Analyzing Health Care Provision for ASD Toddlers in Hospitals of Pakistan: A Case Study of Rawalpindi and Islamabad

By

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Declaration

I, Nimra Qaisar confirm that this thesis titled “Analyzing Health Care Provisions for ASD Children in Hospitals of Pakistan : A Case Study of Rawalpindi and Islamabad” presented for the degree of Master of Science in Bioinformatics, has been composed entirely by myself. This Thesis is based on exclusively the result of my own work. My present thesis has not been submitted for any other degree or professional qualification.

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Acknowledgements and Dedication

First and foremost, I express my deep gratitude to Allah Subhan o Talah. His constant presence and guidance have been instrumental in my journey, providing me with the right opportunities and connecting me with the right people. Alhamdulillah, I am grateful for everything. I am blessed to have Him in my life.

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Annex A to NUST Letter No. 0972/102/Exams/Thesis-Cert dated 23 Dec 16.

THESIS ACCEPTANCE CERTIFICATE

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List of Abbreviations

ASD	Autism Spectrum Disorder
DSM-5	Diagnostic and Statistical Manual of Mental Disorders-Edition 5-Text Revised
ADOS-2	Autism Diagnostic Observation Schedule Version-2
SIC	Social Interaction and Communication
RRB	Restricted and Repetitive Behavior
QCHAT-10	Quantitative Checklist for Autism in Toddlers
SCQ	Social Communication Questionnaire
AQ	Autism Quotient
ADI-R	Autism Diagnostic Interview Revised
CARS	Childhood Autism Rating Scale

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Abstract

Autism Spectrum Disorder (ASD) represents a neurological condition characterized by deficits in social communication, social interaction, and the presence of restricted and repetitive behaviors. The diagnosis of ASD has presented challenges, as it relies primarily on observational assessments of symptoms. Various screening and diagnostic tools are available for ASD assessment, such as QCHAT-10, QCHAT-25, AQ-10, SCQ, ADOS-2, ADI-R, and CARS etc. However, the heterogeneity of these tools has posed serious challenges for professionals, psychiatrists, and individuals with ASD, affecting their quality of life. Thus, standardization of these tools based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revised (DSM-5), is vital for efficient ASD diagnosis.

To address these challenges the study is divided into of four sections. The first section analyzes healthcare provisions and tools used for assessing ASD in Pakistan, while also exploring local trends and tendencies related to ASD diagnosis. The second section establishes the content mapping of ADOS-2 on standard reference guide DSM-5, highlighting its strengths and limitations. The third section involves the development of ADOS-2 screening guidelines (ADOScan1, ADOScan2, and ADOScan3) based on modules 1, 2, and 3 of ADOS-2, ensuring comprehensive coverage of the DSM-5. Finally, the fourth section focuses on developing a web application that aligns any ASD assessment or diagnostic tool on DSM-5. This application categorizes questions into seven subcategories of the DSM-5, providing graphical and tabular outputs to identify strengths and areas for improvement in screening or diagnostic tools.

The study's results demonstrate that ADOS-2 falls short in comprehensively addressing the designated domains within DSM-5, particularly in the areas of relationship development and restricted behavior. This underscores the significance of implementing countermeasures to address these areas and revising the structural configuration of the tool. Moreover, examination of the local dataset reveals that the mean age for autism diagnoses in Pakistan is 7.6 years, suggesting potential gaps in public awareness. Therefore, the creation of a web application alongside DSM-5-aligned ADOS-2 screening guidelines signifies a proactive stride in enhancing awareness among caregivers, educators, healthcare practitioners, specialists, researchers, and tool developers. This initiative not only streamlines the diagnostic process but also promotes early interventions for those with ASD, ultimately fostering an improvement in their quality of life.

CHAPTER 1

INTRODUCTION

Autism Spectrum Disorder (ASD) is a growing neurological disorder characterized by impaired social communication and interaction, as well as restricted and repetitive behaviors, according to the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, Text Revision (DSM-5-TR) [1]. ASD is a complex disorder, and its exact causes are not yet fully understood. However, recent research suggests that both genetic and environmental factors play a role in its development [2]. Autism is one of the rapidly growing disorders in the world. As per the World Health Organization (WHO) report, 1 in 100 children is autistic worldwide [3] [4]. Even in the US, 1 in 36 children is prone to ASD as per the Centers for Disease Control and Prevention (CDC) report 2020 [5] [6].

1.1. ASD Diagnosis

Diagnosing ASD poses a challenge due to the absence of a standardized clinical, medical, or laboratory test [7]. Typically, psychiatrists and clinical professionals rely on subjective assessments using self-administered tools or questionnaires for labeling individuals with ASD.

The challenges associated with diagnosing ASD encompass issues such as misdiagnosis, delayed diagnosis, and excessive diagnosis. These issues significantly impact the early provision of high-quality treatment to individuals undergoing diagnosis, which is crucial for enhancing their prospects of leading stable and typical lives. These problems arise primarily from the absence of standardized assessment tools for professionals, including clinicians, and the non-technical guides for parents/guardians, school counselors, and healthcare providers among others. The lack of uniformity among the available diagnostic tools raises doubts regarding diagnostic accuracy or, in some cases, the absence of a diagnosis altogether. To address this situation, the implementation of a standardized tool validated against established criteria, such as the current DSM-5-TR, is crucial.

1.2. Screening and Diagnostic Tools for ASD

Numerous screening and observational assessment tools are available for the diagnosis of ASD. Some notable options include the Autism Diagnostic Observation Schedule-Second Edition (ADOS-2) and Autism Diagnostic Interview Revised (ADI-R) [8]. Additional choices encompass the Child Behavior Checklist (CBCL) [9], Autism Spectrum Quotient (AQ) [10], Childhood Autism Rating Scale (CARS) [11], and Checklist for Autism in Toddlers (CHAT) [12]. The comprehensive details of the screening and diagnostic tools are given Table 26 [13] and Table 27 [14] in Appendix A.

Among the aforementioned tools, ADOS-2 holds widespread recognition in both literature and clinical settings [15]–[17]. ADOS-2 is a semi structured observational assessment tool that aids in diagnosis of ASD individuals over a life span. It is regarded as the global gold standard [18] and has demonstrated favorable sensitivity (92-100%) and specificity (61-65%) in various populations [19]–[21].

However, ADOS-2 does possess certain limitations. One such limitation is the approximate administration time, which typically takes around 1 hour. Furthermore, ADOS-2 is not open-sourced, meaning that access to the tool is restricted. Proper training is required to administer the ADOS-2 effectively, as it necessitates specialized knowledge and expertise. Another drawback is the absence of comprehensive guides for parents/guardians, school counselors, health workers, or general physicians regarding the utilization of ADOS-2. The lack of these guides hinders the ability of these individuals to screen ASD using standardized methods and subsequently refer them to appropriate professionals for further evaluation.

1.3. Problem Statement

The lack of the content validation of the gold standard ADOS-2 on standardized DSM-5 criteria hinders the efficacy of ASD diagnosis, creating uncertainty in accurately identifying individuals with ASD.

