Artificial intelligence-based early screening and behavioral intervention support system for children with ADHD and autism spectrum disorders

Navdeep Singh[1]*
*[1]*Principal, Indus College of Nursing, Khanda Kheri, Hansi, Haryana, India*

DOI: 10.5281/zenodo.21066509

Abstract:
Attention Deficit Hyperactivity Disorder (ADHD) and autism spectrum disorder (ASD) are among the most common neurodevelopmental disorders in children, often resulting in significant cognitive, behavioural, social, and educational challenges if not identified and managed early. Traditional diagnostic approaches rely on clinical observations, behavioural assessments, and caregiver reports, which may be subjective, time-consuming, and limited by the availability of specialized healthcare professionals. Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Internet of Things (IoT), wearable sensors, computer vision, and digital health technologies have created new opportunities for improving the early detection and management of these disorders. This review explores the application of AI-based early screening and behavioural intervention support systems for children with ADHD and ASD by examining current AI techniques, including machine learning algorithms, speech and facial recognition, eye-tracking technologies, wearable sensor integration, cloud computing, and clinical decision-support systems. The article further discusses the role of AI in personalized behavioural interventions, remote patient monitoring, and multidisciplinary care while addressing critical challenges related to data privacy, cybersecurity, algorithmic bias, ethical considerations, and explainable AI. The findings indicate that AI-assisted screening systems can significantly enhance diagnostic accuracy, reduce diagnostic delays, facilitate personalized treatment planning, and improve long-term developmental outcomes. However, successful implementation requires robust clinical validation, transparent algorithm design, strong regulatory oversight, and collaboration among healthcare professionals, researchers, engineers, and policymakers. Artificial Intelligence should therefore be considered a complementary clinical decision-support technology that enhances rather than replaces professional expertise in paediatric neurodevelopmental healthcare.

Keywords:
Artificial Intelligence, Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorder, Early Screening, Behavioural Intervention, Paediatric Healthcare, Wearable Sensors, Digital Health, Clinical Decision Support.

1. Introduction:
Neurodevelopmental disorders are among the most significant public health challenges affecting children worldwide. Among these disorders, attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) have received considerable attention due to their increasing prevalence, lifelong impact, and complex clinical manifestations. ADHD is characterized by persistent patterns of inattention, hyperactivity, and impulsivity, whereas ASD is primarily associated with impairments in social communication, restricted interests, and repetitive behaviours. Although these disorders differ clinically, they frequently coexist and share several genetic, neurological, and behavioural characteristics, making early diagnosis particularly challenging. Recent advances in artificial intelligence (AI), machine learning (ML), and digital health technologies have opened new possibilities for developing automated screening systems capable of identifying children at risk

during the earliest stages of development, thereby enabling timely intervention and improved long-term outcomes.

The prevalence of ADHD and ASD has increased steadily over the past two decades due to improved diagnostic awareness, expanded screening programs, and evolving diagnostic criteria. Current epidemiological evidence indicates that approximately one in every thirty-six children is diagnosed with ASD, while ADHD affects nearly five to seven percent of school-aged children worldwide. These disorders significantly influence cognitive development, educational achievement, emotional well-being, family functioning, and social participation. Delayed diagnosis often results in missed opportunities for early intervention, increasing the risk of academic failure, psychiatric comorbidities, behavioural disturbances, and reduced quality of life. Consequently, healthcare systems are increasingly emphasizing early detection strategies supported by advanced computational technologies capable of processing multidimensional developmental information.

Artificial intelligence has emerged as one of the most transformative technologies in modern healthcare. AI systems utilize computational algorithms capable of recognizing hidden patterns within large datasets, enabling automated prediction, classification, and decision support with remarkable accuracy. In paediatric neurodevelopment, AI models analyse behavioural observations, facial expressions, speech characteristics, eye-tracking patterns, motor activities, neuroimaging findings, electronic health records, wearable sensor data, and caregiver questionnaires to assist clinicians in identifying children at elevated risk for ADHD and ASD. Unlike traditional diagnostic approaches that rely heavily on subjective clinical observations, AI-based screening systems offer objective, scalable, and data-driven assessments capable of improving diagnostic consistency across diverse healthcare settings[1].

2. Background of ADHD and autism spectrum disorder:

Attention Deficit Hyperactivity Disorder is one of the most common childhood neurodevelopmental disorders affecting executive functioning, attention regulation, behavioural inhibition, and emotional control. Children with ADHD often experience difficulties maintaining concentration, following instructions, organizing tasks, controlling impulsive behaviours, and sustaining academic performance. Symptoms typically emerge before twelve years of age and frequently persist into adolescence and adulthood. The disorder is highly heterogeneous, with clinical presentations varying considerably across individuals depending on genetic susceptibility, environmental influences, cognitive functioning, and psychosocial factors.

Autism Spectrum Disorder encompasses a broad range of developmental conditions characterized by deficits in reciprocal social interaction, communication difficulties, repetitive behaviours, sensory processing abnormalities, and restricted interests. Clinical manifestations vary substantially across the autism spectrum, ranging from individuals requiring extensive daily support to highly independent adults with subtle social communication challenges. Because symptoms may appear gradually during infancy and early childhood, many affected children remain undiagnosed until preschool or school age, despite evidence suggesting that developmental abnormalities often emerge during the first two years of life[2].

