganglia, indicative of impaired synaptic connectivity [28].

Several important abnormalities in neurohistology have been identified with respect to Autism. One of the most predominant findings of these studies is that there are many more minicolumns in the cortex in Autism. Minicolumns are defined as the fundamental building blocks of the cortex, which are vertical arrays of neurons. With such an increase in minicolumnar number or density with the cortex, abnormal synaptic connectivity and processing of information are associated back [29].

Evidence for neuroinflammation as another major neurohistological feature of Autism has been derived from neuropathological findings of up-regulated expression levels of proinflammatory cytokines and activated microglia in individuals diagnosed with Autism. This underpins the neuronal damage and influences abnormal brain development that are causal to the pathophysiology of Autism [29].

In addition, abnormalities in synaptic structure and function have been implicated in autism. Mutations in autistic individuals are mainly in synaptic proteins, including neuroligins and neurexins, which are involved in the formation and maintenance of synaptic contacts. Among others, these mutations can result in defective synaptic transmission and connectivity in the underlying cognitive and behavioral deficits seen in autism [29].

6. Clinical Features

6.1 Clinical Features of ADHD

ADHD diagnoses, driven by concerns about academic performance and behavioural issues, have surged, especially among school-aged children diagnosed by various healthcare professionals following guidelines from organizations like the AAP and APA, although adherence is inconsistent. DSM-5 criteria necessitate developmentally inappropriate behaviour before age 12, persisting for six months, seen in multiple settings, causing significant impairments, and not secondary to another disorder, with presentations as predominantly inattentive, hyperactive-impulsive, or combined. Preschool diagnosis is challenging due to developmental norms. Clinical evaluation involves history, behaviour rating scales, physical exam, and family input, with no definitive laboratory tests, while objective measures aid assessment, though observations may differ [30]. In a cross-sectional study, data from 1,184 Iranian children and adolescents with ADHD were gathered during 2010-2015, using convenience sampling and DSM-IV criteria, validated with a Persian version of the checklist, and analyzed via SPSS software, with ethics approval and informed consent [31].

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 8, 2025
https://theaspd.com/index.php

Figure 6: Features of ADHD

ADHD is commonly diagnosed during elementary school years, with symptoms persisting into adolescence and adulthood, impacting various domains of functioning. Boys are diagnosed more frequently than girls, with prevalence rates in males about twice that in females. While racial/ethnic differences in ADHD prevalence may not exist, disparities in clinical identification and cultural attitudes towards diagnosis and treatment could affect nonwhite children [30]. A study of Iranian children and adolescents with ADHD revealed inattention as the primary reason for clinic referrals, with no gender differences in inattentive symptoms and consistent attention deficits across age groups. However, some hyperactivity-impulsivity symptoms were age-related, suggesting tailored screening questions were needed. Biological differences were noted between boys and girls, with specific symptoms more common in each gender. These findings highlight the importance of gender-specific approaches in ADHD diagnosis and management, especially in clinical settings [31].

ADHD is frequently associated with several other psychiatric disorders, complicating diagnosis, and treatment. Research indicates that 15 to 25 per cent of children with ADHD also have learning disabilities, while 30 to 35 per cent have language disorders. Mood disorders are diagnosed in 5 to 20 per cent, and anxiety disorders in 20 to 33 per cent of children with ADHD. Co-occurring sleep disorders, memory impairments, and decreased motor skills are also common. Oppositional defiant disorder (ODD) co-occurs in approximately 50 per cent of children with ADHD and conduct disorder (CD) is seen in 7 to 20 per cent of cases. A meta-analysis from the National Research Council and Institute of Medicine showed significant odds ratios for ADHD co-occurring with ODD (OR > 10), CD (OR > 10), depression (OR > 5), and anxiety disorders (OR > 2). These comorbid conditions often exacerbate functional impairments and may require tailored interventions to address the complex needs of individuals with ADHD [30].

The relationship between ADHD symptoms and functional impairments varies widely. About 30% of children with ADHD experience symptoms without significant impairments, while others face challenges, particularly those with co-occurring disorders. Externalizing symptoms are associated with severe impairments. Common impairments include speech, language, motor skills, and social development delays, contributing to academic difficulties and learning disabilities. Youth with ADHD often struggle with irritability, low frustration tolerance, and dysregulation impacting social relationships and activities. Impulsivity, a core symptom, is linked to risky behaviours like poor driving, substance abuse, and early pregnancies. Executive functioning deficits, particularly in working memory and reaction time variability, contribute to academic and social challenges [30].