1.4. Objectives

1. The primary objective of this study is to establish a comprehensive mapping between each interrogatory factor utilized in ADOS-2 and the diagnostic criteria outlined in DSM-5.
    a. This mapping endeavor seeks to assess the content validity of ADOS-2's core factors, thereby ensuring their alignment with the well-established diagnostic criteria for ASD.
    b. To analyze any potential gaps in the coverage of ADOS-2, if present, and determine the significance of these areas in relation to the DSM-5 criteria for ASD diagnosis.
2. This study seeks to introduce simple, comprehensive, and efficient observational guidelines based on ADOS-2. These guidelines are specifically designed for parents/guardians, school counselors, teachers, healthcare workers, and other relevant stakeholders.
3. Furthermore, our study aims to develop a web-based application that will enable the mapping of various ASD assessment and diagnostic tools onto the DSM-5 criteria.

1.5. Local and Global Advantages:

As stated previously, ADOS-2 holds the position of being a globally recognized gold standard for diagnosing ASD, with widespread implementation both internationally and within Pakistan. Conducting a mapping and analysis of ADOS-2 content against standard criteria presents several advantages:

1.5.1. Standardization

a) Standardizing ADOS-2 will enhance its efficiency for ASD diagnosis.
b) This standardization has the potential to reduce the number of misdiagnoses.

1.5.2. Awareness

a) Developing ADOS-2-based screening guidelines will increase stakeholders' awareness of the disease.

b) This development will facilitate a smoother transition from screening to diagnosis, streamlining diagnostic procedures.
c) Supporting early intervention through streamlined procedures ensures a better quality of life for individuals with ASD.
d) The web application will serve as a valuable resource for researchers and professionals, offering a standardized platform to validate existing tools or create new ones based on established instructions.
e) By incorporating this technological component, we anticipate enhancing the effectiveness and accuracy of ASD diagnosis.

In conclusion, this study encompasses three essential steps: validating the content of ADOS-2 against DSM-5 criteria, developing comprehensive observational guidelines, and creating a web-based application for mapping ASD assessment tools onto DSM-5 criteria. By undertaking these initiatives, we aim to strengthen the diagnostic process for ASD, ultimately leading to improved outcomes and a higher quality of life for individuals on the autism spectrum.

CHAPTER 2

LITERATURE REVIEW

In this section we will be initially focusing on ADOS-2, its historical development, and its implementation in clinical settings.

Next, we will explore the importance of the standard criteria for diagnosis outlined in the Diagnostic and Statistical Manual of Mental Disorders - Fifth Edition (DSM-5). We will highlight how the lack of content validity in these tools contributes to variations among the different assessment instruments available.

To conclude this section, we will introduce our efforts to address a gap we have identified in the existing literature. We will explain how our work aims to fill this gap and contribute to the understanding and improvement of diagnostic and screening tools for ASD.

2.1. ADOS-2

ADOS-2 is an activity-based diagnostic tool comprising five modules, each specifically designed for different age ranges and language/speech abilities. The Toddler module is for children aged 12 to 30 months, Module 1 is for children with limited or no language ability but older than toddlers, Module 2 is for individuals with some speech but not fluent, Module 3 is for individuals with fluent speech aged 12-16, and Module 4 is for adolescents and adults with fluent speech and communication skills [22].

The administration of ADOS-2 typically takes approximately 60 minutes. During the assessment, the examiner evaluates the child's behavior in various contexts by engaging them in different activities and utilizing toys. Additionally, the examiner assigns scores based on the severity of symptoms exhibited by the individuals, aiding in the determination of their diagnostic classification.

ADOS, initially developed in the 1980s by Catherine Lord and Eric Schopler at the University of Chicago [23], was primarily intended for diagnosing ASD in individuals with conversational abilities. Over time, ADOS evolved and introduced the Pre-linguistic ADOS (PL-ADOS) in the

1990s for children with non-verbal speech aged 2-5. In 2000, ADOS-Generic (ADOS-G) was developed to assess individuals with verbal abilities across different age groups. This version introduced the four modules currently in use, which share some questions but differ in activities and language abilities based on age [24].

As early intervention showed positive effects on the lives of children with ASD, ADOS-G was updated to ADOS-2 in 2012. The new version included a toddler module and four modules for diagnosing children aged 12-30 months with limited verbal abilities. ADOS-2 has since been utilized to efficiently diagnose children using appropriate modules [22].

In conclusion, ADOS has undergone several developments and updates since its inception in the 1980s, becoming an essential tool for diagnosing ASD in individuals with different language abilities and age groups.

2.2. DSM-5 Standard Criteria

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), was initially published in 2013, and a revised version was released on March 2, 2022 [1]. For the sake of clarity, we will refer to the revised version as DSM-5. DSM-5 serves as a standardized reference used by professionals to diagnose various mental disorders, including Autism, by assessing the mental and behavioral characteristics.

According to the diagnostic criteria outlined in DSM-5 for ASD, individuals are evaluated based on two main domains: social and communication interaction, and restricted and repetitive behavior. The guidelines state that individuals with ASD should exhibit symptoms in all three categories within the social and communication interaction domain, namely, Social-Emotional Reciprocity, Non-Verbal Communicative Behaviors and Developing and Maintaining Relationships. Moreover, ASD individuals should exhibit symptoms in at least two out of four categories within the restricted and repetitive behavior domain, namely, Stereotyped or Repetitive Behavior, Unusual Fixated Interests, Restricted behavior and Hypo or Hyper Reactivity [1]. More detailed information about these domains and their respective categories can be found in [25].

In studies, validation methods are employed to assess the psychometric properties of tools ,including sensitivity, specificity, positive predictive value, and negative predictive value [26]. However, there is a limited amount of research in which these tools are mapped onto the standard DSM-5 criteria to validate whether they adequately cover all the diagnostic criteria specified in DSM-5 for identifying individuals with ASD. This lack of content validity in globally utilized tools may be a potential cause of delayed diagnosis, misdiagnosis, or absence of diagnosis altogether.

To the best of our knowledge there are only two studies that have compared the ADOS-2 with DSM-5. In Study [27], the author examined four participants who had received an autism diagnosis using ADOS-2. However, when these same participants were assessed using the DSM-5 criteria, all of them were classified as non-autistic.

Another study [28] focused on assessing the content validity of ADOS-2, the 3di, and DISCO instruments in relation to the DSM-5 criteria. The findings from this study suggest that these instruments do not fully encompass all the symptoms of ASD as specified in the DSM-5 criteria.

These studies did not provide a comprehensive analysis of the specific areas within ADOS-2 that do not align with DSM-5 criteria. Therefore, there is a requirement for a comprehensive mapping analysis of ADOS-2 on DSM-5 to identify areas that require improvement.