3. Importance of Early Screening:

Early childhood represents a critical period of rapid brain development characterized by heightened neuroplasticity. During this developmental window, neural circuits responsible for language acquisition, executive functioning, emotional regulation, and social communication undergo extensive maturation. Interventions initiated during early childhood demonstrate substantially greater effectiveness than those introduced later because developing neural networks remain highly adaptable to environmental stimulation. Therefore, early screening constitutes one of the most effective strategies for improving long-term developmental outcomes among children with ADHD and ASD.

Traditional diagnostic procedures often involve lengthy clinical evaluations requiring multidisciplinary specialists, standardized behavioral assessments, caregiver interviews, developmental histories, and repeated observational sessions. These procedures may require several months or even years before a definitive diagnosis is established, particularly in resource-limited healthcare settings where pediatric neurologists, developmental pediatricians, and child psychologists are scarce. Such delays postpone intervention during the period when therapeutic effectiveness is greatest, emphasizing the need for scalable automated screening technologies capable of supporting frontline healthcare providers[3].

4. Evolution of artificial intelligence in pediatric healthcare:

Artificial intelligence has evolved rapidly over the past decade owing to advances in computational power, cloud computing, big data analytics, and deep learning algorithms. Initially developed for industrial automation and computer vision applications, AI has expanded into healthcare where it supports disease diagnosis, medical imaging interpretation, clinical decision support, personalized treatment planning, and remote patient monitoring. Pediatric healthcare has particularly benefited from AI because developmental disorders generate complex multidimensional datasets that exceed the analytical capacity of conventional statistical methods.

5. Rationale for an AI-based early screening and behavioral intervention support system:

Despite significant improvements in pediatric healthcare, early diagnosis of ADHD and ASD remains inconsistent across countries due to shortages of trained specialists, geographic disparities, lengthy waiting periods, socioeconomic inequalities, and limited access to developmental assessment services. Many children residing in rural or underserved communities receive diagnoses several years after symptom onset, substantially reducing opportunities for early intervention. Therefore, scalable, affordable, and accessible screening technologies are urgently needed to complement existing healthcare infrastructure.

An AI-based early screening and behavioral intervention support system addresses these challenges by combining automated behavioral analysis with intelligent clinical decision support. Such systems continuously collect developmental information from multiple digital sources, analyse behavioural patterns using machine learning algorithms, estimate individualized developmental risk scores, and provide evidence-based recommendations for clinicians, therapists, educators, and caregivers. Importantly, these technologies are designed to assist—not replace—clinical professionals, improving efficiency while maintaining expert oversight[4].

6. Artificial intelligence in healthcare:

Artificial Intelligence (AI) has emerged as one of the most influential technological innovations in modern healthcare. AI refers to computational systems capable of performing tasks that traditionally require human intelligence, including learning, reasoning, decision-making, pattern recognition, and problem-solving. In healthcare environments, AI technologies support disease diagnosis, risk prediction, treatment planning, patient monitoring, and healthcare resource management. The increasing availability of electronic health records, medical imaging data, genomic information, and real-time physiological monitoring has accelerated the adoption of AI across diverse clinical specialties. Within pediatric healthcare, AI offers unprecedented opportunities to improve the early detection and management of neurodevelopmental disorders such as ADHD and Autism Spectrum Disorder (ASD) by identifying subtle behavioral patterns that may not be immediately apparent to clinicians during routine evaluations.

Traditional clinical assessments depend heavily on direct observation, caregiver interviews, standardized questionnaires, and professional judgment. Although these methods remain essential components of diagnosis, they are often subject to variability arising from clinician experience, environmental conditions, and subjective interpretation. Artificial intelligence addresses these limitations by providing objective and reproducible analyses based on large-scale datasets. Through advanced computational techniques, AI systems can evaluate thousands of behavioral and physiological variables simultaneously, generating predictive insights that support evidence-based clinical decision-making. Such capabilities are particularly valuable in neurodevelopmental disorders where symptom presentation can be highly heterogeneous and evolve over time[5].

7. Eye-tracking technologies for early detection:

Eye-tracking technology has become an important tool in autism and ADHD research because visual attention patterns provide valuable insights into cognitive and social development. Eye-tracking systems measure gaze direction, fixation duration, pupil responses, and visual scanning behaviors while children interact with social and non-social stimuli.

Children with ASD frequently exhibit atypical gaze behaviour characterized by reduced attention to faces, diminished eye contact, and increased focus on objects rather than social cues. Eye-tracking studies have demonstrated that these differences can emerge during infancy, often before overt behavioral symptoms become clinically apparent. Consequently, AI-enhanced eye-tracking technologies offer promising opportunities for identifying autism risk at very early developmental stages.

Children with ADHD also demonstrate distinct attentional patterns detectable through eye-tracking assessments. Difficulties sustaining attention, increased distractibility, and frequent gaze shifts can be quantified objectively using computerized visual tasks. Machine learning models analyse eye-movement metrics to estimate attentional control and impulsivity, supporting more accurate screening and intervention planning[6].

8. Introduction to iot and wearable technologies:

The Internet of Things (IoT) refers to interconnected devices capable of collecting, transmitting, and analysing real-time information through digital networks. In healthcare settings, IoT technologies enable continuous monitoring of physiological, behavioral, and environmental parameters outside traditional clinical environments. Wearable sensors, smartwatches, activity trackers, biosensors, and mobile health applications generate valuable datasets that support AI-driven developmental assessment and intervention.

Wearable devices can monitor physical activity levels, sleep patterns, heart rate variability, movement behaviors, and physiological responses associated with ADHD and ASD. Because these measurements are collected continuously, wearable technologies provide a more comprehensive picture of everyday functioning than periodic clinical evaluations. AI algorithms analyse sensor data to identify behavioral patterns indicative of developmental concerns, symptom progression, or therapeutic response[7].

