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Review

APPLICATION OF TELEMEDICINE TECHNOLOGIES IN THE DIAGNOSIS OF AUTISM SPECTRUM DISORDERS IN CHILDREN: A NARRATIVE REVIEW

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SUMMARY

Background: *The application of telemedicine technologies in providing psychiatric care to children with autism spectrum disorders (ASD) became widespread during the COVID-19 pandemic. This review aims to describe the types, structure, and features of tools used for the remote diagnosis of ASDs in children, based on contemporary scientific literature and our own experience.*

Methods*: We conducted a descriptive review of scientific studies published from January 2013 to December 2024. Works presented in the electronic databases PubMed, Web of Science, and eLibrary were analyzed. Descriptive analysis was used to summarize the obtained data.*

Results: *The analysis convincingly demonstrates a sufficient representation of remote tools for screening, assessment scales, and structured diagnostic procedures for ASD across various countries, exhibiting high levels of specificity and sensitivity.*

Conclusions: *The use of telemedicine diagnostic methods in clinical practice contributes to the early detection of ASDs, potentially enhancing the timeliness and effectiveness of medical and correctional interventions.*

Key words: *autism spectrum disorders - childhood - psychometric assessments - remote diagnostics - telemedicine*

Abbreviations: *ASD – autism spectrum disorders; SCQ - Social Communication Questionnaire; M-CHAT - Modified Checklist for Autism in Toddlers; ADI-R - Autism Diagnostic Interview - Revised; ADOS - Autism Diagnostic Observation Schedule; CASD - Checklist for Autism Spectrum Disorder; Leiter-R - Leiter international performance scale-revised; BRIEF-P - The Behavior Rating Inventory of Executive Function–Preschool Version; CBCL - The Child Behavior Check List; MCDI - MacArthur Communicative Development Inventories; CARS2-QPC - Childhood Autism Rating Scale. 2nd ed.; RBS-R - The Repetitive Behavior Scale - Revised; SP - The Sensory Profile ; SRS - Social Responsiveness Scale ; PSI4 - The Parenting Stress Index 4; VABS-II - Vineland Adaptive Behavior Scales, Vineland-II; SORF - Systematic Observation of RedFlags; BOSA - Brief Observation of Symptoms of Autism; NODA - Naturalistic Observation Diagnostic Assessment; TEDI - Telehealth Evaluation of Development for Infants; CPP - The Communication Play Protocol; AOSI - The Autism Observation Scale for Infants*

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INTRODUCTION

Limitations in the accessibility of specialized psychiatric care are observed worldwide, driven by the high prevalence of mental disorders and a deficit of specialized professionals. Autism spectrum disorders (ASD) have become one of the most pressing issues in child psychiatry in recent decades. This is due to their steady increase in prevalence, diagnostic challenges, and complexities in comprehensive intervention. The diagnosis of ASD is often significantly delayed, particularly in rural and remote areas, and among children from families with lower socioeconomic status (Antezana et al. 2017).

Late diagnosis of ASD reduces the success of corrective and therapeutic measures (Liu & Ma 2022). For instance, in the USA, the average age of initial ASD diagnosis is just over four years, with 27% of children not being diagnosed until age eight (Constantino et al. 2020).

The aim of this review is to describe the types, structure, and features of tools for the remote diagnosis of autism spectrum disorders in children, based on contemporary scientific literature and our own experience.

METHODS

We udnertook a descriptive review of scientific studies published from January 2013 to December 2024, wth analysis of research presented in the electronic databases PubMed and eLibrary. Search queries included keywords such as "telemedicine diagnostics," "telemedicine consultations," "autism spectrum disorders," and "children." Studies were deemed acceptable for analysis if they described validated telemedicine (remote) methods for screening, diagnosis, and quantitative and qualitative assessment of ASD in children. Fifty-seven articles were reviewed, among which 23 were selected for descriptive analysis which served to summarize the obtained data.

RESULTS

The active use of telemedicine consultations increased globally due to the COVID-19 pandemic (Hincapié et al. 2020). The remote format for diagnosing ASD in childhood is applied in various clinical situations: screening for ASD risk, quantitative assessment of ASD symptoms using standardized scales and methods, and as part of traditional clinical and psychopathological examinations.

Level I ASD risk screening tools are designed for parents, educational institution specialists, or primary healthcare networks for mass screening of children in the general population. Given the absence of a need for specialized user training (primarily parents and educators), their brevity and simplicity, the possibility of automation, and feasibility of application without direct specialist involvement, the remote version of Level I screening methods offers maximum effectiveness and cost-efficiency. In various countries world-wide, the Modified Checklist for Autism in Toddlers (M-CHAT), a Level I ASD risk screening method for children aged 16-30 months, has been validated for remote application (Robinset al. 2022, Kadam et al. 2022).