We performed an analysis of QCHAT-10, one of the widely used screening tools in literature for early ASD screening in toddlers and commonly employed in machine learning studies [29]–[35]. We mapped the 10 questions of QCHAT-10 to the aforementioned DSM-5 criteria. The results indicated that all the questions in QCHAT-10 only belong to the first domain of DSM-5 criteria, which is Social Interaction and Communication. Consequently, we concluded that there is a need to establish content validity of comprehensive and widely used diagnostic tools like ADOS-2 based on the DSM-5 standard criteria. The QCHAT-10 mapping analysis is presented in Table 28 in Appendix B.

During our literature search we encountered the fact that there is a dearth of comprehensive guides available for parents, school counselors, healthcare workers, or general physicians based

on ADOS-2. This lack of guides hampers their ability to screen for ASD using standardized methods and subsequently refer individuals for further evaluation by appropriate professionals.

Our research extensively explored the availability of automated applications capable of categorizing ASD assessment questions into DSM-5 subcategories. However, to the best of our knowledge, no such application currently exists.

2.3. Gap Analysis

Consequently, we have identified several gaps during our comprehensive literature review:

1. Lack of validation of screening and diagnostic tools against standardized criteria: There exists a heterogeneity among the pool of screening and diagnostic tools for ASD, which highlights the need to investigate their content validity based on standardized criteria.
2. Absence of validated simple screening questionnaires based on ADOS-2: Currently, there is a dearth of validated, user-friendly screening questionnaires that are specifically based on the ADOS-2 and have been evaluated against standardized criteria.
3. Non-availability of automatic mapping application: There is a notable absence of application applications that can perform content matching and categorization of ASD assessment tools into the categories and subcategories specified by the DSM-5.

Identifying these gaps is essential for highlighting areas of improvement and potential avenues for future research in the field of ASD assessment and diagnosis. By addressing these gaps, we aim to enhance the validity, accessibility, and efficiency of ASD assessment processes.

CHAPTER 3

MATERIALS AND METHODS

This section encompasses the materials and methods employed in our study to achieve the desired outcomes. It commences with an explanation of the participant dataset and the adopted data analysis approach. To fulfill our initial objective of mapping ADOS-2 items onto DSM-5 subcategories, we elucidate the mapping procedure and describe the ADOS-2 items utilized. Moving forward, we outline the methodology employed for our second objective, which involved the development of ADOS-2 Screening Guidelines referred to as ADOScan1, ADOScan2, and ADOScan3 for the respective modules of ADOS-2. Within this section, we provide a comprehensive account of the development process. Additionally, we elucidate the process involved in creating the DSM-5 Mapping Application, named AutiMap, in the subsequent section.

3.1. Data Analysis

Participants:

Our study involved 28 individuals diagnosed with ASD within the age range of 3 to 16 years. The data of these individuals was collected from Benazir Bhutto Hospital in Rawalpindi. The data spanned a one-year period from February 2022 to February 2023. The diagnosis of ASD was made by a team consisting of two MBBS child psychiatrists and a psychologist. The assessment tools employed included the Autism Diagnostic Observation Schedule-2 (ADOS-2), which served as a standardized measure for evaluating ASD in individuals. Additionally, a developmental history was obtained from the parents, and sound and speech tests were conducted on the participants. The patient data was documented in ADOS-2 sheets and stored in a file.

Dataset: The dataset has been divided into three modules of ADOS-2.

Module 1 of ADOS-2 comprises a total of 23 items and 14 instances. Among these, 21 are quantitative variables, while 2 are categorical variables. Within the 16 interrogatory items, there

are two distinct domains: Social Affect (SA) and Restricted and Repetitive Behavior (RRB). The SA domain encompasses 11 questions, while the RRB domain includes 5 questions. Additionally, the analysis considers two variables: Age and Gender.

The SA Score, RRB Score, and Total Score (which is the sum of SA Score and RRB Score) represent the overall scores for their respective domains. These scores serve as indicators of social affect and restricted and repetitive behavior. Moreover, a Comparison Score variable has been introduced as a scoring algorithm to determine the presence of ASD in the individuals. This score considers the Age and Total Score of the individuals being assessed.

Finally, the ASD Class variable has been categorized into four groups: High ASD, Low ASD, Moderate ASD, or No ASD. The assignment of a specific class to individuals is based on their respective Comparison Score, providing a classification of their ASD status.

Module 2 and 3 each encompass a total of 21 variables across 7 instances. Among these variables, 19 are classified as quantitative variables, while the remaining 2 are categorized as categorical variables. Within this set of variables, 14 are identified as interrogatory factors, which are further divided into two distinct domains: SA and RRB. The SA domain comprises 10 questions, whereas the RRB domain consists of the remaining 4 questions. The remaining variables and the scoring algorithm employed in these modules are identical to those utilized in Module 1.

Analysis: We eliminated extraneous variables, such as SA Score and RRB Score, by consolidating them into a single variable called Total Score. Subsequently, we conducted a thorough examination for missing values and spelling errors. Our investigation revealed the absence of any missing values and spelling errors within the dataset.

Descriptive statistics, including the total number of instances, mean, standard deviation, skewness, kurtosis, minimum, and maximum values, for the quantitative variables, were examined using JASP software [36].

During the exploratory data analysis (EDA) phase, we assessed the distribution of quantitative variables, namely Age, Total_Score, and Comparison_Score, by generating histograms along with a normal curve. For the categorical variables "Gender" and "ASD Class," we employed

individual bar charts for visualization. Additionally, we represented the relationships between categorical variables and both quantitative and categorical variables using grouped bar charts. The info graphics were generated using SPSS software [37] .

3.2. Mapping of Items

All the items in ADOS-2 modules 1, 2, and 3 have been compared with DSM-5 sub-categories. Module 1 comprises a total of 15 questions, while modules 2 and 3 consist of 14 questions each. Within DSM-5 criteria, there are two main domains and seven sub-domains. The keywords associated with each interrogatory factor have been carefully matched with the corresponding description of each sub-category. It is important to note that this mapping process was subjective and performed manually. To the best of our knowledge, no application currently exists for automatic mapping. A comprehensive explanation of each sub-category is provided in this document [25].

3.3. ADOScan Development

We developed a set of comprehensive guidelines based on the ADOS-2, modules 1, 2, and 3, namely ADOScan1, ADOScan2, and ADOScan3 respectively. These guidelines consist of questionnaires designed to assess individuals with the disease. Each questionnaire comprised 15 questions divided into three sections mirroring the structure of the ADOS-2. The first two sections, social communication, and social interaction, fall under broader domains of Social Interaction and Communication. The third section focuses on restricted and repetitive behaviors.

Within each section, there are five questions, making a total of ten questions for the Social Interaction and Communication domain and five questions for the restricted and repetitive behavior domain. This division aligns with the DSM-5 criteria for diagnosing autism, which stipulates that individuals should exhibit symptoms from all categories within the Social Interaction and Communication domain, and at least 50% of symptoms from the restricted and repetitive behavior domain. Consequently, the final section contained 50% fewer questions than the previous section [1].