9. AI-based early screening framework:

The increasing prevalence of attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) has created an urgent need for intelligent screening systems capable of identifying developmental abnormalities at the earliest possible stage. Conventional screening methods primarily depend on clinical observation, behavioral questionnaires, developmental assessments, and caregiver interviews. Although these approaches remain indispensable, they are often time-consuming, subjective, and influenced by variations in professional expertise. Artificial Intelligence (AI) provides a complementary solution by integrating computational intelligence with clinical assessment to produce rapid, objective, and scalable developmental screening. AI-based early screening frameworks combine behavioral analytics, physiological monitoring, machine learning algorithms, and clinical decision support into a unified healthcare platform capable of continuously evaluating children's developmental progress.

An effective AI-based screening framework functions as a multilayered ecosystem rather than a single diagnostic tool. Data are continuously collected from multiple sources, including caregiver questionnaires, teacher observations, wearable sensors, smartphone applications, electronic health records, speech recordings, facial expression analysis, eye-tracking systems, and educational performance reports. These heterogeneous datasets are transmitted to cloud-based analytical platforms where machine learning algorithms identify behavioral patterns associated with ADHD and ASD. The resulting risk predictions are subsequently reviewed by healthcare professionals who determine whether comprehensive clinical evaluation or early intervention is warranted[7].

10. Architecture of the AI-based screening system:

The proposed Artificial Intelligence-Based Early Screening and Behavioral Intervention Support System consists of multiple interconnected components designed to facilitate continuous developmental monitoring, automated risk prediction, and personalized intervention planning. The overall architecture integrates data acquisition, secure communication, cloud computing, artificial intelligence analytics, clinical decision support, caregiver engagement, and long-term developmental monitoring into a unified digital healthcare ecosystem.

The first component is the data acquisition layer, which continuously collects developmental information from diverse sources. These include wearable biosensors measuring physiological activity, mobile applications documenting daily behaviors, teacher assessment forms evaluating classroom performance, caregiver questionnaires describing developmental milestones, electronic medical records containing clinical history, and multimedia recordings capturing speech, facial expressions, and social interactions. The diversity of these information sources improves prediction accuracy by providing a holistic understanding of each child's developmental profile.

The second layer involves secure communication through Internet of Things (IoT) technologies and encrypted cloud services. Sensor data generated by wearable devices and mobile applications are transmitted automatically to cloud servers using secure communication protocols. Cloud computing enables large-scale storage, high-speed processing, and centralized management of developmental datasets collected from multiple healthcare facilities. Moreover, cloud infrastructure facilitates collaboration among pediatricians, psychologists, speech therapists, occupational therapists, and educational professionals involved in the child's care[8].

11. Data collection module:

Accurate artificial intelligence models depend fundamentally on high-quality data. Consequently, the data collection module represents one of the most important components of the proposed screening system. This

module gathers structured and unstructured developmental information from multiple sources while ensuring standardized data formatting, quality control, and secure storage for subsequent machine learning analysis.
Clinical information collected during pediatric evaluations includes prenatal history, birth complications, developmental milestones, neurological examinations, previous diagnoses, medication history, family medical history, and standardized behavioral assessments. These structured clinical variables provide essential contextual information supporting AI-based prediction models. Electronic Health Records (EHRs) facilitate automated retrieval of such information while minimizing manual documentation burden for healthcare professionals[8].

12. Artificial intelligence analytics and risk prediction engine:

The AI analytics engine represents the computational core of the proposed system. Its primary function is to transform raw developmental information into clinically meaningful predictions using advanced machine learning and deep learning algorithms. Before analysis begins, collected datasets undergo preprocessing procedures including missing value imputation, normalization, feature extraction, dimensionality reduction, and data balancing. These preprocessing steps improve algorithm performance while reducing computational complexity.
Following preprocessing, machine learning algorithms identify relationships among behavioral, physiological, and demographic variables. Classification models estimate the probability that a child belongs to categories such as neurotypical development, ADHD, ASD, or combined ADHD-ASD presentation. Ensemble learning techniques combining multiple predictive models often improve diagnostic accuracy by reducing model-specific errors and increasing robustness across diverse patient populations[9].

13. Behavioural intervention support system:

Early identification alone cannot improve developmental outcomes unless accompanied by timely intervention. Therefore, the proposed framework integrates an intelligent behavioral intervention support system that provides personalized recommendations for clinicians, therapists, educators, and families. Artificial intelligence continuously monitors developmental progress, evaluates intervention effectiveness, and adapts therapeutic recommendations according to each child's individual needs.
Behavioral intervention recommendations are generated using evidence-based clinical guidelines combined with individualized developmental profiles. Children demonstrating communication difficulties may receive speech-language therapy recommendations, whereas children exhibiting hyperactivity and attentional impairments may benefit from behavioral parent training, classroom management strategies, cognitive behavioral therapy, or executive function interventions. AI assists clinicians by organizing relevant information and suggesting appropriate evidence-based treatment options while preserving clinician authority over final therapeutic decisions[10].

