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Review Article

Artificial intelligence in childhood attention-deficit/hyperactivity disorder: A review of diagnosis, treatment, and forensic dimensions

Vefa Abdurrahimova

İstanbul University – Cerrahpaşa, Institute of Forensic Medicine and Forensic Sciences, Department of Social Sciences, İstanbul, Türkiye

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that begins in childhood and, if left untreated, is associated with impulsivity and self-control issues, posing significant risks in terms of risky behavior and criminal tendencies. The aim of this study is to review research examining the role of artificial intelligence (AI) technologies in the diagnosis and treatment processes of ADHD in children. Accordingly, the research was conducted using a review methodology. The literature search was performed in databases such as Google Scholar, PubMed, Scopus, and Web of Science. The findings indicate that AI-based methods can achieve high accuracy rates, particularly in diagnostic processes, and enable a comprehensive analysis of behavioral, cognitive, and neurophysiological data. Additionally, it was determined that AI-supported intervention approaches—such as gamification, mobile health applications, and social robots—enhance children's motivation and facilitate their active participation in treatment processes. However, factors such as data privacy, ethical issues, explainability, and clinical integration were identified as significant barriers limiting the widespread adoption of these technologies. In conclusion, while AI technologies offer significant opportunities in the field of ADHD, more comprehensive, standardized, and multidisciplinary research is needed to ensure these technologies can be used effectively and safely in clinical practice.

Keywords: Artificial intelligence; attention-deficit/hyperactivity disorder; child; review

INTRODUCTION

Artificial intelligence (AI) is defined as systems capable of mimicking human cognitive processes to perform specific tasks and improve through experience [1]. Today, AI technologies have become an integral part of daily life, often without our realizing it [2]. These technologies are used in various fields, such as autonomous vehicles, smartphone applications, and smart home systems. They are also being effectively utilized in critical sectors, including finance, education, logistics, and particularly, healthcare [3]. In recent years, big data, increased computational power, and algorithmic advancements have enabled the more effective and widespread use of AI across different disciplines [4]. These developments are significantly contributing to the transformation of healthcare services into faster, more accessible, data-driven structures. Big data analytics, increased computational capacity, and advanced algorithmic approaches have significantly expanded the accuracy and scope of AI systems' applications. This transformation enables faster, more scalable, data-driven decision-making processes, especially in healthcare [5]. Consequently, a new healthcare paradigm is emerging that allows for more objective and systematic evaluations than traditional methods.

Using AI applications in healthcare provides significant benefits to processes such as diagnosis, treatment planning, and disease monitoring [6]. In particular, analyzing disease-related data with machine and deep learning techniques helps healthcare professionals make faster, more accurate decisions [7]. AI is a key tool in developing clinical decision support systems and

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Corresponding Author: Vefa Abdurrahimova, İstanbul University – Cerrahpaşa, Institute of Forensic Medicine and Forensic Sciences, Department of Social Sciences, İstanbul, Türkiye
Email: vefa.abdurrahimova@gmail.com

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interpreting complex medical data [8]. These technologies allow large datasets to be analyzed, reducing human error and facilitating the development of clinical decision support systems [9]. Additionally, data-driven approaches standardize diagnostic and treatment processes, reducing variability across clinical practices. These technologies reduce costs and increase the accessibility of healthcare services [10]. Furthermore, wearable technologies, remote patient monitoring, and virtual health applications allow specialists to monitor and evaluate individual data in real time [11]. Digital health applications offer significant advantages, particularly in managing chronic diseases and providing long-term patient follow-up [12]. The time-consuming and subjective nature of traditional clinical assessment processes has increased the need for more objective, data-driven approaches. This need is especially apparent in mental health, where diagnostic processes are complex and multifaceted [13]. AI is becoming increasingly important in the early diagnosis and monitoring of psychological disorders. The need for AI-based applications is particularly pronounced in mental health due to the complex nature of diagnostic and assessment processes. Consequently, AI-based approaches enhance opportunities for early intervention in mental health services and contribute to the development of individualized assessment processes [14].

Attentiondeficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder that typically emerges during childhood. It affects an individual's attention, impulse control, and behavioral regulation skills [15]. It can significantly impact academic performance, social relationships, and daily functioning [16]. Its effects are not limited to childhood, but may persist into adolescence and adulthood [17]. Because the diagnostic process relies heavily on subjective assessments, such as clinical observations and reports from parents and teachers, delays and inconsistencies in diagnosis may occasionally occur. These subjective assessments lead to variations in the diagnostic process dependent on the observer and make standardizing clinical decisions challenging [18]. The prevalence of ADHD, one of the most common neurodevelopmental disorders in childhood worldwide, is reported to range from approximately 3% to 7% [19]. This underscores the importance of early intervention. Given its high prevalence, an early and accurate ADHD diagnosis has significant implications at the individual and societal levels [20]. Without early diagnosis and intervention, ADHD can negatively impact an individual's academic, social, and psychological functioning throughout their lifetime [21]. Consequently, there is a growing need for more objective, reliable, and evidence-based methods to address the limitations of current diagnostic approaches.

ADHD that goes untreated during childhood is frequently associated not only with academic and social difficulties but also with an increased risk of behavioral problems such as impulsivity, poor self-control, and difficulty adhering to social norms [22]. These challenges can persist into adolescence and adulthood and may lead to behavioral disorders, substance use, and an increased likelihood of committing crimes or engaging in criminal behavior [23]. From a forensic perspective, ADHD is not merely viewed as a clinical condition but also as a potential risk factor that, if left untreated, may lead to antisocial and criminal behavior. Therefore, understanding the developmental course of ADHD is of critical importance for identifying at-risk individuals and implementing early intervention. Early diagnosis and appropriate treatment strategies can play a preventive role by reducing the likelihood of individuals becoming involved in criminal activities [24].

In recent years, advancements in AI technologies have led to the development of more objective, data-driven approaches for diagnosing and treating ADHD [25]. In particular, analyzing behavioral and neurophysiological data obtained from individuals using deep and machine learning algorithms has the potential to improve diagnostic accuracy [26]. AI models analyze ADHD-specific behavioral patterns, such as attention, impulsivity, and cognitive performance, to provide alternative or supplementary solutions to traditional assessment methods [27]. Deep learning methods, such as convolutional neural networks (CNNs), can extract meaningful insights from data to automatically identify features associated with the disorder. The joint analysis of imaging data and behavioral datasets, in particular, enables multidimensional assessment [28]. These technologies contribute significantly to early diagnosis and individualized treatment planning by supporting experts in their decision-making processes. Additionally, AI-based systems can monitor individuals' responses to treatment and enable dynamic updates to interventions [29]. However, research in this field is still in its early stages, and more research is needed to integrate these findings into clinical practice. Many current studies are limited by small sample sizes and have various limitations regarding the generalizability of the resulting models [30]. Furthermore, factors such as data privacy, ethical concerns, and clinical reliability limit the widespread adoption of AI-based applications [31]. Therefore, in order for AI-based approaches to be used safely and effectively in clinical settings, methodological standards must be developed and the number of long-term studies must increase.

This study aims to examine the use of AI in diagnosing and treating ADHD in children, and to highlight the opportunities and limitations of these technologies based on the current literature. While the use of AI applications in healthcare has been the subject of an increasing number of studies in recent years, there is a dearth of research addressing ADHD in a systematic, comprehensive, and comparative manner [25,32,33]. In this context, the present study aims to evaluate the feasibility of these technologies by reviewing the existing literature on the use of AI in healthcare, particularly in the context of ADHD. Through a review of the existing literature, this study aims to assess

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the potential contributions of AI-based approaches in the field of ADHD. In this context, the study also aims to highlight the importance of early diagnosis and intervention in ADHD, as well as the potential for preventing long-term behavioral and social consequences. By addressing ADHD from a multidisciplinary perspective, including its relationship with forensic sciences, this study demonstrates the broader impacts of effective and timely treatment approaches.

Method

Ethical Considerations

Ethics committee approval was not required because this study is a literature review based exclusively on previously published studies and did not involve human participants, animals, or identifiable personal data.