For Level II ASD screening, the Social Communication Questionnaire (SCQ) (Derks et al. 2017) and the Checklist for Autism Spectrum Disorder (CASD) (Califano et al. 2024) are widely used. These assessment tools have higher specificity, but require special training and more time for results interpretation, thus being conducted only by specialized professionals.

Remote ASD diagnostic models can be synchronous or asynchronous, depending on the mode of interaction between specialists and recipients of care (Alfuraydan et al. 2020). The synchronous option involves observing the child's behavior in an online videoconference mode, while the asynchronous option involves reviewing video recordings. Parents can record videos of the most prominent behavioral manifestations of the child at a convenient time. For over ten years, the "gold standard" methods for ASD diagnosis – The Autism Diagnostic Interview-Revised (ADI-R) and the Autism Diagnostic Observation Schedule (ADOS) (Reese et al. 2013) – have been used in a remote synchronous format via video conferencing.

Narzisi (2020) presented an algorithm for a telemedicine diagnostic assistance model that includes both synchronous and asynchronous options. It is worth examining the components of this diagnostic system in more detail, as with some variations, they are present in most methods for remote assessment of ASD manifestations. In the first stage, it is proposed to prepare short video recordings (15–20 minutes in length) illustrating the child's behavior at home in fixed situations. It is recommended to make video recordings on different days to obtain a more comprehensive view of the child's behavior. Brief descriptions of the several approaches follow:

- *Free play of the child with a parent (analogous to the ADOS-BOSCC method).* Here, parents are asked to arrange toys on the floor and play with the child as they would in a typical home situation, without imposing additional demands. For example, this could entail regular play with LEGO construction sets. There is assessment of the child's social interaction skills, such as the ability to take turns with another person, resolve disagreements, and other aspects of interactions.
- *Hild's solitary play (analogous to ADOS-2).* Here, parents place toys on the floor and table for self-selection. Functional and symbolic use of toys, attention to their isolated sensory characteristics (e.g., auditory, tactile, and olfactory), presence of restricted and repetitive behaviors, and ability to vary play activities are noted .
- *Child's play with a sibling.* Variants of scenarios 1 and 3 above allow for the assessment of social and play interaction skills, including responses to asking for help, joint attention, the child's ability to attract attention, and mastery of other verbal and non-verbal communication tools.
- *Family meal.* Oral-motor skills and potential presence of food selectivity are assessed. Any behavior that causes parental concern is noted. Next, parents are sent questionnaires and assessment scales for completion from a wide range.

Results of these assessments are scored by a range of scales, i.e., Leiter international performance scale-revised (Leiter-R); The Behavior Rating Inventory of Executive Function–Preschool Version (BRIEF-P); The Child Behavior Check List (CBCL);

MacArthur Communicative Development Inventories (MCDI); Childhood Autism Rating Scale. 2nd ed. (CARS2-QPC); The Repetitive Behavior Scale - Revised (RBS-R); The Social Communication Questionnaire (SCQ)–Life Time Form (SCQ-LT); The Sensory Profile (SP); Social Responsiveness Scale (SRS); The Parenting Stress Index 4 (PSI4).

Remote ASD Diagnostics: A Comprehensive Overview

Over the subsequent four days above assessments, a detailed anamnesis is collected online, followed by assessments using ADI-R (Autism Diagnostic Interview - Revised) and VABS-II (Vineland Adaptive Behavior Scales, Vineland-II). A certified ADOS-2 (Autism Diagnostic Observation Schedule-2) specialist then evaluates the prepared home video recordings. Subsequently, a speech-language pathologist, psychologist, and motor therapist conduct individual online video consultations, each lasting 25-45 minutes, to assess specific skills of the child. The summarized diagnostic evaluation, adhe-

ring to DSM-5 criteria, is communicated to parents during a concluding consultation, also conducted via video conferencing.

Advancements in Remote Diagnostic Tools

Over the past 5-10 years, several remote assessment tools have been developed, many of which are online versions of traditional in-person ASD diagnostic methods (Riva et al. 2024). Examples include NODA (Naturalistic Observation Diagnostic Assessment) (Nazneen et al. 2015; Smith et al. 2017, Dow et al. 2020), and BOSA (Brief Observation of Symptoms of Autism) (Lord et al. 2020, Dow et al. 2022). Our earlier publication provides a detailed review of developed remote ASD diagnostic methodologies and studies confirming their high levels of sensitivity and specificity, equivalent to in-person assessment formats (Khairetdinov& Rubakova 2023).