14. Mobile applications for parents and teachers:

Parents and teachers play indispensable roles in recognizing developmental abnormalities because they observe children's behaviour across diverse daily environments. Accordingly, the proposed AI framework incorporates dedicated mobile applications that facilitate continuous communication between families, educational institutions, and healthcare providers. These applications provide structured behavioral reporting tools, developmental milestone checklists, symptom tracking, appointment scheduling, educational resources, and personalized intervention guidance.
Parents can record daily observations regarding communication, emotional regulation, sleep quality, sensory sensitivities, repetitive behaviors, attention span, and adaptive functioning using intuitive smartphone interfaces. Artificial intelligence analyses these reports together with wearable sensor data to identify meaningful behavioral trends. Automated notifications remind caregivers about developmental assessments, therapy sessions, medication schedules, and recommended home-based intervention activities.

15. Clinical decision support dashboard:

Healthcare professionals require efficient access to comprehensive developmental information during clinical consultations. Therefore, the proposed framework includes an interactive clinical dashboard that summarizes behavioral observations, physiological measurements, AI-generated risk predictions, developmental trajectories, intervention progress, and clinical recommendations within a unified interface. This dashboard supports evidence-based decision-making while reducing administrative workload.
The dashboard presents individualized developmental risk scores accompanied by graphical visualization of behavioral trends over time. Clinicians can review symptom progression, compare current functioning with

previous assessments, evaluate intervention effectiveness, and identify emerging developmental concerns requiring immediate attention. Explainable AI features display the primary variables contributing to diagnostic predictions, improving transparency and facilitating informed clinical interpretation.

Integrated communication features allow healthcare professionals to exchange reports with psychologists, therapists, educators, and caregivers, promoting multidisciplinary collaboration throughout the diagnostic and intervention process. Such coordinated care models improve treatment continuity while minimizing fragmentation across healthcare and educational systems[11].

16. Performance Evaluation of Artificial Intelligence Models for ADHD and ASD Screening:

The successful implementation of Artificial Intelligence (AI) in pediatric neurodevelopmental healthcare depends not only on the sophistication of machine learning algorithms but also on rigorous evaluation of their clinical performance. AI systems intended for early screening of Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) must demonstrate high levels of accuracy, sensitivity, specificity, reliability, and generalizability before they can be integrated into routine healthcare practice. Unlike conventional software applications, AI models directly influence clinical decision-making; therefore, their evaluation requires extensive validation using representative pediatric populations collected across diverse geographical, cultural, and healthcare settings.

Performance evaluation begins during the model development stage, where datasets are divided into training, validation, and testing subsets. The training dataset enables the algorithm to learn relationships between developmental features and diagnostic outcomes, while the validation dataset assists in optimizing algorithm parameters. The independent testing dataset subsequently evaluates the model's predictive capability using previously unseen data. This separation minimizes overfitting, a phenomenon in which algorithms perform exceptionally well on training data but fail when applied to new clinical populations[12].

17. Evaluation metrics used in AI-based screening systems:

Diagnostic performance cannot be adequately summarized using accuracy alone. Multiple statistical indicators are required to determine whether an AI screening system provides clinically meaningful information. Each metric evaluates a different aspect of predictive performance, contributing to comprehensive assessment of algorithm reliability.

Accuracy represents the proportion of correctly classified observations among all evaluated children. Although frequently reported, accuracy may be misleading when disease prevalence is low because algorithms can achieve apparently high performance by predicting the majority class. Consequently, researchers emphasize additional performance measures that account for diagnostic balance between affected and unaffected populations[13].

18. Recent clinical validation studies:

During the past several years, substantial progress has been achieved in validating artificial intelligence applications for pediatric neurodevelopmental disorders. Advances in machine learning, deep learning, wearable sensing technologies, computer vision, and digital phenotyping have significantly improved screening accuracy while expanding opportunities for remote developmental assessment.

Several multicentre investigations have evaluated machine learning algorithms using standardized autism diagnostic datasets. These studies consistently demonstrate that supervised learning models—including Random Forests, Support Vector Machines, Gradient Boosting algorithms, and Artificial Neural Networks—can accurately classify ASD based on behavioral questionnaires and developmental observations. Many models achieved diagnostic accuracies exceeding 90%, highlighting AI's considerable potential as an adjunctive screening tool rather than an independent diagnostic system.

Deep learning research has expanded beyond questionnaire-based screening toward analysis of naturalistic behavioral information. Convolutional Neural Networks (CNNs) have successfully analysed facial expressions, eye gaze, social engagement, and motor behaviour extracted from smartphone videos. Several investigations demonstrated that AI systems could identify atypical developmental characteristics during routine parent-child interactions without requiring specialized laboratory environments. These findings support the feasibility of home-based developmental screening using commercially available mobile devices[14].

19. Advantages of AI-based early screening systems:

Artificial intelligence offers numerous advantages over conventional developmental screening approaches, particularly when integrated into multidisciplinary pediatric healthcare. One of its greatest strengths lies in the capacity to process enormous quantities of heterogeneous information simultaneously. Human clinicians may struggle to interpret thousands of behavioral observations, physiological measurements, educational records, and multimedia datasets, whereas AI algorithms efficiently integrate these variables into coherent developmental risk assessments.

AI-supported screening substantially reduces diagnostic delay. Many children experience prolonged waiting periods before receiving comprehensive developmental evaluation because of shortages of pediatric neurologists, developmental pediatricians, psychologists, and speech-language pathologists. Automated risk stratification enables healthcare providers to prioritize children demonstrating the highest probability of neurodevelopmental disorders, thereby optimizing utilization of limited specialist resources[15].

Objectivity constitutes another major advantage. Traditional behavioral assessments inevitably involve subjective interpretation influenced by clinician experience, caregiver perception, environmental context, and cultural expectations. Artificial intelligence applies standardized computational criteria consistently across all evaluated children, reducing inter-observer variability while improving reproducibility of developmental assessment.