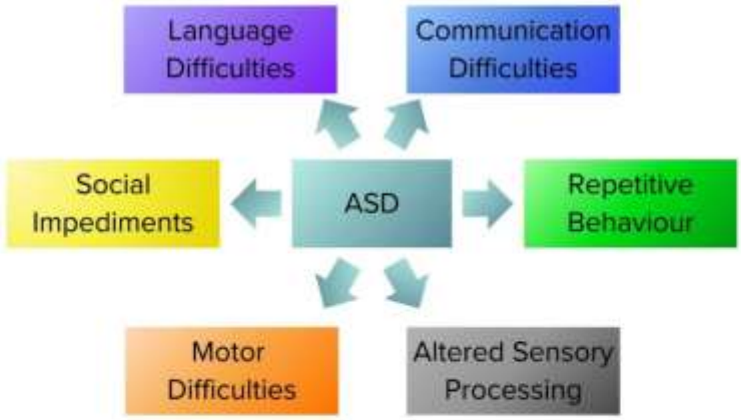

Figure 7: Features of ASD

6.2 Clinical Features of Autism

ASD, officially recognized in the DSM-III in 1980 and redefined in the DSM-5 in 2013, encompasses a spectrum of symptoms without subcategories like autistic disorder or Asperger syndrome. DSM-5 criteria require persistent impairments in social communication and interactions, along with restricted or repetitive behaviours, starting in early childhood and causing significant functional impairments not better explained by intellectual disability. Diagnosis is typically made by age 3, although median ages in the US exceed five years due to barriers like long wait times and socioeconomic disparities [32]. Assessment includes behavioural observations, parental interviews, and cognitive and physical exams, with genetic testing sometimes indicated. Early screening is crucial, yet some cases may be missed initially. Genetic factors play a role, with associations noted in conditions like fragile X and tuberous sclerosis [33].

ASD typically manifests around age 3, with social-communication difficulties often noticeable earlier but characteristic behaviours emerging more clearly by this age. Early intervention and increased public awareness have led to earlier identification. By school age, children with ASD become more socially aware, though behavioural challenges may increase, and adolescents show variable outcomes—some make gains, others regress. Access to treatment and earlier detection have improved outcomes, with more adults achieving independence, attending college, and becoming employed. ASD is more prevalent in males than females, with disparities by socioeconomic factors and race/ethnicity [32].

Comorbidities are complex, particularly in those without spoken language, with ASD associated with increased risks of intellectual disability and epilepsy. School-age children often experience attentional difficulties, irritability, and mood disorders, with younger children at higher risk of injuries and bullying. Functional skills are consistently impaired, hindering self-sufficiency and requiring intervention in social skills, communication, and daily living. The severity of impairment varies, with changes over age, and terms like "high functioning" or "low functioning" do not always correlate with cognitive abilities [29]. Diagnosis involves comprehensive evaluation by experts and disorder-specific screening, with genetic testing limited to single-gene conditions. Early intervention and evidence-based treatments aim to minimize disruption and enhance adaptive functioning throughout life [32].

ASD is a set of neurodevelopmental disorders among the most severe in terms of prevalence, morbidity, and societal impact. Characterized by a complex behavioural phenotype and deficits in both social and cognitive functions, the exact cause of ASD is still not fully known, but genetic and environmental factors play crucial roles. Environmental factors likely interact with genetic profiles, causing aberrant changes in brain growth, neuronal development, and functional connectivity. Despite enhanced clinical tests and diagnostic tools, early detection of ASD remains challenging. Research indicates the involvement of endogenous biomarkers in ASD pathophysiology, affecting brain connectivity, mirror neurons, and the inhibition-excitation balance. This review integrates evidence on the pathophysiology of ASD, highlighting key diagnostic markers and differentiating symptoms from other developmental disorders [33].

7. Diagnosis & Treatment of ADHD and Autism

7.1 Diagnosis of ADHD

A thorough assessent by a medical professional, which includes a review of symptoms, a medical history, and behavior assessments, is usually required to diagnose ADHD. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) lists symptoms including impulsivity, hyperactivity, and inattention as part of the criteria for diagnosing ADHD. The diagnosis may be supported by the use of extra instruments such rating scales, parent and teacher interviews, and behavioral observations [36].

7.2 Diagnosis of Autism

A multidisciplinary method is used to diagnose autism, which includes behavioral assessments, genetic testing, and developmental screenings. The DSM-5 diagnostic criteria for autism includes restricted and repetitive activities in addition to core symptoms such as impairments in social communication and interaction. Two frequently used instruments to help with the diagnosis process are ADOS and ADI-R. Autism Diagnostic Observation Schedule (ADOS) includes activities to observe social interactions, social skills, and repetitive behaviors and Autism Diagnostic Interview-Revised (ADI-R) includes series of questions about the individual's developmental history, social interactions, social skills, and repetitive behaviors [37].

7.3 Treatment for ADHD

A mix of behavioral therapy, medication, and educational initiatives is frequently used in the treatment of ADHD. Methylphenidate and amphetamine salts are two stimulant drugs that are frequently administered to treat symptoms of hyperactivity and inattention. For people with ADHD, behavioral interventions including parent education and classroom modifications can also be helpful in enhancing their behavior and academic achievement [38].