To develop these guidelines, we relied on ADOS-2 modules 1, 2, and 3 technical and professional score sheets as our foundation [38]–[40]. Additionally, we referenced the Social Communication Questionnaire (SCQ) [41], Autism Quotient-10 (Child, Adolescent, and Adult versions) [10], [42], [43], and Quantitative Checklist for Autism in Toddlers (QCHAT-10 and QCHAT-25) [44], [45]. These reference questionnaires were selected based on their robust psychometric properties, high sensitivity, specificity, as well as their content readability, simplicity, and comprehensiveness [43], [46], [47].

To evaluate the similarity between our guidelines and reference questionnaires, we calculated a similarity score using the Jaccard distance metric. Jaccard distance, a measure of dissimilarity between two sets, is commonly employed in computational mathematics, data analysis, information retrieval, and natural language processing [48]. In our context, we utilized this measure in natural language processing to determine the similarity between the contents of our guide questionnaires and reference questionnaires. This involved comparing and matching keywords present in both sets. Tables XVII, XX, XXIII, of each module guide present the common keywords and their respective similarity scores for the guide and reference questionnaires.

To validate the content of our guidelines, we employed a self-created web-application tool (AutiMap) to assess the coverage of DSM-5 subcategories within the questions. Tables XVIII. XXI, XXIV, display the questions in our guides alongside the DSM-5 subcategories to which they belong, organized by module.

Furthermore, we developed a scoring algorithm for our guides similar to the ADOS-2 scoring algorithm. Each question allowed for three possible responses:0, 1, or 2, depending on the observed behavior. "Not at all" or "Rarely" indicates the absence of the behavior, "Occasionally" or "Inconsistently" suggests infrequent manifestation, and "Consistently" or "Frequently" signifies frequent occurrence of the behavior. A comprehensive guide detailing the scoring of each question based on the chosen response option is provided at the conclusion of each module guide. The merits and demerits of the ADOScans are given in Table 1.

The scoring algorithms for the items in ADOScan 1, 2, and 3 were identical. The items within the Social Interaction and Communication sections had negative scores. This implies that the

response "Not at all" or "Rarely" is assigned the highest score of 3, while the answer "Consistently" or "Frequently" is given the lowest score of 0. In contrast, items within the restricted and repetitive behavior sections scored positively. In this instance, the first option was given a score of 0 and the last option was given the maximum score of 3. The screening guides are given in Figures 15, 16, and 17 in Appendix C.

TABLE 1 MERITS AND DEMERITS OF ADOSCANS

Sr. no	Merits	Demerits
1.	These guidelines are designed to be easily understood and accessible to individuals seeking to assess their children for ASD.	These guidelines have not yet undergone testing on a population to ascertain their psychometric properties, including sensitivity, specificity, and accuracy.
2.	They have been developed based on the internationally recognized diagnostic method ADOS-2 and incorporate keywords derived from popular ASD screening tools.	Additionally, these guidelines do not currently include a predefined cutoff score, as this is yet to be determined.
3.	These guidelines have the potential to enhance public awareness of ASD and contribute to early diagnosis.	The accuracy and applicability of these guidelines across diverse populations are still under investigation.
4.	Notably, these guidelines are mapped onto the criteria outlined in DSM-5, distinguishing them from other available screening guidelines.	
5.	These guidelines also encompass the domain of developing and maintaining relationships, which distinguishes them from the ADOS-2.	

3.4. Web-Application Development

AutiMap was developed to facilitate the alignment of questions pertaining to ASD assessment with the standardized diagnostic criteria outlined in DSM-5. This application utilizes keyword matching logic, wherein keywords from the questions are compared against a DSM-5 category database. Subsequently, the application provides the subcategory/subcategories within DSM-5 that correspond to the given question, along with the matched keywords from the category description. In this section, we will discuss the application's development process, including the creation of the database, the underlying code logic, the application's inputs and outputs, and the user interface.

3.4.1. Database Development and Code logic

The database for this application was constructed using an MS Excel workbook [49]. It comprised of two columns, where the first column represented the category names, and the second column contained the corresponding category descriptions. The database was further enhanced by incorporating commonly used keywords from ASD assessment questionnaires such as AQ-10 (Child, Adolescent, Adult) versions [10], [42], [43], QCHAT (QCHAT-10, QCHAT-25) versions [44], [45], and SCQ [41]. To optimize the database, redundant words were removed, and only unique words for each category were retained. Pronouns and certain stop words were eliminated, while lemmatization was applied to ensure the words were in their original form. Additionally, special characters were removed from the descriptions to cleanse the database, rendering it ready for use.

The code logic was developed using the Python programming language [50] and the Jupyter Notebook environment [51]. Natural Language Processing (NLP) capabilities were incorporated using the NLTK library to facilitate keyword matching [52].

Step 1: The code preprocesses both the user question and the category description by tokenizing the text, removing stop words, lemmatizing the tokens, and eliminating special characters, among other preprocessing steps.

Step 2: Synonyms of each word in the user question are obtained, thereby increasing the likelihood of keyword matching. This step enhances the application's versatility in matching user questions to specific categories.

Step 3: The code matches the user's question with category descriptions by comparing similar keywords. It examines each word in the user's question and compares it against the database. The application stores the matching keywords and their corresponding category names. Next, it tallies the number of matching keywords and assigns the question to the category with the highest count. If multiple categories have an equal number of matching keywords, the application provides the names of all those categories to which the question could belong. This code logic was integrated into a web-based application known as the AutiMap.

Given that the coding was done using the Python programming language, the web application was developed using the corresponding Flask web framework [53]. Visual Studio Code served as the integrated development environment (IDE) [54]. The web interface was designed using HTML, with CSS employed for styling [55], [56].

3.4.2. Application Functionality

Input: The application initiates by prompting the user to select their desired input type. The user is presented with two options: either to input their question directly into a text bar or to upload a text file (.txt) containing multiple user questions. These input styles are visually represented in Figure 1. In the first option, users are requested to write their questions related to ASD in the provided text bar. Additionally, they are required to input the indices of their questions in either numerical or alphanumeric format, as illustrated in Figure 2. For the second option, users are instructed to upload a text file from their personal computer, and they are also required to input the corresponding indices of their questions in either numerical or alphanumeric format, as depicted in Figure 3.