Continuous monitoring further distinguishes AI systems from conventional episodic assessments. Wearable technologies, smartphone applications, and home-based monitoring devices generate longitudinal developmental information reflecting children's everyday behaviour rather than isolated clinical observations. Such continuous assessment provides a more accurate representation of real-world functioning while enabling early identification of subtle developmental changes requiring intervention[16].

20. Technical challenges and limitations of AI-based screening:

Despite remarkable technological progress, numerous challenges continue to limit widespread implementation of artificial intelligence within pediatric developmental healthcare. One of the most significant barriers involves the availability of high-quality datasets. Machine learning algorithms require extensive, accurately labelled, and representative developmental information to achieve reliable predictive performance. Unfortunately, many existing datasets remain relatively small, geographically restricted, and demographically homogeneous, limiting algorithm generalizability.

Diagnostic labelling presents another major challenge. ADHD and ASD diagnosis frequently depends upon multidisciplinary clinical judgment rather than definitive biological markers. Variability among clinicians, evolving diagnostic criteria, and symptom overlap introduce uncertainty into reference labels used for machine learning training. Consequently, AI algorithms may inadvertently learn inconsistencies present within clinical datasets rather than objective developmental characteristics.

Class imbalance represents a common statistical problem. Most screening populations contain substantially more neurotypical children than children diagnosed with ADHD or ASD. Without appropriate balancing techniques, machine learning models may become biased toward majority populations, reducing sensitivity for detecting relatively uncommon developmental disorders. Researchers increasingly employ oversampling, synthetic data generation, and cost-sensitive learning methods to address this limitation[17].

21. Ethical considerations in artificial intelligence-based pediatric healthcare:

The rapid integration of Artificial Intelligence (AI) into pediatric healthcare has introduced unprecedented opportunities for improving the early detection, diagnosis, and management of neurodevelopmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). However, alongside these technological advancements, significant ethical challenges have emerged regarding the responsible use of AI in clinical decision-making. Since AI systems increasingly influence diagnostic recommendations and intervention planning, ethical principles including beneficence, non-maleficence, autonomy, justice, transparency, accountability, and respect for patient rights must remain central throughout system development and implementation. Pediatric healthcare requires particularly stringent ethical oversight because children constitute a vulnerable population with limited capacity to provide informed consent, thereby increasing the responsibility of healthcare professionals, researchers, developers, and policymakers to ensure that AI technologies prioritize children's welfare above technological innovation[18].

Unlike conventional medical software, AI systems continuously learn from large volumes of clinical and behavioral information, enabling dynamic prediction and adaptive decision-making. While these capabilities improve diagnostic efficiency, they also introduce uncertainty regarding how algorithms reach specific conclusions. Clinicians may encounter situations in which AI-generated recommendations conflict with their own clinical judgment or parental observations. Consequently, ethical implementation requires that AI function strictly as a clinical decision-support tool rather than an autonomous diagnostic authority. Final diagnostic decisions should always remain under the supervision of qualified paediatricians, developmental paediatricians, child psychiatrists, psychologists, or multidisciplinary healthcare teams capable of considering social, cultural, environmental, and family-related factors beyond computational analysis.

The principle of beneficence requires AI systems to maximize clinical benefit while minimizing harm. In developmental healthcare, this principle implies designing algorithms capable of improving early identification without generating excessive false-positive or false-negative results. False-positive predictions may expose children and families to unnecessary anxiety, additional medical evaluations, financial burden, and social stigma. Conversely, false-negative predictions may delay access to evidence-based interventions during critical periods of neurodevelopment when therapeutic effectiveness is greatest. Therefore, ethical AI development requires careful optimization of sensitivity and specificity while continuously monitoring algorithmic performance after deployment in real-world healthcare environments.

Another important ethical consideration involves respect for parental autonomy and shared decision-making. Parents and caregivers remain the primary decision-makers regarding children's healthcare. AI systems should therefore provide understandable explanations rather than opaque probability scores that families cannot interpret. Transparent communication strengthens trust between healthcare providers and families while ensuring that technological recommendations support rather than replace meaningful clinical discussion. Parents should receive clear information regarding how developmental data are collected, analysed, stored, and used during AI-assisted screening, allowing informed participation throughout the diagnostic process.

The ethical principle of justice emphasizes equitable access to AI-assisted healthcare irrespective of socioeconomic status, geographical location, ethnicity, language, disability, or educational background. Considerable disparities currently exist in access to developmental specialists, particularly within rural and low-resource regions. Properly implemented AI systems may reduce these inequalities by expanding screening services through smartphones, wearable technologies, telemedicine platforms, and community healthcare centers. However, ethical implementation requires deliberate efforts to prevent technological innovations from benefiting only affluent healthcare systems while excluding disadvantaged populations lacking digital infrastructure or internet connectivity[19].

22. Data privacy and cybersecurity in ai-based screening systems:

Artificial Intelligence-based developmental screening systems depend upon continuous collection of highly sensitive personal information. These data include demographic characteristics, developmental histories, behavioral observations, educational records, speech recordings, facial images, physiological measurements, wearable sensor outputs, electronic health records, genetic information, and family medical histories. Because these datasets involve minors, ensuring robust privacy protection becomes a fundamental ethical and legal obligation throughout every stage of data collection, storage, transmission, analysis, and sharing.