Naturalistic Observation Diagnostic Assessment (NODA) also relies on home video recordings, made according to specific instructions, and extending across a range of everyday situations (e.g., family meals, joint play, solitary play, parental hygiene, and other care activities). Technically, the method comprises a mobile phone application, NODA Smart Capture, for creating video recordings, and a web portal, NODA Connect, for specialists to analyze video segments and correlate them with DSM-5 ASD criteria within the context of the child's developmental history.

The Systematic Observation of RedFlags (SORF) is designed for analyzing video recordings of toddlers (16 to 24 months old) and their interactions with parents in a home setting. Video clips, lasting 30 minutes or longer, should illustrate five daily living situations: playing with toys, playing with people, eating meals, hygiene care, and performing household chores/family duties. Twenty-two "red flags" (concerning signs) of autism are assessed based on DSM-5 diagnostic criteria.

Brief Observation of Symptoms of Autism (BOSA). Developed at the UCLA Center for Autism Research and Treatment, this method can be applied in both synchronous and asynchronous telemedicine consultations. Accordingly, it involves analyzing parent-child interactions either observed live via video conferencing or analyzed from video recordings lasting 12–14 minutes. The method is an adaptation of ADOS-2 by the same research team (Lord et al. 2020) and BOSCC (Brief Observation of Social Communication Change). The BOSA-MV (minimally verbal) variant is applicable to children of any age. The actions of accompanying persons are regulated in terms of duration, sequence, and toy selection, similar to ADOS-2. For approved use of BOSA, specialists require certification in ADOS-2 application for clinical and research purposes. It is also recommended to supplement remote BOSA assessments with other standardized instruments, such as ADI-R, CARS-2, and methods for assessing adaptive behavior and cognitive level.

Diagnosing ASD in infants poses the greatest challenges, even during in-person examinations. In this regard, the Telehealth Evaluation of Development for Infants (TEDI) method, designed for synchronous remote diagnosis, is of undeniable interest, demonstrating the potential for remote detection of ASD risk in infants aged 6-12 months (Talbott et al. 2022). The protocol contains ten semi-structured parent-child play interactions to assess social contact, play, imitation, and other behavioral domains based on verbal instructions and written "prompt cards" from The Communication Play Protocol (CPP) (Adamson & Bakeman 2016), five of which are borrowed from The Autism Observation Scale for Infants (AOSI) (Bryson et al. 2008).

The Autism Detection in Early Childhood – Virtual (ADEC-V) is a remote modification of the offline Autism Detection in Early Childhood (ADEC) method for children up to 3 years of age (Kryszak et al. 2022). Modifications to the original instrument concerned the wording of instructions for parents in assessed structured situations and parents' comments on behavioral details less accessible for direct observation via webcam (e.g., peculiarities of eye contact).

One of the most frequently used and cited methods, TELE-ASD-PEDS (TAP), was specifically developed for the remote assessment of ASD in non-verbal children under three years of age at the Vanderbilt University TRIAD Medical Center (Nashville, USA), beginning even before the COVID-19 pandemic (Wagner et al. 2021). Structural elements of TAP with the highest prognostic value specifically for young children were selected using machine learning technology from a database of several hundred individuals with ASD and a normative control group. TAP administration consists of ten items and takes approximately 20 minutes. It assesses socially oriented responses, turn-taking during interactions with others, ability to express requests, and characteristics of spontaneous and adult-guided play (e.g., hide-and-seek, tickling, bubbles).

Remote ASD Diagnostics in Russia

In Russia, the Order for Conducting Preventive Medical Examinations of Minors (in accordance with Orders of the Ministry of Health of the Russian Federation No. 514n of August 10, 2017, and No. 396n of June 13, 2019) mandates screening for mental developmental disorders in children aged two years through parental questionnaires. However, the volume of routine "paper-based" ASD screening remains extremely low due to a shortage of personnel and time resources, as well as the perceived stigmatization of psychiatric care. Currently, in Russia, remote electronic access to Level I screening methods is primarily implemented by non-profit organizations, such as

charitable foundations and parent advocacy groups. Specialized medical and correctional-rehabilitation organizations, by hosting Level I and Level II screening tools on their websites, possess extensive opportunities for pre-clinical two-stage examination and initial patient routing. It is important to note that these processes can be fully automated and carried out without the direct involvement of organizational staff.