Research Design

This study was conducted as a narrative literature review in accordance with general principles of research synthesis [34]. Existing studies on the use of AI in the diagnosis, assessment, and treatment of childhood ADHD were reviewed and synthesized using a descriptive thematic approach. Common themes were identified to evaluate the applications, potential benefits, and limitations of AI-based methods.

Literature Review Process

As part of the study, relevant national and international literature was reviewed. Searches were conducted in Google Scholar, PubMed, Scopus, and Web of Science using combinations of the following terms: "attention-deficit/hyperactivity disorder," "childhood ADHD," "artificial intelligence," "machine learning," "deep learning," "diagnosis," "treatment," and "juvenile delinquency. Studies identified during the search were evaluated for direct relevance to the topic, and appropriate studies were selected for the research objective. The identified studies underwent preliminary evaluation based on their titles and abstracts, and those deemed suitable were then subjected to fulltext review. One of the primary inclusion criteria was that the studies directly linked AIbased methods (e.g., machine learning and deep learning algorithms) to ADHD diagnosis, assessment, or treatment processes. Furthermore, efforts were made to prioritize more recent publications to ensure access to uptodate information. Duplicate studies were excluded during the screening process.

Data Analysis

The studies were evaluated using descriptive analysis, a qualitative data analysis method [35]. Studies in the literature were reviewed to identify common themes, and classifications were made based on these themes [36]. The use of AI in the diagnosis and treatment of ADHD, along with its advantages and limitations, was examined comparatively. The findings were presented systematically and coherently, highlighting similar and distinct approaches in the literature.

Results

Diagnosing ADHD remains challenging because current assessment methods largely rely on behavioral observations and subjective evaluations. The heterogeneity of ADHD symptoms and overlap with other neurodevelopmental disorders further complicate the diagnostic process [37-40]. Therefore, recent studies have increasingly focused on AI-based approaches to support more objective, data-driven, and reliable assessment methods.

Significant advances in AI, particularly in machine and deep learning techniques, have enabled the identification of complex data patterns and are driving a transformation in the diagnostic process for ADHD. These technologies can analyze behavioral, cognitive, and neurophysiological data, providing more objective results than traditional assessment methods. Empirical studies demonstrate that AI-based models can achieve high levels of accuracy and reliability in diagnosing ADHD. For instance, hybrid models combining various machine learning algorithms (e.g., Random Forest, Temporal Convolutional Network, and Adaptive Control of ThoughtRational (ACTR)) have been reported to achieve accuracy rates exceeding 98%, particularly in electroencephalography (EEG) data analysis [41]. Similarly, studies employing support vector machines (SVMs) and deep learning–based classification methods achieved high accuracy rates in distinguishing between ADHD diagnoses and healthy individuals. These methods have been demonstrated to be effective in supporting clinical decisions [42]. Additionally, studies combining neuroimaging data, such as magnetic resonance imaging (MRI), with behavioral datasets have found that deep learning models can distinguish ADHD with success rates ranging from 70% to 90% [43]. These findings demonstrate that AI methods support the diagnostic process and enable a more comprehensive analysis of the multidimensional nature of disorder by integrating different types of data. However, the effectiveness of AI applications depends on the quality of the data used. Data heterogeneity, scarcity, and privacy pose significant challenges to the development and generalizability of these systems [44]. Indeed, many studies cite the limited sample size of datasets and the inadequacy of standardized data sharing as key factors limiting the generalizability of the resulting models to different populations [25,30,32]. Thus, creating large-scale, standardized datasets is critical for reliably and sustainably using AI-based diagnostic systems in clinical practice.

Traditional assessment tools used in the ADHD diagnostic process are evolving. When combined with AI-supported approaches, these tools offer more objective and multidimensional evaluations. Continuous performance tests have long been fundamental tools for measuring attention and impulse control. Integrating these tests into digital platforms and supporting them with AI algorithms allows for a more precise, measurable analysis of attention performance. Computer-based tests developed in this context, such as the MOXO distractor continuous performance test (MOXO d-CPT), can separately assess key