Data privacy begins with informed parental consent. Before developmental information is collected, parents or legal guardians should receive comprehensive explanations regarding the purpose of data collection, expected clinical benefits, potential risks, data storage duration, information sharing policies, cybersecurity safeguards, and opportunities to withdraw participation. Transparent consent procedures strengthen trust while ensuring compliance with international ethical standards governing pediatric medical research and digital healthcare technologies.

Secure data transmission represents another critical cybersecurity requirement. Wearable sensors, smartphones, educational platforms, and clinical information systems continuously exchange developmental information through digital communication networks. Without adequate encryption, unauthorized individuals may intercept sensitive pediatric health information during transmission. Consequently, AI-based healthcare platforms should employ end-to-end encryption, secure communication protocols, virtual private networks, and authentication mechanisms to prevent unauthorized access to confidential developmental records[20].

Cloud computing has become indispensable for large-scale AI implementation because developmental screening generates enormous volumes of multimedia information requiring substantial storage and computational capacity. However, cloud infrastructure introduces additional cybersecurity challenges, including unauthorized database access, ransomware attacks, accidental data leakage, and insider threats. Healthcare organizations must therefore implement multilayer cybersecurity architectures incorporating encrypted databases, role-based access control, intrusion detection systems, continuous security monitoring, disaster recovery planning, and regular vulnerability assessments to safeguard pediatric information against evolving cyber threats.

Data anonymization and pseudonymization constitute essential privacy-preserving techniques within AI research. Personally identifiable information such as names, addresses, telephone numbers, and unique identifiers should be removed or replaced before datasets are used for algorithm training. Although complete anonymization may be difficult for multimodal developmental datasets containing facial images or voice recordings, advanced privacy-preserving computational methods substantially reduce re-identification risks while maintaining research utility.

Federated learning has emerged as an innovative approach for balancing artificial intelligence development with patient privacy. Unlike conventional centralized machine learning, federated learning enables hospitals to train AI models locally while sharing only model parameters rather than raw patient information. Consequently, developmental data remain securely within individual healthcare institutions while collaborative machine learning improves algorithm performance across multiple hospitals. This decentralized approach substantially reduces privacy risks associated with centralized data repositories and has gained increasing attention within paediatric digital healthcare research[21]

23. Algorithmic bias and fairness in AI-based developmental screening:

Artificial Intelligence systems are fundamentally dependent upon the quality, diversity, and representativeness of the data used during algorithm development. If training datasets contain systematic imbalances or historical biases, AI models may inadvertently reproduce or even amplify existing healthcare inequalities. Algorithmic bias therefore represents one of the most significant ethical and scientific challenges confronting AI-assisted developmental screening for ADHD and ASD.

Training datasets frequently underrepresent important demographic groups, including children from rural communities, minority ethnic populations, low-income families, multilingual households, and geographically isolated regions. Algorithms trained primarily using data collected within specialized urban hospitals may demonstrate reduced accuracy when applied to culturally diverse populations. Such disparities could contribute to delayed diagnosis among already underserved communities, contradicting the ethical principle of healthcare equity.

Sex-based bias also requires careful consideration. Historically, ADHD and ASD research has focused predominantly on boys because these disorders are diagnosed more frequently in males. However, increasing evidence suggests that girls often exhibit different symptom presentations, particularly regarding social communication, inattentive behaviors, emotional regulation, and masking strategies. AI systems trained using predominantly male datasets may therefore demonstrate lower sensitivity when evaluating female children, increasing the risk of underdiagnosis and delayed intervention[22].

24. Future Directions of Artificial Intelligence in ADHD and ASD Care:

The future of Artificial Intelligence (AI) in pediatric neurodevelopmental healthcare extends far beyond early screening and diagnostic assistance. Advances in machine learning, deep learning, wearable technologies, digital therapeutics, cloud computing, robotics, and precision medicine are expected to transform the management of Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) over the coming decade. Rather than functioning solely as diagnostic support tools, future AI systems will likely serve as comprehensive developmental health ecosystems capable of continuously monitoring children's cognitive, behavioral, emotional, and physiological development throughout childhood and adolescence.

One of the most promising future developments involves the integration of multimodal developmental data. Current screening systems often rely on limited datasets such as questionnaires or behavioral observations. Future AI platforms are expected to combine information from wearable biosensors, speech analysis, eye-tracking technologies, neuroimaging, genetic testing, educational performance metrics, environmental exposures, and electronic health records. The integration of these diverse data streams will enable more accurate developmental profiling and support earlier identification of subtle neurodevelopmental abnormalities before clinically observable symptoms become apparent.

Advances in deep learning are also expected to enhance predictive accuracy significantly. As larger and more diverse pediatric datasets become available, AI algorithms will be capable of identifying increasingly complex developmental patterns associated with ADHD and ASD. These predictive models may eventually estimate developmental risk during infancy, enabling preventive interventions before significant behavioral impairments emerge. Such a shift from reactive treatment to proactive prevention represents a major objective of future paediatric healthcare systems[23].

25. Integration of precision medicine and personalized behavioral intervention:

Precision medicine represents one of the most transformative concepts in contemporary healthcare. Unlike traditional treatment approaches that apply standardized interventions to broad patient populations, precision medicine emphasizes individualized healthcare based on genetic, biological, behavioral, environmental, and psychosocial characteristics. Artificial intelligence plays a central role in this paradigm by analysing large and complex datasets that exceed the analytical capabilities of conventional statistical methods.