7.4 Treatment for Autism

Training in social skills, speech therapy, occupational therapy, and behavioral therapies are the mainstays of treatment for autism. A popular behavioral therapy that aids in the development of new abilities and the reduction of problematic behaviors in people with autism is applied behavior analysis (ABA). For people with autism, medications may be recommended to treat symptoms like anxiety, anger, or hyperactivity. There are some similarities between ADHD and Autism as both require tailored care and early intervention, with behavioral therapies playing a critical role in both disorders. However, ADHD and Autism are separate conditions with different diagnostic criteria and treatment approaches. Healthcare professionals can better tailor treatment plans to meet the unique needs of individuals with ADHD and Autism by understanding the similarities in their diagnostic criteria and effects on social interactions and communication skills [39].

8. Rehabilitation using AI

Artificial Intelligence (AI) has shown huge effect in enhancing the lives of individuals with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD). For ASD, AI aids in early diagnosis through machine learning algorithms and deep learning have helped clinicians and parents to detect the disorders early for the best treatment. AI also facilitates social skills training using virtual reality and improves speech and language therapy through real-time feedback and customized exercises. For ADHD, AI assists in accurate diagnosis and monitoring by analyzing behavioral patterns and utilizing wearable devices. It supports personalized treatment plans with adaptive learning tools and cognitive training programs and aids in medication management by adjusting dosages in real-time. It also offers patients predictive analytics for proactive behavioural interventions and virtual coaches for real-time symptom management. The overall benefits of AI in these areas include increased accessibility, cost-effectiveness, and personalised care. Thus, AI offers promising advancements in the diagnosis, treatment, and management of ASD and ADHD, making interventions more effective and while maintaining the essential human element in care [40].

8.1. Detection tools

Artificial intelligence (AI) has emerged as a powerful tool in the field of medicine, offering innovative solutions for complex diagnostic challenges. It helps to obtain precise valuable insights from diverse sources of information, including neuroimaging scans, genetic data, and behavioral assessments [41].

Both ADHD and ASD are currently diagnosed primarily through clinical evaluations performed by specialists such as psychiatrists and pediatricians. These evaluations help them to find whether an individual meets the criteria outlined in the DSM-5(Diagnotic and Statistical Manual of Mental disorder, 5th Edition), which includes having five or more symptoms related to the disorders. These assessments last for at least an hour making it time consuming for the diagnosis. To handle these challenges, there is a high demand to incorporate AI technology into the diagnosis of ADHD and ASD to improve efficiency and accessibility [42, 43]. AI systems can integrate multimodal data from brain imaging, genetic information, and behavioral assessments to provide a comprehensive risk evaluation, facilitating early and targeted interventions. This integration of AI in healthcare streamlines the diagnostic process and ensures timely, precise support for individuals with ASD and ADHD, enhancing their developmental outcomes and quality of life [43].

8.1.1 Machine learning and deep learning

Machine learning (ML) and deep learning (DL) are parts of artificial intelligence (AI) that can help to learn data by computers. ML world by using statistics to find patterns in labeled data, while DL uses neural networks to automatically learn patterns from raw data. ML needs humans to choose which features to look at and adjust the settings, while DL can figure it out on its own. ML works well with organized data and smaller sets, while DL is great with unorganized data and big sets. So, the choice between ML and DL depends on the availability of data [44].

8.1.2 sMRI and fMRI

Brain characteristics of ADHD and ASD patients can be detected using functional magnetic resonance imaging (fMRI) and structural magnetic resonance imaging (sMRI). They are mostly used in combination to study the neural correlates of brain disorders and cognitive processes. sMRI is used to investigate the structure and morphology of the brain, the developmental trajectories, which are then linked to functional deficits using fMRI data. On the other hand, fMRI is well-suited for examining brain activity and function, mapping the neural correlates of cognitive and behavioral processes, and finding atypical patterns in brain activation and functional connectivity in various neurological and psychiatric disorders. The integration of sMRI and fMRI data helps in understanding the complex relationships between brain structure, function, and behavior, enabling researchers to gain deeper insights into the neural mechanisms underlying both normal and pathological brain processes [45, 46, 47, 48].

8.1.3 Natural Processing Languages (NLP)

Natural Language Processing is a branch of computer science to ease the interactions between computers and human languages. It involves studying how people use and understand language to create tools and techniques that enable computers to understand natural languages. One application of NLP is chatbots, which can help clinicians save time and keep patient records. NLP allows users to receive feedback in the form of written questions or answers that resemble human responses. Each user input is saved and compared with others to create a basis for diagnosing symptoms. The phrases and sentences used by patients are then analyzed to figure out the severity of their symptoms [49].

8.1.4 Mobile Applications

Artificial Intelligence (AI) and mobile applications are playing significant role in detecting autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD). These technologies can provide early diagnosis, helps with ongoing monitoring, and personalized interventions, enhancing the overall management of thes conditions. Kanne, Carpenter, and Warre introduced a new evaluation tool, a mobile application named Cognoa, designed to assess autism risk in both general and high-risk populations, covering ages 18 months to 5 years. In the initial phase, parents complete a 15-question multiple-choice survey, modeled after the Autism Diagnostic Interview-Revised. A machine learning algorithm analyzes the responses and categorizes the risk into four levels: low, moderate-not autism, moderate, and elevated. In the second phase, parents record up to 4-to-1–2-minute videos of their child's daily activities. These videos are then rated by analysts using another algorithm that produces the same four risk categories. The tool quantifies autism severity and translates it into categorical risk levels such as "low" or "increased" [49].