In the Russian-language literature, we found only one publication on a comparative study of ASD diagnosis within telemedicine and in-person consultations, which was conducted at the Scientific and Practical Center for Mental Health of Children and Adolescents n.a. G.E. Sukhareva, Moscow Department of Healthcare (Khairetdinov & Rubakova 2023). The comparison data comprised 84 telemedicine and 310 in-person consultations of patients with ASD, examined by one of the authors between January 2020 and June 2022. All consultations, both remote and in-person, adhered to a consistent, clear structure: preliminary review of examination materials from medical documentation (10-30 minutes); direct interaction with patients, their parents, and center specialists (30-50 minutes). Mandatory components included observation and assessment of the child's spontaneous behavior, as well as structured interaction situations: a) with parents; b) with specialists (attending physician, psychologist, speech therapist, etc.); c) with the remote consultant. The collected information was quantitatively assessed using the original Clinical and Ethological Scale for Autism Diagnostics (Khairetdinov & Rubakova 2023). The qualification of the child's spontaneous behavior and interaction with parents and specialists present in the room did not significantly differ between remote and in-person consultations; some differences were primarily determined by the quality of equipment and the resolution of video and audio communication. On the other hand, assessing the nature of the child's interaction with the remote consultant had certain fundamental peculiarities. Several distinctive parameters for conducting telemedicine consultations were identified: difficulties and the risk of inaccurate assessment of "through-the-screen" eye contact, the degree of the patient's subjective relation to the consultant, and the presence or absence of non-verbal reactions to background visual, auditory, and other stimuli not perceptible to the consultant. For example, a child's gaze that appeared sufficient when directed at the remote specialist often turned out to be merely oriented towards the consultant, but focused on technical details of the equipment, or distractors like their own image in the video chat. Even assessing the focus of the child's gaze posed difficulties related to the differences in the localization of the webcam's lens ("eyepiece") and the image of the interlocutor's eyes on the screen. To overcome these challenges, additional mandatory actions were introduced into the telemedicine consultation procedure for the consultant. These include "trials" of turning off the monitor, or moving the camera or specialist within the frame, with registration of the presence or absence of subject-oriented non-verbal communicative reactions from the patient. A phenomenon we termed the "keyhole effect" can account for distorted assessment and incorrect diagnostic conclusions; this refers to the obligatory fragmentation of the image and soundscape of the space where the patient and their environment -which can comprise family members, pets, and electronic gadgets - are located during telemedicine consultations. This creates difficulties in assessing the presence or absence of a child's reactions to distant, background noises, sounds, speech, and other stimuli inaccessible to the consultant. Consequently, misqualification of various observed phenomena is possible; for instance, what appeared to the physician as "objective" signs of hallucinations could be rather the focusing of gaze on perfectly real stimuli. In such cases, it is necessary to resolve doubts by asking additional clarifying questions to parents about possible sources of the child's non-verbal reactions.

DISCUSSION

The analysis of the publications presented in this review convincingly demonstrates a wide range of remote tools applied in various countries for Level I screening, assessment scales, and structured ASD diagnostic procedures, all exhibiting high levels of specificity and sensitivity. Tools for remote risk diagnosis of ASD have been developed, including applications designed for infants.

Synchronous variants of remote ASD diagnostics closely resemble traditional in-person consultations, but with special limitations in relation to the need for coordinating consultant and patient/parent schedules. Furthermore, it may not always be possible to observe all relevant patient behavioral characteristics within a limited consultation period.

The advantages of asynchronous consultation variants include the ability to obtain the full spectrum of important visual information about the child's behavior in their standard home environment, the ability to video record at a convenient time for the necessary duration, and the absence of scheduling complexities for simultaneous participation of both parties.

Publications on the use of remote ASD diagnostics in Russia are extremely scarce in the literature available to us. A further limitation of this review is that some relevant studies on the topic might have been missed, as a as did not employ a systematic search strategy in the selection of literature reports. Additionally, the methodology of material presentation and data completeness varied across different publications, lacking sufficient homogeneity.

CONCLUSIONS

The implementation of telemedicine diagnostic methods in clinical practice contributes to the early detection of ASD, enhancing the timeliness and effectiveness of medical and corrective interventions. In Russia, given the country's significant geographical expanse, the adaptation and practical implementation of developed foreign remote diagnostic tools, as well as the creation of domestic analogues, are highly relevant.

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Oleg Khairetdinov & Lusiena Rubakova: literature review, data analysis, manuscript writing.

Marina Pavlova: data analysis and manuscript writing.

Eva Asatryan & Giuseppe Tavormina: data analysis, manuscript writing.

Andrey Vlasov: literature review.

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