Children diagnosed with ADHD or ASD exhibit substantial heterogeneity in symptom severity, cognitive functioning, communication skills, sensory processing, emotional regulation, and treatment responsiveness. Consequently, interventions that prove effective for one child may demonstrate limited benefit for another. AI-driven precision medicine systems address this challenge by identifying individualized developmental profiles and predicting likely responses to various therapeutic strategies[24].

Future behavioral intervention platforms may continuously evaluate treatment effectiveness using real-time developmental monitoring. Machine learning algorithms could analyse changes in communication skills, social engagement, emotional regulation, sleep patterns, attention span, and adaptive functioning to determine whether current interventions are achieving desired outcomes. If therapeutic progress slows or deteriorates, the system could recommend modifications to intervention plans, enabling more responsive and adaptive healthcare delivery.

Genomic medicine may further enhance personalization. Although ADHD and ASD are influenced by complex interactions among genetic and environmental factors, ongoing advances in genomics are improving understanding of biological pathways associated with neurodevelopmental disorders. Future AI systems may integrate genetic, behavioral, and physiological information to support highly individualized developmental risk assessment and treatment planning. Such integration could contribute significantly to the advancement of precision developmental medicine during the coming decades[25].

26. Proposed artificial intelligence-based early screening and behavioral intervention model:

Based on current scientific evidence, a comprehensive AI-based developmental healthcare model can be proposed for the early identification and management of ADHD and ASD. This conceptual framework integrates data acquisition, artificial intelligence analytics, clinical decision support, personalized intervention planning, and continuous developmental monitoring into a unified healthcare ecosystem.

The first stage involves multisource data collection, including electronic health records, caregiver questionnaires, teacher assessments, wearable sensor measurements, speech recordings, facial expression analysis, eye-tracking information, developmental milestone assessments, and educational performance data. Collecting information from multiple environments improves ecological validity and supports comprehensive developmental evaluation.

The second stage consists of secure data transmission and cloud-based storage. Information collected from various sources is transmitted through encrypted communication channels and stored within secure cloud infrastructure. Privacy-preserving technologies such as encryption, anonymization, and federated learning protect sensitive pediatric information while supporting large-scale machine learning analysis.

The third stage involves the AI analytics and risk prediction engine. Machine learning and deep learning algorithms analyse behavioural, physiological, and developmental information to estimate individualized risk scores for ADHD, ASD, or co-occurring neurodevelopmental conditions. Explainable Artificial Intelligence (XAI) techniques provide transparency regarding the factors influencing diagnostic predictions, thereby supporting clinician trust and informed decision-making[26].

27. Recommendations:

Several recommendations can be proposed to support the responsible implementation of AI-based early screening and behavioral intervention systems for ADHD and ASD.

First, researchers should prioritize the development of large, diverse, and representative pediatric datasets that include participants from different ethnic, cultural, linguistic, socioeconomic, and geographical backgrounds. Diverse datasets improve algorithm fairness, reduce bias, and enhance generalizability across populations.

Second, healthcare organizations should implement robust privacy and cybersecurity frameworks to protect sensitive pediatric information. Encryption, access control, federated learning, anonymization, and continuous cybersecurity monitoring should become standard components of AI-based developmental healthcare infrastructure.

Third, clinicians should receive specialized training regarding artificial intelligence technologies, machine learning principles, algorithm limitations, and ethical considerations. Effective integration requires healthcare professionals to understand both the capabilities and limitations of AI-assisted decision-support systems.

Fourth, governments and healthcare policymakers should establish clear regulatory frameworks governing AI validation, clinical implementation, safety monitoring, accountability, transparency, and post-deployment surveillance. Standardized regulatory guidelines will facilitate responsible innovation while protecting patient welfare.

Fifth, future research should emphasize longitudinal clinical studies evaluating the long-term effectiveness of AI-assisted developmental screening and intervention. Evidence regarding real-world clinical outcomes remains essential for guiding widespread implementation within healthcare systems worldwide[27].

28. Conclusion:

Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) represent complex neurodevelopmental conditions that significantly affect children's cognitive, behavioral, emotional, educational, and social development. Early identification remains one of the most effective strategies for improving long-term outcomes because therapeutic interventions are most effective during periods of heightened neuroplasticity. However, traditional diagnostic approaches frequently encounter challenges related to delayed diagnosis, limited specialist availability, subjectivity, and healthcare accessibility

Artificial Intelligence has emerged as a transformative technology capable of addressing many of these challenges through automated behavioral analysis, machine learning-based risk prediction, multimodal data integration, continuous developmental monitoring, and personalized intervention support. Advances in computer vision, speech analysis, wearable sensing technologies, cloud computing, deep learning, and digital health platforms have demonstrated considerable potential for enhancing the early detection and management of ADHD and ASD

Despite these promising developments, successful implementation requires careful consideration of ethical principles, privacy protection, cybersecurity, algorithmic fairness, transparency, and regulatory oversight. Artificial intelligence should be viewed not as a replacement for clinical expertise but as a powerful decision-support tool that complements multidisciplinary developmental healthcare. Human judgment, family involvement, and individualized clinical assessment remain indispensable components of pediatric neurodevelopmental

Future integration of AI with precision medicine, digital therapeutics, telehealth services, wearable technologies, and genomic science has the potential to revolutionize developmental healthcare by enabling highly personalized, proactive, and data-driven interventions. Through responsible innovation and collaborative implementation, AI-based early screening and behavioral intervention support systems may contribute significantly to improving developmental outcomes, quality of life, and long-term well-being for children affected by ADHD and Autism Spectrum Disorder worldwide.