Similarly, Mamun et al. introduced the Smart Autism application, which follows three stages: screening, virtual assessment, and actual assessment. This app inputs a child's details, selects an appropriate detection method based on age, and presents interactive questionnaires with images, animations, and videos. After analyzing the responses, if the results are positive, the app records the child's reactions to a rating video. Experts then review the video, and if needed, refer the child to specialized centers for a formal autism diagnosis [49].

In conclusion, the use of artificial intelligence (AI) techniques for the detection of autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD) holds promise for advancing diagnostic capabilities and improving patient outcomes. It can also help clinicians to develop predictive models that aid in early detection, personalized treatment for individuals with ASD and ADHD. AI-based approaches will help to find out more effective diagnostic and therapeutic strategies in the future [40].

8.2 VR AND VSR

Sensory processing difficulties can negatively impact the wellbeing of adults with disabilities. Researchers have explored a range of interventions to address these sensory challenges. One promising approach is the use of virtual reality (VR) and VSR technology to provide sensory interventions. Several research shows that children with autism spectrum disorder (ASD) or attention-deficit/hyperactivity disorder (ADHD) tend to enjoy using computers and technology. These children have made good progress in learning through different technology-based training programs. This includes things like educational cartoons, videos that model behaviors, computer-based lessons, interactive computer games, and virtual world environments. The interactive and immersive nature of these technology-based tools seems to work well for helping children with ASD or ADHD learn and develop new skills [41, 42].

Several virtual reality (VR) applications have been effectively implemented for assessment and intervention of ASD and ADHD as recorded in the literature such as:

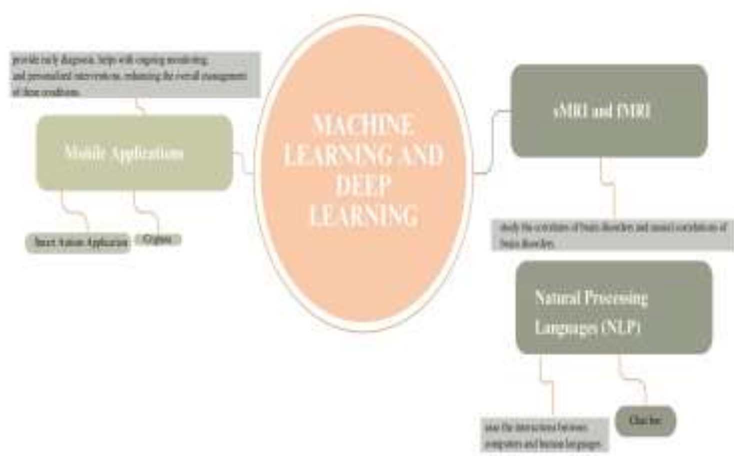

Figure 8: Types of Machine learning and its main effect to detect ASD and ADHD

8.2.1 Classroom- CPT

Classroom-CPT which is a VR-based version of the Continuous Performance Test (CPT), the participant is immersed in a virtual classroom setting and are asked to respond to certain target stimuli (e.g. letters, numbers). This allows clinicians and researchers to evaluate the individual's ability to maintain focus, selectively attend to relevant information, and inhibit inappropriate responses in a simulated classroom environment. This provides a more ecologically valid assessment of attention and inhibition compared to traditional paper-and-pencil CPT tests, as it recreates distractions and demands present in a real classroom setting. This can be especially useful in attention deficits children and adolescents with conditions like ASD and ADHD [43].

8.2.2 VRESS

The VRESS system is another type of VR which helps individuals with ASD find the context, understand the obstacles, and improve their social skills through simulated social interactions within the virtual environment. It helps individuals with social scenarios like the usual common adult activities in daily life, such as renewing a gym membership, buying movie tickets, browsing, and buying a smartphone, attending a seminar class, and taking part in a job interview. These social stories approach provides individuals with autism spectrum disorder (ASD) with a visual representation and description of the social situation, preparing them for what to expect and the underlying reasons behind the events. This allows individuals with ASD to better understand the complexity of interpersonal communication and apply them more appropriately and effectively. For individuals with ASD, the VRESS system provides a controlled and safe environment where they can practice social interactions and learn strategies for more effective communication. The ability to repeatedly take part in realistic social scenarios, receive personalized feedback, and gradually increase the complexity of the situations allows users to build confidence and develop essential social skills. This approach aligns with the cognitive-behavioral framework, which aims to help individuals recognize and modify maladaptive thought patterns and behaviors [44].

In conclusion, VSR and the broader application of VR technology in the field of neurodevelopmental disorders represent an exciting method for enhancing the lives of individuals with ASD and ADHD. By creating immersive, customizable, and evidence-based interventions, VR-based approaches hold the potential to empower these individuals, improve their social and cognitive functioning, and ultimately enhance their overall quality of life [45].