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components, including attention, timing, impulsivity, and hyperactivity, and provide measurements with greater ecological validity through distractors that simulate real-life scenarios [45]. Systems integrated with AI can automatically analyze performance data to support clinical decision-making processes. Additionally, ADHD diagnosis is increasingly incorporating neurophysiological and biometric data-based approaches. EEG, eye-tracking, and neuroimaging techniques, in particular, contribute to the objective assessment of attention processes and cognitive functions [46,47]. Findings obtained through eye-tracking technologies reveal differences in the attentional processes of children diagnosed with ADHD and show that their responses to visual stimuli differ significantly from those of healthy individuals [46,47]. Similarly, analyzing data from EEG and other neurophysiological measurements using AI algorithms yields high accuracy rates in the diagnostic process [37-39]. However, the clinical use of these technologies is limited by the need for specialized equipment, cost, and implementation challenges [48]. These limitations hinder the integration of these methods into routine clinical practice, underscoring the need for more accessible, cost-effective solutions.

AI-based approaches are being used more and more in the diagnostic process for ADHD, as well as in treatment and intervention processes. Social robots, gamification-based applications, and digital therapeutic systems, in particular, are emerging as innovative tools for developing children's attention, motivation, and social interaction skills. Studies indicate that AI-supported therapeutic applications increase children's engagement and motivation compared to traditional methods [49]. Interventions conducted via social robots allow children to interact with lower anxiety levels than with human therapists, positively impacting the therapeutic process [50]. Interactions with humanoid robots have been shown to facilitate the development of therapeutic relationships, especially with children who have difficulty with social communication, and to support learning processes. Additionally, cognitive training programs structured using gamification-based approaches have been reported to increase children's attention spans and improve task performance [49]. Supported by AI algorithms, these systems provide personalized interventions by offering content tailored to an individual's performance. Additionally, analyzing data collected during the therapeutic process through AI-based systems allows for monitoring of progress and dynamic intervention updates [51]. These systems make treatment processes more flexible, data-driven, and tailored to the individual. However, AI-based interventions have limitations. Notably, artificial systems' inability to replicate human traits such as empathy and emotional understanding is considered a significant disadvantage [52]. Additionally, the literature highlights potential negative effects, such as the risk of developing technology dependency with long-term use and the limitation of children's social interactions [43]. For this reason, it is emphasized that AI-based treatment approaches should not be used as a standalone alternative, but rather as a tool to support traditional therapeutic methods [52].

Discussion

This study examines the role of AI applications in diagnosing and treating ADHD. Findings suggest that AI-based approaches could offer more objective, data-driven, and highly accurate assessments, especially in the diagnostic process [7,9,13]. The challenges faced by individuals with ADHD are not only individual but also related to family, school, and social environments [15]. In this context, the findings suggest that AI applications can support individual assessment processes and the monitoring and management of environmental factors [11]. The literature frequently emphasizes that interventions implemented with family collaboration, school support, and early diagnosis yield positive outcomes. The results of this study suggest that AI-supported systems could facilitate earlier intervention by improving opportunities for early diagnosis [25,26]. Although medication-based treatments are effective for ADHD, there are various reservations about these treatments at the individual and societal levels [52]. At this point, the development of AI-based alternative and supportive intervention methods presents a significant opportunity for diversifying treatment approaches [29].

Another important consideration is the potential long-term significance of untreated ADHD from a forensic perspective. If ADHD symptoms such as impulsivity, poor behavioral inhibition, and emotional instability are not treated during childhood, they have the potential to lead to behavioral disorders, disciplinary problems at school, substance use, and an increased risk of criminal behavior during adolescence and adulthood [22]. From this perspective, ADHD should be considered not only as a neurodevelopmental disorder affecting academic and psychosocial functioning but also as a condition with potential implications for forensic sciences. Therefore, early diagnosis, ongoing monitoring, and effective intervention can play a significant preventive role in reducing individual and societal risks that may arise in the future.