29. References:

(1) American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Text Revision (DSM-5-TR). Washington (DC): American Psychiatric Association Publishing; 2022.

(2) Lord C, Charman T, Havdahl A, Carbone P, Anagnostou E, Boyd B, et al. The Lancet Commission on the future of care and clinical research in autism. Lancet. 2022;399(10321):271–334.

(3) Hyman SL, Levy SE, Myers SM. Identification, evaluation, and management of children with autism spectrum disorder. Pediatrics. 2020;145(1):e20193447.

(4) Cortese S, Adamo N, Del Giovane C, Mohr-Jensen C, Hayes AJ, Carucci S, et al. Comparative efficacy and tolerability of medications for attention-deficit hyperactivity disorder in children, adolescents, and adults: A systematic review and network meta-analysis. Lancet Psychiatry. 2021;8(9):727–738.

(5) Maenner MJ, Warren Z, Williams AR, Amoakohene E, Bakian AV, Bilder DA, et al. Prevalence and characteristics of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, United States, 2020. MMWR Surveill Summ. 2023;72(2):1–14.

(6) Polanczyk GV, Willcutt EG, Salum GA, Kieling C, Rohde LA. ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. Int J Epidemiol. 2015;44(2):525–544.

(7) Dawson G, Rogers S, Munson J, Smith M, Winter J, Greenson J, et al. Randomized controlled trial of an intervention for toddlers with autism: The Early Start Denver Model. Pediatrics. 2010;125(1):e17–e23.

(8) Zwaigenbaum L, Bauman ML, Choueiri R, Kasari C, Carter A, Granpeesheh D, et al. Early intervention for children with autism spectrum disorder under 3 years of age: Recommendations for practice and research. Pediatrics. 2015;136(Suppl 1):S60–S81.

(9) Topol EJ. Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. New York: Basic Books; 2019.

(10) Beam AL, Kohane IS. Big data and machine learning in health care. JAMA. 2018;319(13):1317–1318.

(11) Rajkomar A, Dean J, Kohane I. Machine learning in medicine. N Engl J Med. 2019;380(14):1347–1358.

(12) Esteva A, Robicquet A, Ramsundar B, Kuleshov V, DePristo M, Chou K, et al. A guide to deep learning in healthcare. Nat Med. 2019;25(1):24–29.

(13) Duda M, Haber N, Daniels J, Wall DP. Crowdsourced validation of a machine-learning classification system for autism and ADHD. Transl Psychiatry. 2016;6:e865.

(14) Abbas H, Garbajosa J, Bibi S, Ali S, Kumari S. Artificial intelligence approaches for autism spectrum disorder diagnosis: A systematic literature review. IEEE Access. 2022;10:59319–59345.

(15) Goodfellow I, Bengio Y, Courville A. Deep Learning. Cambridge (MA): MIT Press; 2016.

(16) LeCun Y, Bengio Y, Hinton G. Deep learning. Nature. 2015;521(7553):436–444.

(17) Heinsfeld AS, Franco AR, Craddock RC, Buchweitz A, Meneguzzi F. Identification of autism spectrum disorder using deep learning and the ABIDE dataset. NeuroImage Clin. 2018;17:16–23.

(18) Hashemi J, Tepper M, Esler A, Anagnostou E, Wolff J, Ghoneim A, et al. Computer vision tools for low-cost and non-invasive measurement of autism-related behaviors. NPJ Digit Med. 2018;1:16.

(19) Bertoni A, Mazzeschi C, Esposito G, Venuti P. Artificial intelligence and natural language processing for autism spectrum disorder assessment: A systematic review. Front Psychiatry. 2023;14:1187953.

(20) Jones W, Klin A. Attention to eyes is present but declines in 2–6-month-old infants later diagnosed with autism. Nature. 2013;504(7480):427–431.

(21) Sarkar S, Jamuna PP. Effectiveness of structured teaching programme on the importance of feeding colostrum to newborn babies among the primigravida mothers attending OPD at Dr. B. R. Ambedkar Hospital. Int J Creat Res Thoughts. 2023;11(1):398-412.

(22) Johnson MMM, Siddiqa BBA, Jamuna PP, Mallick P, Aniya T. A study to evaluate the effectiveness of video-assisted teaching program on knowledge regarding menstrual hygiene among adolescent girls in Dayananda Sagar Pre-University College. Int J Creat Res Thoughts. 2023;11(1):562-571.

(23) Jamuna PP, Sohi D. A study to evaluate the effectiveness of planned teaching programme on knowledge regarding selected aspects of reproductive health among adolescent girls in a selected pre-university college of Moodbidri. IDC Int J. 2021;8(2):9-12.

(24) Varughese J, Jamuna PP. An experimental study to assess the effectiveness of Lamaze breathing techniques on reduction of labour pain perception and duration of labour among primigravida mothers. Int J Drug Des Discover. 2026;16(31S):464-474.

(25) Jamuna PP, Seethi S. Self-efficacy: believing in yourself matters. Int J All Res Educ Sci Methods. 2025;13(10):610-615.

(26) Jamuna PP, Rose ZS. Stillbirth prevention and bereavement care: A comprehensive review article. Int J Res Anal Rev. 2024;11(4):740-744.

(27) Varshitha SS, Jamuna PP, Sidan M, Biradar P. Effectiveness of postnatal support education program among spouses of primiparous mothers at selected hospitals in Ramanagara District, Karnataka. J Chem Health Risks. 2025;15(6):1016-1023.