8.3Robotics

Robotics offers unique opportunities for supporting individuals with ADHD and autism spectrum disorder (ASD) by providing interactive and customizable interventions tailored to their specific needs. Robots are seen to be promising tools to support people with disabilities. Research has seen a growing interest in integrating social robots into clinical practice aimed at the care of people with neurodevelopmental disorders [46,47]. In a study, authors reported the behaviors of ASD individual towards social robots and suggested that these robots could be an effective attractor and a promising application for reduction of repetitive and stereotyped behaviors [47]. In 2021, Saleh et al's comprehensive review on the use of social bots for ASD patients in the literature revealed that NAO robot was a common intervention aimed to improve learning skills [43]. Nao is one of the most employed devices for emotional and cognitive therapies in children with ASD. Recent studies using randomized controlled trials have demonstrated that robots can significantly enhance social communication and behavior in participants [48, 49, 50]. For instance, QTrobot has proven effective in long-term emotional training with children. Other robots, such as KASPAR, FACE (Facial Automaton for Conveying Emotions), and ZENO, have shown benefits in promoting social-emotional understanding and facial emotion recognition, aiding in the treatment of autism and ADHD. Despite these promising results, research on the effectiveness of these robots is still relatively limited, indicating a need for more extensive studies [51, 52]. A thorough review of larger studies has revealed that social robots can be valuable tools in clinical settings, enhancing behavioral and cognitive responses in children with ASD [45]. Additionally, evidence suggests that individuals with ASD often respond better to robots than to human trainers. This could be because robots lack the social biases and preferences inherent in humans, offering consistent and reliable interaction, which is particularly useful in therapy [53]. For example, robots can assist with tasks such as improving eye contact, encouraging self-initiated interactions, and teaching turn-taking. Different robots provide various types of stimuli, such as facial expressions and vocal tones, and research indicates that more complex interactions with robots are generally more effective than simpler ones. Thus, selecting the right robot to meet everyone's needs is crucial for successful therapy.

ROBOTS	EFFECTS
NAO Robot	Improve learning skills
OT Robot	Effective in long term emotional training with children
KASPAR, FACE, ZENO	Promotes social and emotional understanding and facial emotion recognition.

Table 1: Features of robots in helping ASD patients

In summary, robots offer a structured and engaging way for individuals with ASD to learn and interact, making them an asset in therapeutic settings. Future research should focus on developing robots with advanced capabilities. For social skills training, robots equipped with artificial intelligence and natural language processing can serve as interactive partners, engaging users in conversations and role-playing scenarios to enhance social skills in a supportive environment. Robots can also be programmed to recognize and respond to emotional cues, helping individuals with ADHD and ASD develop better emotion regulation skills. For instance, a robot might offer feedback or calming strategies when it detects signs of distress. Additionally, robotic assistants can help individuals with ADHD organize tasks, manage schedules, and remember important activities. They can use natural language understanding to interpret commands and preferences, making daily tasks more manageable. Robots can further provide sensory integration therapy by incorporating multi-sensory stimuli, such as lights, sounds, and tactile feedback, to engage users in activities that support sensory processing and integration skills [54]. They can also encourage physical activity in individuals with ADHD through interactive games and exercises, with robotic platforms equipped to track movements and progress. For individuals with ASD who have difficulty with verbal communication, robots can support communication and language development using augmentative and alternative communication (AAC) devices. These robots can facilitate nonverbal communication through gestures, symbols, or text-to-speech features. Additionally, robots can offer personalized feedback and reinforcement based on individual performance, adapting their interactions to enhance motivation and engagement in therapeutic activities.
While robotic interventions show great potential, they should be integrated into comprehensive therapeutic programs overseen by trained professionals. Ethical considerations regarding privacy, autonomy, and human-robot interactions must also be carefully managed to ensure the responsible and effective use of robotics in ADHD and autism treatment.

9. Future Directions

AI in future will significantly improve the the efficiency of healthcare and save time for clinicians with the help of AI to ease their work without replacing their roles. It will advance patient care, personalize treatments by identifying the individual thresholds for intervention. AI will also play a strong role in preventive medicine: which is challenging to manage manually due to its vast volume of data. AI will bring specialist diagnostic support and reduce referral waiting times and provide rapid diagnostic support [55]. These challenges can be improved, but it will take enough more time to resolve them. However, balancing technological advancement with keeping the human element in medicine is crucial to overcome public resistance to AI in healthcare in this developing world.

10. CONCLUSION

AI is altering the management of Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) by providing better diagnostic, therapeutic, and rehabilitation tools and technologies. Machine-analyzing algorithms detect symptoms early by analyzing behavioural and cognitive data, allowing prompt therapies. AI-powered virtual reality settings and robotic-assisted therapy in ASD provide immersive experiences that help with social skills, communication, and motor abilities. Through real-time medication management, adaptive learning tools, and continuous monitoring with wearables, artificial intelligence (AI) plays a crucial role in providing precise diagnosis and individualized treatment strategies for ADHD, ensuring the accuracy and effectiveness of AI in healthcare.