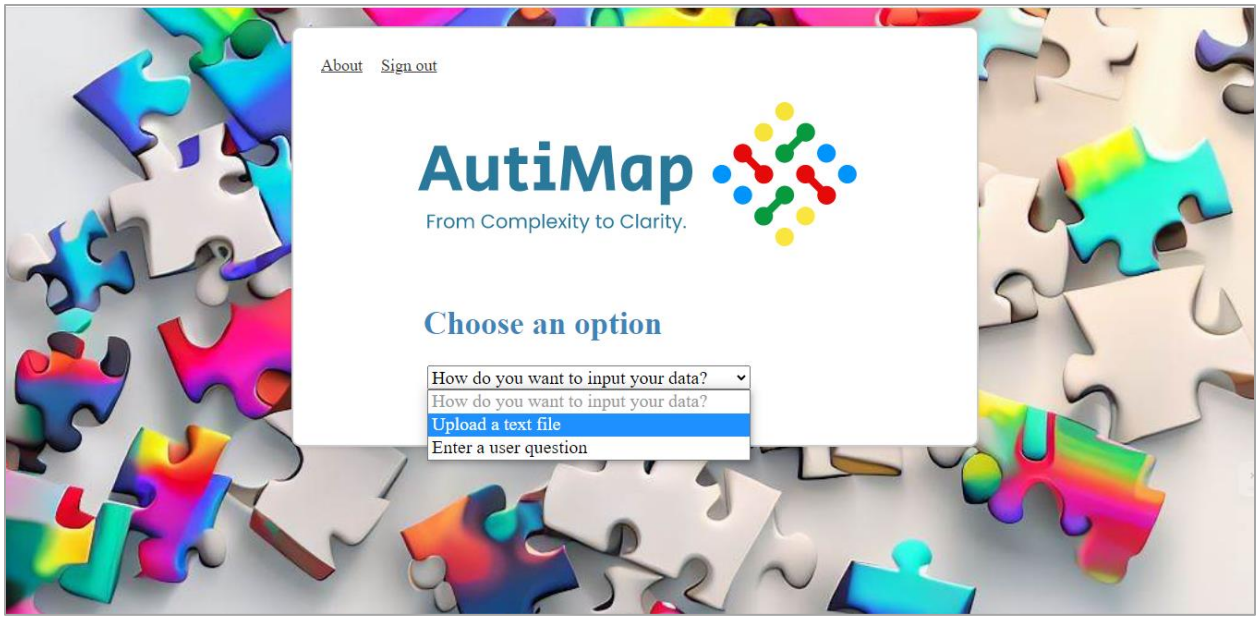


Fig. 1. The Input Choice of Users in AutiMap

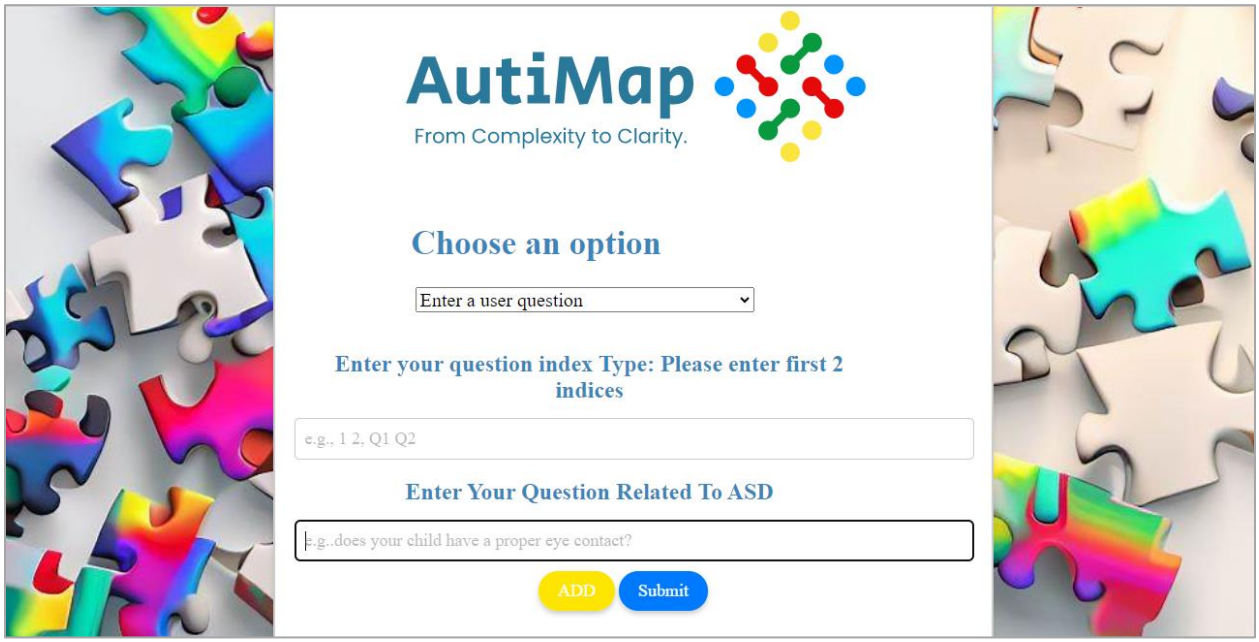


Fig. 2. The Question Input Section of AutiMap. The user is required to enter question indices following the input of user question. The ADD button in yellow color will allow the user to enter multiple simultaneously. The submit button will submit the results.

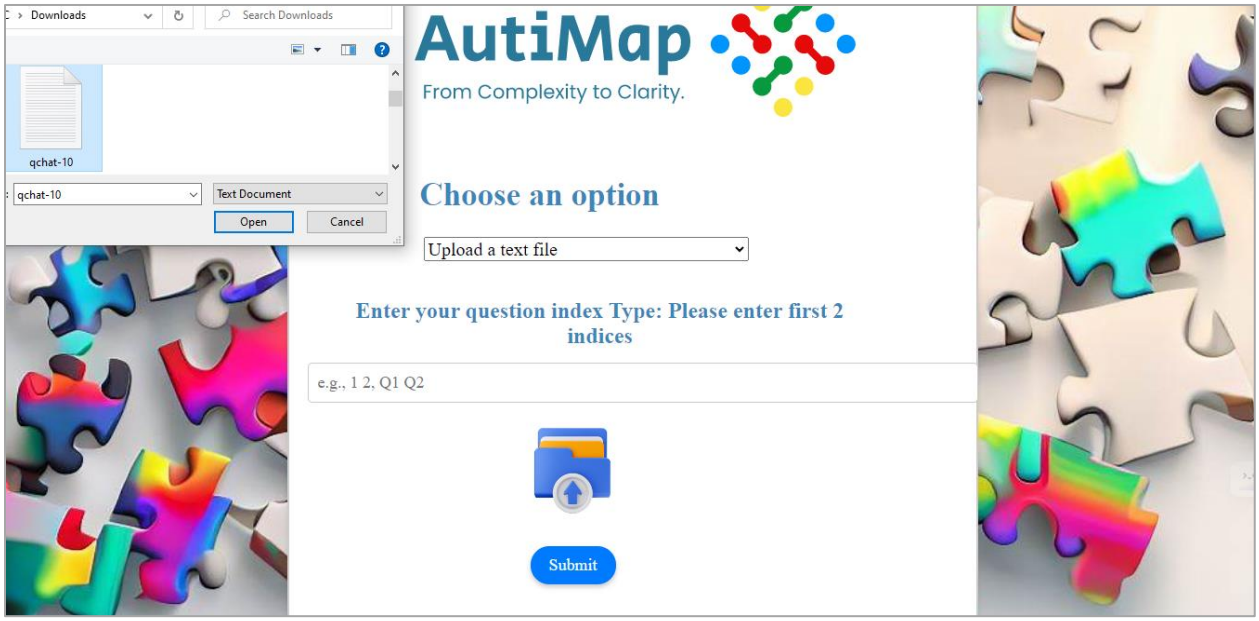


Fig. 3. File Upload AutiMap. The index column is shown above the file upload icon. This requires the user to enter the index of the type mentioned. The file upload icon in blue color will allow the user to upload file from their PC.