Examining the role of AI-based applications in ADHD treatment reveals that interventions primarily using gamification, mobile health apps, and social robots positively impact attention, motivation, and behavioral regulation skills [6]. Literature indicates that game-based digital applications increase children's active participation in learning processes, yielding positive academic performance outcomes by extending attention spans [53]. Educational content delivered via tablets and mobile devices increases the motivation levels of children with ADHD, particularly when immediate feedback and reward mechanisms are employed. These results suggest that the interactive structure of AI-based systems aligns well with ADHD-specific cognitive characteristics [54]. Additionally, mobile health apps have been found to effectively monitor daily behaviors, collect parental feedback, and organize routines. For instance, MOBERO has been reported to strengthen parent-child interaction, improve sleep patterns, and structure daily routines [55]. Furthermore, it has been observed that therapeutic interventions conducted through

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social robots facilitate children's social interactions and encourage their participation in the therapeutic environment [43,50]. These AI-supported systems make treatment processes more flexible and effective by offering personalized interventions that can be adapted to each individual's performance [51]. Therefore, AI-based applications can be considered complementary to, rather than an alternative for, traditional ADHD treatment methods.

Despite the advantages of AI-based applications, there are various limitations and ethical debates surrounding these technologies. For example, AI systems are considered to have a significant disadvantage in that they can offer only a limited level of empathy and emotional understanding compared to human interaction, particularly in the field of mental health [52]. For a disorder with strong emotional and behavioral components, such as ADHD, the quality of the therapeutic relationship is very important. In this context, AI-based systems' inability to fully address children's emotional needs is a risk factor that could negatively impact their participation in the treatment process. Additionally, the literature highlights that prolonged, intensive use of AI applications can foster technology addiction in children. Reward mechanisms in gamification-based systems may lead children to become overly reliant on external motivation, weakening their internal motivation. Furthermore, the data-driven nature of AI systems raises concerns about data privacy and security [5]. Failing to ensure ethical standards when collecting, storing, and processing sensitive health data pertaining to children significantly limits the use of these technologies. Furthermore, the "black box" nature of many AI models makes interpreting the obtained results difficult and can lead to trust issues in clinical decision-making processes [8]. These issues underscore the need for transparency, explainability, and ethical oversight mechanisms to enable the widespread adoption of AI-based systems in clinical settings.

Due to the potential of AI-based approaches in the field of ADHD, future research should be conducted using larger samples and multicenter datasets [26]. Developing multidimensional models that integrate different types of data, such as behavioral, neurophysiological, and environmental data, could lead to a more comprehensive and precise assessment of ADHD. However, the limited sample sizes of many current studies restrict the generalizability of the findings [29]. Therefore, it is necessary to establish standardized data collection processes and increase international collaborations that support data sharing.

CONCLUSION

This study examined the role of AI technologies in diagnosing and treating ADHD in children using a narrative approach. The findings suggest that AI-based methods could offer more objective, rapid, and precise assessments, especially during the diagnostic phase. AI applications were found to provide a more comprehensive analysis of the multidimensional nature of ADHD due to their ability to integrate behavioral, cognitive, and neurophysiological data. Additionally, AI-supported intervention methods, such as gamification, mobile health applications, and social robots, were found to enhance children's motivation, facilitate their active participation in treatment processes, and provide personalized intervention options. However, the integration of AI-based approaches into clinical practice faces significant limitations, including data privacy concerns, ethical issues, lack of explainability, and long-term effects. For this reason, it is important to view AI applications as a tool that complements, rather than replaces, traditional clinical approaches. In addition, research findings emphasize that the timely diagnosis and treatment of ADHD may be of greater importance than simply managing symptoms. Indeed, early intervention can help prevent the long-term behavioral and social consequences associated with untreated ADHD. In this context, the integration of effective assessment and treatment strategies may also be considered significant from a forensic perspective, particularly in reducing the risk of future criminal behavior among at-risk children.

From a clinical practice perspective, integrating AI-based systems into diagnostic and treatment processes can enable faster and more accurate interventions by providing decision support to healthcare professionals. For this integration to be effective, however, clinicians must be trained in AI technologies, and these systems must be user-friendly, explainable, and reliable. Additionally, it is important to consider the ethical, legal, and social dimensions of AI applications to ensure that these technologies are used in a sustainable and safe manner. Future research focusing on technological performance, clinical efficacy, user experience, and long-term outcomes will help clarify the full potential of AI-based approaches in mental health. In conclusion, although AI technologies offer significant opportunities in the field of ADHD, multidisciplinary approaches, methodological standards, and more comprehensive research are needed to ensure their effective and safe use in clinical practice.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

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