Despite tremendous development, several ethical difficulties remain, including data privacy, algorithmic transparency, and equal access to AI technology. Addressing these problems is critical to ensuring equitable deployment across varied populations. Integrating AI into clinical settings should complement, not replace, the functions of healthcare professionals, ensuring a balance between technical innovation and human control. AI has the potential to drive additional improvements in neuroimaging, customized medication, and predictive analytics, therefore enhancing treatment quality and outcomes for people with ASD and ADHD while promoting equal access to these technologies.

REFERENCES

[1] Moreau, C., Deruelle, C., & Auzias, G. Machine Learning for Neurodevelopmental Disorders. In O. Colliot (Ed.), 2023, Machine Learning for Brain Disorders. (pp. 977–1007). Humana.
[2] Canals, J., Morales-Hidalgo, P., Voltas, N., & Hernández-Martínez, C. (2024). Prevalence of comorbidity of autism and ADHD and associated characteristics in school population: EPINED study. Autism Research, 17(6), 1276–1286.
[3] Iannone, A., & Giansanti, D. (2023). Breaking Barriers-The Intersection of AI and Assistive Technology in Autism Care: A Narrative Review. Journal of personalized medicine, 14(1), 41.
[4] Uddin, M., Wang, Y. & Woodbury-Smith, M. Artificial intelligence for precision medicine in neurodevelopmental disorders. npj Digit. Med. 2, 112 (2019).
[5] Salari N, Ghasemi H, Abdoli N, Rahmani A, Shiri MH, Hashemian AH, et al. The global prevalence of ADHD in children and adolescents: a systematic review and meta-analysis. Ital J Pediatr. 2023 Apr 20;49(1).
[6] Song P, Zha M, Yang Q, Zhang Y, Li X, Rudan I. The prevalence of adult attention-deficit hyperactivity disorder: A global systematic review and meta-analysis. J Glob Health. 2021 Feb 11;11(04009).
[7] Zeidan J, Fombonne E, Scorah J, Ibrahim A, Durkin MS, Saxena S, et al. Global prevalence of autism: A systematic review update. Autism Res. 2022;15(5):778-90.
[8] Maenner MJ. Prevalence and characteristics of autism spectrum disorder among children aged 8 years — Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2020. MMWR Surveill Summ. 2023 Mar 24;72(2). Available from: https://www.cdc.gov/mmwr/volumes/72/ss/ss7202a1.htm
[9] AlSagob M, Colak D, Kaya N. Genetics of autism spectrum disorder: an update on copy number variations leading to autism in the next generation sequencing era. Discov Ment. 2015 May 1;19(106):367-79. Available from: https://pubmed.ncbi.nlm.nih.gov/26105700/
[10]Puddu G, Rothhammer P, Carrasco X, Aboitiz F, Rothhammer F. Déficit atencional con hiperactividad: trastorno multicausal de la conducta, con heredabilidad y comorbilidad genética moderadas. Rev Méd Chile. 2017 Mar;145(3):368-72. Available from: https://scielo.conicyt.cl/scielo.php?pid=S0034-98872017000300011&script=sci_arttext&tlng=e
[11]Ma SL, Chen LH, Lee CC, Lai KYC, Hung SF, Tang CP, et al. Genetic overlap between attention deficit/hyperactivity disorder and autism spectrum disorder in SHANK2 gene. Front Neurosci. 2021 Apr 27;15.
[12]Satterstrom FK, Walters RK, Singh T, Wigdor EM, Lescai F, Demontis D, et al. Autism spectrum disorder and attention deficit hyperactivity disorder have a similar burden of rare protein-truncating variants. Nat Neurosci. 2019 Nov 25;22(12):1961-5.
[13]Khalid U, Naeem M, Stasolla F, Syed M, Abbas M, Coronato A. Impact of AI-powered solutions in rehabilitation process: recent improvements and future trends. Int J Gen Med. 2024 Mar 1;17:943-69.
[14]Rahman MM. AI for ADHD: Opportunities and challenges. [Internet]. 2023 Apr 11;27(8):797-9.
[15]Bracho-Sanchez E. ADHD rates in kids have increased over the past 20 years, new study says [Internet]. ABC News; 2018. Available from: https://abcnews.go.com/Health/adhd-rates-kids-increased-past-20-years-study/story?id=57526368
[16]Bohnsack C. CDC releases new data on autism prevalence to 1 in 36 children in U.S., 1 in 36 in Ariz. [Internet]. Southwest Autism Research & Resource Center (SARRC). 2023. Available from: https://autismcenter.org/autismprevalence/
[17]Signalling pathways in autism spectrum disorder: mechanisms and therapeutic implications. [Internet]. Available from: https://www.researchgate.net/figure/Genetic-architecture-of-autism-spectrum-disorder-ASD-a-The-inheritance-patterns-of_fig1_361914216 [Accessed 29 May 2024]
[18]Dougnon G, Matsui H. Modelling Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperacticity Disorder (ADHD) Using Mice and Zebrafish. International Journal of Molecular Science. 2022 Jul 7;23(14):7550.
[19]Thapar A, Cooper M, Eyre O, Langley K. What have we learnt about the causes of ADHD? J Child Psychol Psychiatry. 2013 Jan;54(1):3-16.
[20]Geschwind DH. Genetics of autism spectrum disorders. Trends Cogn Sci. 2011 Sep;15(9):409-16.
[21]Ronald A, Hoekstra RA. Autism spectrum disorders and autistic traits: A decade of new twin studies. Am J Med Genet B Neuropsychiatr Genet. 2011 Mar;156(3):255-74.
[22]Rice D, Barone S. Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models. Environ Health Perspect. 2000 Aug;108(Suppl 3):511-33.
[23]Grandjean P, Landrigan PJ. Neurobehavioural effects of developmental toxicity. Lancet Neurol. 2014 Mar;13(3):330-8.