Fig. 3. File Upload AutiMap.

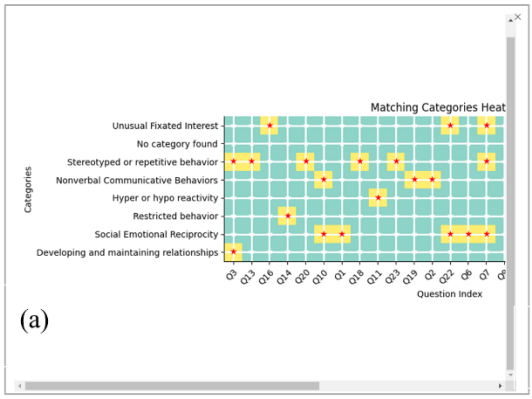
Output: Following the user's chosen input method, the results are displayed on the results page, as shown in Figure 4. The results page exhibits three distinct types of output presented to the user through individual cards. These cards are named "Heatmap," "Category Analysis," and "Result Table." In Figure 5, the three types of outputs are demonstrated.

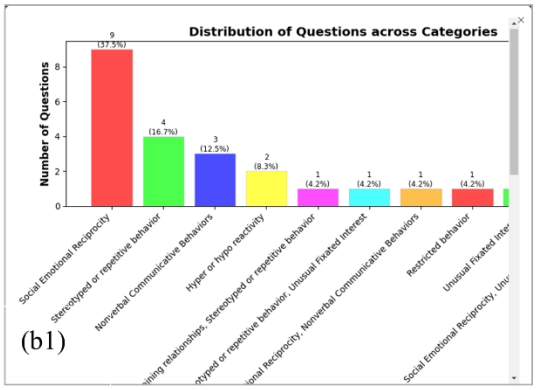
The "Heatmap" card features a heatmap that provides a summary indicating which question or questions belong to specific categories. The "Category Analysis" card showcases a bar graph representing the total number of questions present in each category. Additionally, it presents a category table arranged in ascending order, with the category having the highest question count displayed at the top.

The third card, referred to as the "Result Table," comprises four rows, namely "Question Index," "Question," "Matched Category," and "Matched Keywords." If the user's question does not match any category, the table will indicate "No matched category" or "No keyword" in the respective columns.

Furthermore, the application generates a download link for a Word document titled "Results.doc," enabling the user to retrieve the document. The content within the "Results.doc" file will mirror the results displayed on the page.

Fig. 4. Result Page AutiMap. Three Cards containing the corresponding outputs are displayed.





Category Counts Table

Categories	Question Count
Social Emotional Reciprocity	9
Stereotyped or repetitive behavior	4
Nonverbal Communicative Behaviors	3
Hyper or hypo reactivity	2
Developing and maintaining relationships, Stereotyped or repetitive behavior	1
Social Emotional Reciprocity, Stereotyped or repetitive behavior, Unusual Fixated Interest	1
Social Emotional Reciprocity, Nonverbal Communicative Behaviors	1
Restricted behavior	1
Unusual Fixated Interest	1
Social Emotional Reciprocity, Unusual Fixated Interest	1

(b2)

Index	User Question	Matched Category	Matched Keywords
Q1	Does your child look at you when you call his/her name?	Social Emotional Reciprocity	name, call, look
Q2	How easy is it for you to get eye contact with your child?	Nonverbal Communicative Behaviors	eye, contact
Q3	When your child is playing alone, does s/he line objects up?	Developing and maintaining relationships, Stereotyped or repetitive behavior	playing, line
Q4	Can other people easily understand your child's speech?	Social Emotional Reciprocity	speech
Q5	Does your child point to indicate that s/he wants something (e.g. a toy that is out of reach)	Social Emotional Reciprocity	want, point
Q6	Does your child point to share interest with you (e.g. pointing at an interesting sight)?	Social Emotional Reciprocity	interest, pointing, share, point, interest, sight
	How long can your child's interest be	Social Emotional	interest,

(c)

Fig. 5. Output AutiMap. (a) Heatmap card output displaying the categorization results. Categories are represented on the Y-axis, and question indices are depicted on the X-axis, indicating the correspondence between questions and categories. The red stars denote successful question-category matches. (b1) First segment of Category Analysis card output. The bar graph illustrates the distribution of questions among different categories. (b2) Second segment of Category Analysis card output. A tabular representation is presented, listing each category along with its respective question counts. (c) Result Table card output presenting a table containing questions, their corresponding matched DSM-5 subcategories, and matched keywords.

3.4.3. Application Users and Future Updates

The application has been specifically designed to cater to the needs of diagnostic professionals specializing in the disorder, researchers, and creators of ASD questionnaires. Diagnostic professionals can utilize this application to validate the content of their diagnostic tools against the criteria outlined in DSM-5, thereby gaining a comprehensive understanding of the standard criteria for diagnosing ASD. By incorporating this app into their practice, diagnostic professionals can enhance the validity and reliability of their diagnostic assessments.

Researchers can leverage this tool to validate the content of existing screening and diagnostic tools in relation to the standard criteria, enabling them to identify the strengths and weaknesses

of these tools. This additional validation step provides researchers with valuable insights and can potentially lead to improvements in the development of future assessment tools. Moreover, this approach offers an alternative to the conventional method of validation solely through psychometric measures, thereby augmenting the overall robustness of the research process.

Furthermore, ASD questionnaire/tools creators can effectively utilize this application to develop questionnaires that align with the standard criteria established in DSM-5. This approach promotes consistency and decreases heterogeneity among assessment tools, paving the way for the emergence of a globally standardized tool. By adhering to the standard criteria, the development of questionnaires can be enhanced, ensuring their effectiveness and validity across diverse populations.

Overall, this application serves as a valuable resource for diagnostic professionals, researchers, and ASD questionnaire creators, contributing to the advancement of ASD assessment and facilitating the establishment of globally recognized standards in the field.

The app has the potential for future enhancements, incorporating the following suggested updates:

1. The app will undergo expansion to be accessible via the internet, enabling users to access it conveniently from various devices and locations.
2. The app will be equipped to accept and process a wide range of file types, surpassing the current limitation of exclusively accepting text files. This enhancement will provide users with greater flexibility in uploading their assessment data.
3. Users will have the option to download files in multiple formats, extending beyond the current availability of only Word documents. This update will accommodate diverse user preferences and requirements for data exportation.
4. The database will undergo optimization to minimize instances of multiple category outputs. By refining the matching algorithms and criteria, the app will enhance its accuracy in assigning questions to specific categories, reducing any potential ambiguity.
5. Acknowledging that there are certain behaviors commonly observed in individuals with ASD that may not be explicitly covered in the DSM-5 standard criteria, the app will be augmented to incorporate such behaviors. This expansion will ensure that questions

related to these additional behaviors are included, allowing for a more comprehensive assessment of items.