[24]Stiles J, Jernigan TL. The basics of brain development. Neuropsychol Rev. 2010 Dec;20(4):327-48.
[25]Courchesne E, Campbell K, Solso S. Brain growth across the life span in autism: age-specific changes in anatomical pathology. Brain Res. 2011 Apr 18;1380:138-45.
[26]Shaw P, Lerch J, Greenstein D, Sharp W, Clasen L, Evans A, et al. Longitudinal mapping of cortical thickness and clinical outcome in children and adolescents with attention-deficit/hyperactivity disorder. Arch Gen Psychiatry. 2006 May;63(5):540-9.
[27]Ecker C, Ginestet C, Feng Y, Johnston P, Lombardo MV, Lai MC, et al. Brain surface anatomy in adults with autism: the relationship between surface area, cortical thickness, and autistic symptoms. JAMA Psychiatry. 2013 Jan;70(1):59-70.
[28]Volkow ND, Wang GJ, Kollins SH, Wigal TL, Newcorn JH, Telang F, et al. Evaluating dopamine reward pathway in ADHD: clinical implications. JAMA. 2009 Sep 9;302(10):1084-91.
[29]Vargas DL, Nascimbene C, Krishnan C, Zimmerman AW, Pardo CA. Neuroglial activation and neuroinflammation in the brain of patients with autism. Ann Neurol. 2005 Jan;57(1):67-81.
[30]Boat TF, Wu JT, Disorders C to E the SSIDP for C with M, Populations B on the H of S, Board on Children Y, Medicine I of, et al. Clinical characteristics of attention deficit hyperactivity disorder [Internet]. National Academies Press (US); 2015. Available from:https://www.ncbi.nlm.nih.gov/books/NBK332879/
[31]Ghanizadeh A, Salehi A, Moeini SR. Clinical presentation of attention-deficit hyperactivity disorder symptoms in terms of gender and chronological age. Int J Community Based Nurs Midwifery. 2019 Jul;7(3):241-6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6614349/#:~:text=Symptoms%20such%20as%20inattention%2C%20hyperactivity
[32]Boat TF, Wu JT. Clinical characteristics of autism spectrum disorder [Internet]. National Academies Press (US); 2015. Available from: https://www.ncbi.nlm.nih.gov/books/NBK332891/
[33]Fakhoury M. Autistic spectrum disorders: A review of clinical features, theories and diagnosis. Int J Dev Neurosci. 2015 Jun;43:70-7.
[34]Background theory - Alleviate children's health issues through games and machine learning [Internet]. [cited 2024 May 29]. Available from: https://ppiconsulting.dev/thesis_book/chapter2/
[35]Cabral MDI, Liu S, Soares N. Attention-deficit/hyperactivity disorder: diagnostic criteria, epidemiology, risk factors and evaluation in youth. Translational Pediatrics. 2020;9(S1):S104–13.
[36]Okoye C, Obialo-Ibeawuchi CM, Obajeun OA, Sarwar S, Tawfik C, Waleed MS, et al. Early Diagnosis of Autism Spectrum Disorder: A Review and Analysis of the Risks and Benefits. Cureus [Internet]. 2023 Aug 9;15(8).
[37]Nazarova VA, Sokolov AV, Chubarev VN, Tarasov VV, Schiöth HB. Treatment of ADHD: Drugs, Psychological therapies, devices, Complementary and Alternative Methods as Well as the Trends in Clinical Trials. Frontiers in Pharmacology [Internet]. 2022 Nov 17;13(13).
[38]Soares EE, Bausback K, Beard CL, Higinbotham M, Bunge EL, Gengoux GW. Social Skills Training for Autism Spectrum Disorder: a Meta-analysis of In-person and Technological Interventions. Journal of Technology in Behavioral Science [Internet]. 2020 Nov 17;6(1):1–15.
[39]Helmy E, Elnakib A, Yaser ElNakieb, Khudri M, Abdelrahim M, Yousaf J, et al. Role of Artificial Intelligence for Autism Diagnosis Using DTI and fMRI: A Survey. Biomedicines [Internet]. 2023 Jun 29 [cited 2023 Aug 9];11(7):1858–8. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10376963/
[40]Wazid M, Das AK, Chamola V, Park Y. Uniting cyber security and machine learning: Advantages, challenges and future research. ICT Express. 2022 Apr;8(3):180-6.
[41]Loh HW, Ooi CP, Barua PD, Palmer EE, Molinari F, Acharya UR. Automated detection of ADHD: Current trends and future perspective. Comput Biol Med. 2022 Jul;146:105525. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0010482522003171
[42]Moridian P, Ghassemi N, Jafari M, Salloum-Asfar S, Sadeghi D, Khodatars M, et al. Automatic autism spectrum disorder detection using artificial intelligence methods with MRI neuroimaging: A review. Front Mol Neurosci. 2022 Oct 4;15:999605. Available from: https://arxiv.org/abs/2206.11233
[43]Kourtesis P, Kouklari EC, Roussos P, Mantas V, Papanikolaou K, Skaloumbakas C, et al. Virtual Reality Training of Social Skills in Adults with Autism Spectrum Disorder: An Examination of Acceptability, Usability, User Experience, Social Skills, and Executive Functions. Behavioral Sciences. 2023 Apr 17;13(4):336.
[44]Vagnetti, R., Di Nuovo, A., Mazza, M. et al. Social Robots: A Promising Tool to Support People with Autism. A Systematic Review of Recent Research and Critical Analysis from the Clinical Perspective. Rev J Autism Dev Disord (2024). https://doi.org/10.1007/s40489-024-00434-5
[45]Pennisi, P., Tonacci, A., Tartarisco, G., Billeci, L., Ruta, L., Gangemi, S., & Pioggia, G. (2016). Autism and social robotics: A systematic review. Autism research : official journal of the International Society for Autism Research, 9(2), 165–183. https://doi.org/10.1002/aur.1527
[46]Saleh, M. A., Hanapiah, F. A., & Hashim, H. (2021). Robot applications for autism: A comprehensive review. Disability and Rehabilitation: Assistive Technology, 16(6), 580–602.
[47]Marino F., Chilà P., Sfrazzetto S.T., Carrozza C., Crimi I., Failla C., Busà M., Bernava G., Tartarisco G., Vagni D., et al. Outcomes of a Robot-Assisted Social-Emotional Understanding Intervention for Young Children with Autism Spectrum Disorders. J. Autism Dev. Disord. 2020;50:1973–1987. doi: 10.1007/s10803-019-03953-x.

[48]van den Berk-Smeekens I., de Korte M.W., van Dongen-Boomsma M., Oosterling I.J., den Boer J.C., Barakova E.I., Lourens T., Glennon J.C., Staal W.G., Buitelaar J.K. Pivotal Response Treatment with and without robot-assistance for children with autism: A randomized controlled trial. Eur. Child. Adolesc. Psychiatry. 2021;9:79. doi: 10.1007/s00787-021-01804-8.

[49]Tleubayev B., Zhexenova Z., Zhakenova A., Sandygulova A. Robot-assisted therapy for children with ADHD and ASD: A pilot study; Proceedings of the 2019 2nd International Conference on Service Robotics Technologies, ICSRT; Beijing, China. 22—24 March 2019.

[50]Costa A., Kirsten L., Charpiot L., Steffgen G. Mental health benefits of a robot-mediated emotional ability training for children with autism: An exploratory study; Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN); Montreal, QC, Canada. 1 May 2019.

[51]Costa A.P., Charpiot L., Lera F.J., Ziafati P., Nazarikhorram A., van der Torre L., Steffgen G. More Attention and Less Repetitive and Stereotyped Behaviors using a Robot with Children with Autism; Proceedings of the 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN); Chicago, IL, USA. 5 March 2018.

[52]Kumazaki, H., Muramatsu, T., Yoshikawa, Y., Matsumoto, Y., Ishiguro, H., Kikuchi, M., Sumiyoshi, T., & Mimura, M. (2020). Optimal robot for intervention for individuals with autism spectrum disorders. Psychiatry and clinical neurosciences, 74(11), 581–586. https://doi.org/10.1111/pcn.13132

[53]Puglisi, A., Caprì, T., Pignolo, L., Gismondo, S., Chilà, P., Minutoli, R., Marino, F., Failla, C., Arnao, A. A., Tartarisco, G., Cerasa, A., & Pioggia, G. (2022). Social Humanoid Robots for Children with Autism Spectrum Disorders: A Review of Modalities, Indications, and Pitfalls. Children (Basel, Switzerland), 9(7), 953. https://doi.org/10.3390/children9070953

[54]uchman VH, Ahmed I, Mauthappu M. Artificial intelligence in medicine: current trends and future possibilities. Br J Gen Pract [Internet]. 2018;68(668); 143-4. Available from: https://doi.org/10.3399/bjgp18x695213

[55]Davenport T, Kolkata R. The potential for artificial intelligence in healthcare. Future Healthcare Journal. 2019 June 6 (2): 94-8.