6. Additionally, this app will integrate contextual understanding and artificial intelligence models to enhance the accuracy of categorization. By leveraging advanced algorithms and contextual analysis techniques, the app will be able to comprehend the nuanced context of the questions and database. This integration of context-awareness and artificial intelligence will significantly contribute to improving the precision and reliability of the categorization process.

By implementing these suggested updates, the app will become more versatile, user-friendly, and encompassing, further strengthening its effectiveness as a tool for ASD item analysis.

This application serves as a foundational tool for assessing the content validity of questionnaires used in diagnosing various observation-based diseases and disorders, including Attention-deficit/hyperactivity disorder (ADHD), Depression and Anxiety Disorders, Obsessive-Compulsive Disorder (OCD), and more. The approach employed in this application can be effectively utilized to develop similar applications, specifically designed for diagnosing diseases and disorders that rely solely on observational data. By leveraging this methodology, researchers and clinicians can enhance the accuracy and reliability of diagnostic tools across a wide range of conditions, ensuring alignment with the standardized diagnostic criteria, such as the DSM-5.

CHAPTER 4

RESULTS

4.1. EDA Module 1:

Data Distribution: Figure 6 presents the data distribution of qualitative and quantitative variables of Module 1. It is observed that the dataset comprises approximately three times as many males as females, suggesting a potential higher occurrence of ASD in males compared to females , as also evident by literature [57]. Additionally, the data indicates a higher number of individuals with moderate ASD compared to those with high and low ASD. This suggests that individuals assessed with module 1 may exhibit moderate ASD symptoms.

Analyzing the histograms of Age reveals a positive skewness, indicating a concentration of data towards the left side of the mean age (5.33). This is further supported by the skewness value of 1.417, as reported in Table 2 of descriptive statistics. These findings suggest that the dataset predominantly consists of individuals aged below 5 years. The curve demonstrates leptokurtosis, characterized by fat tails, as indicated by the positive kurtosis value of 1.5 presented in Table 2.

In the histograms of *Total_Score* and *Comparison_Score*, a slight negative skewness is observed with values of -0.4 and -0.2, respectively. Both variables exhibit leptokurtosis, with kurtosis values of 0.59. These results indicate that *Total_Score* and *Comparison_Score* variables are relatively closer to a normal distribution compared to the Age variable.

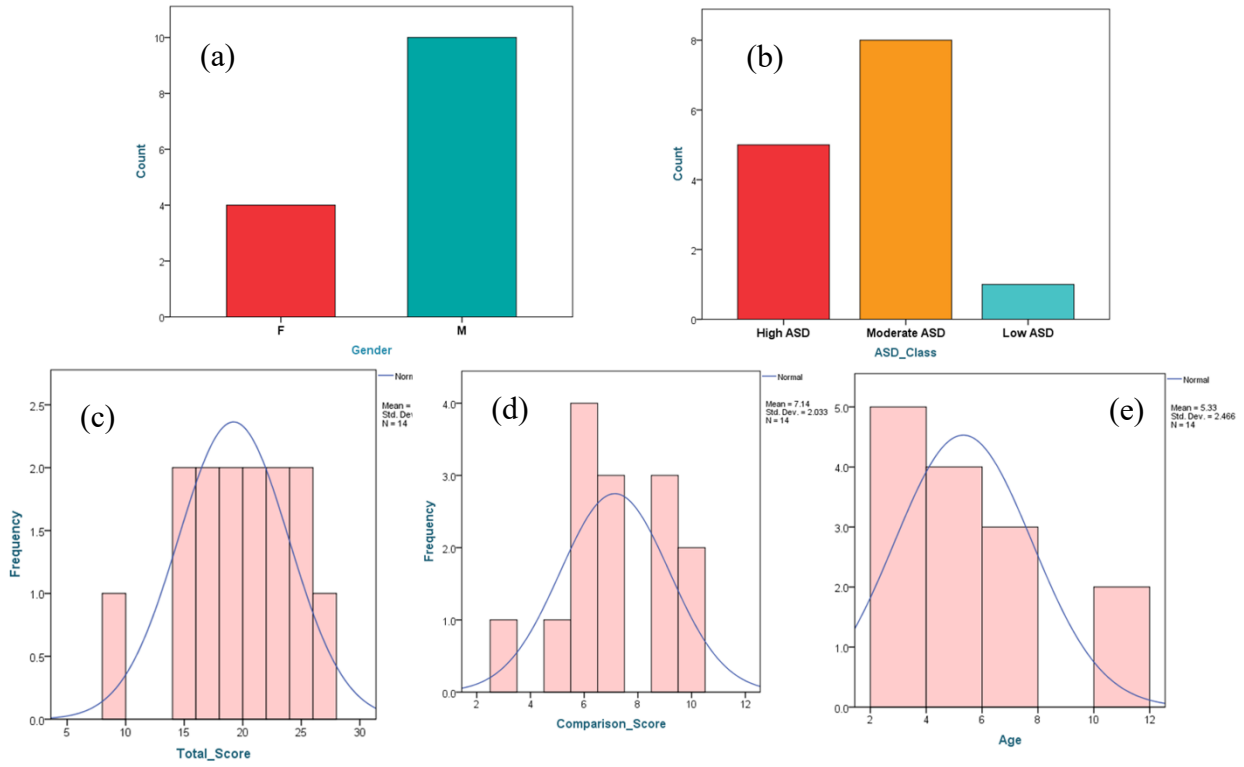


Fig. 6. Data Distribution Module 1. (a) The Gender data distribution graph. (b) The *ASD_Class* data distribution graph. (c) *Total_Score* histogram. (d) *Comparison_Score* histogram. (e) Age histogram.

Relationships: The relationships between categorical variables, quantitative variables, as well as between categorical and quantitative variables, were examined and depicted in Figure 7 and 8. Analysis of the *ASD_Class* vs. Gender graph shown in Figure 2 reveals that across all ASD class categories (High ASD, Moderate ASD, and Low ASD), males outnumber females. The grouped scatter plot of Age vs *Comparison_Score* and *Total_Score* demonstrates the absence of a linear relationship between Age and both score variables. Furthermore, the scatter plot of *Comparison_Score* vs *Total_Score* reveals a somewhat linear relationship between the two variables. However, the presence of different *Total_Score* values for the *same Comparison_Score* suggests that there may be additional variables, such as Age, that contribute to determining the *Comparison_Score*, as implied by the scoring algorithm of ADOS-2.

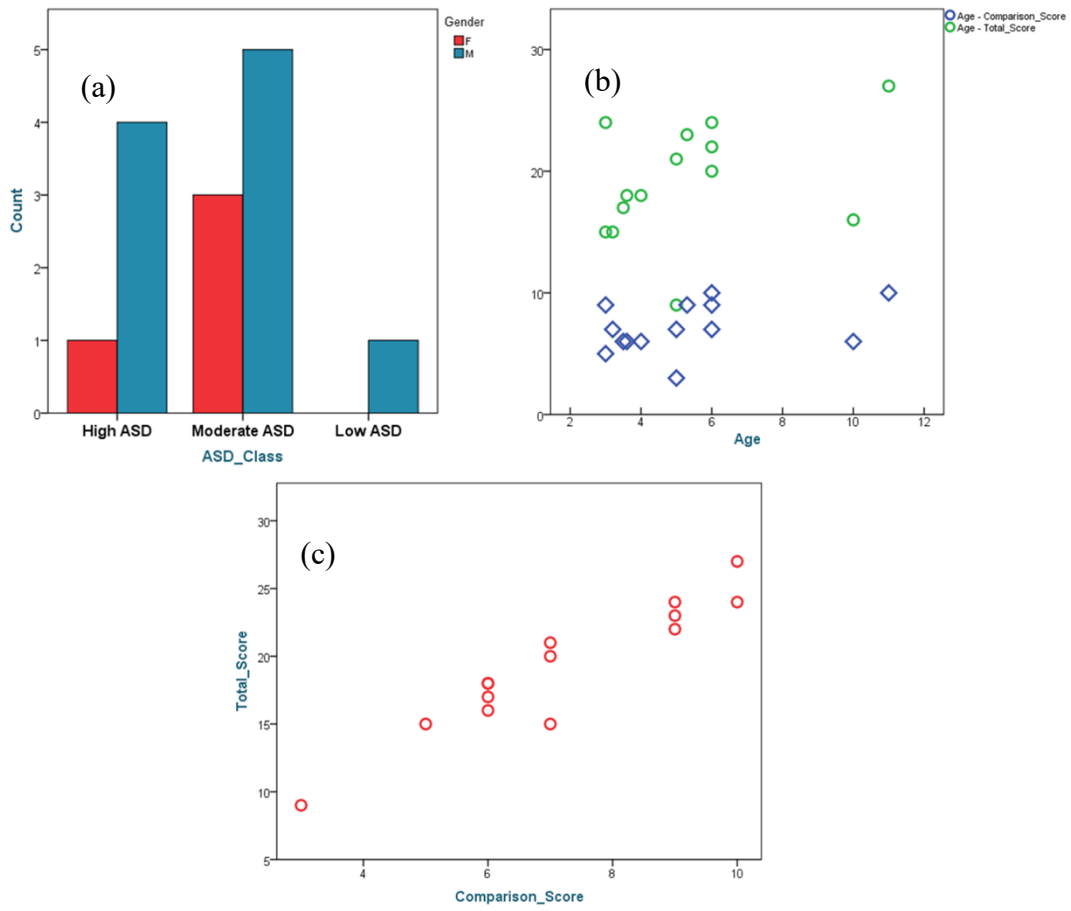


Fig. 7. Relationship Among Categorical Variables and Quantitative Variables of Module 1 (a) Grouped bar chart of *ASD_Class* vs Gender. (b) Scatter Plot of Age vs Comparison Score (blue diamonds) and Age vs *Total_Score* (Red Circles). (c) Scatter Plot of *Comparison_Score* vs *Total_Score*.

Moreover, as shown in Figure 8, the analysis of the relationship between *ASD_Class* and mean age indicates that individuals with High ASD have an average age of 6 years, while the other two categories consist of individuals with ages ranging from 4 to 4.5 years. These findings underscore the significance of early intervention for ASD, as individuals with lower or moderate symptoms can benefit from timely treatment, which may be more challenging in later stages when symptoms become more severe and pronounced [58].

Additionally, the relationship between *Total_Score* and *Comparison_Score* with *ASD_Class* was explored. It was observed that higher scores corresponded to more intense symptoms, aligning

with the High ASD class. Similarly, when examining the relationship between Gender and mean Age variables, it was found that males had a higher mean age of 5.5 years compared to females, whose mean age was 4.5 years. This suggests that males tend to receive a diagnosis at a later stage, despite exhibiting prominent and more frequent symptoms of the disease. Moreover, an analysis of the mean *Total_Score* and *Comparison_Score* by gender revealed that both genders displayed similar average scores.

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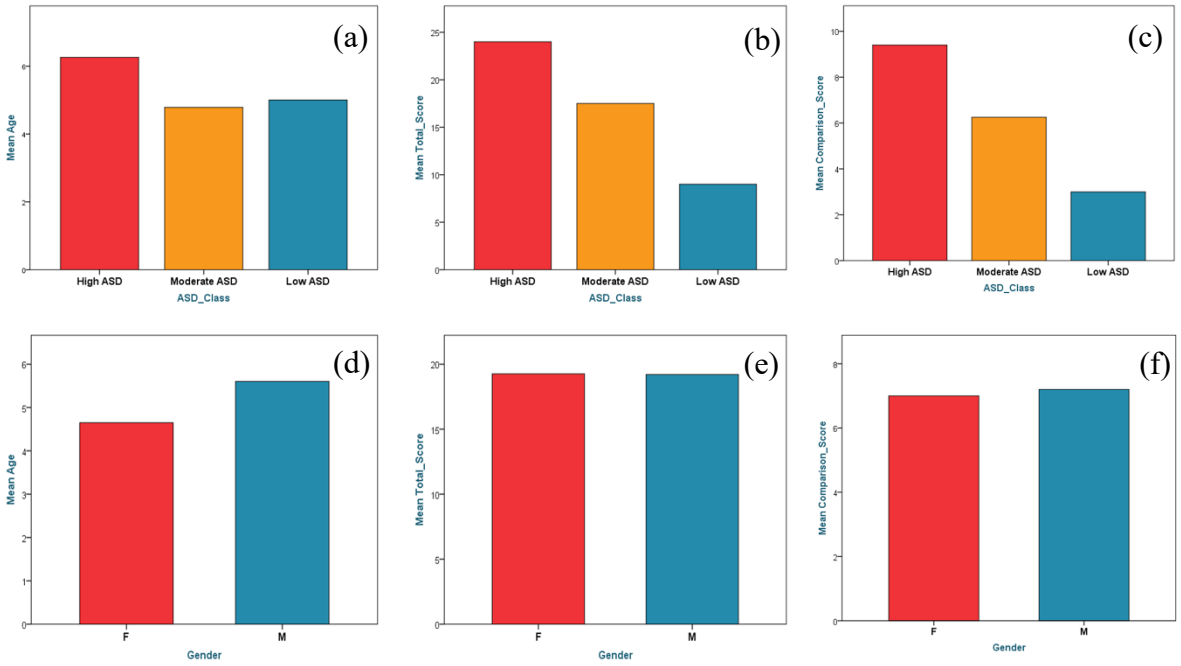


Fig. 8. Relationship of Categorical vs Quantitative Variables of Module 1. (a) *ASD_Class* vs Mean Age graph. (b) *ASD_Class* vs Mean *Total_Score* graph. (c) *ASD_Class* vs Mean *Comparison_Score* graph. (d) Gender vs Mean Age graph. (e) Gender vs Mean *Total_Score* (f) Gender vs Mean *Comparison_Score* graph.

TABLE 2 DESCRIPTIVE STATISTICS MODULE 1

	Valid	Missing	Mean	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
Age	14	0	5.329	2.466	1.417	0.597	1.504	1.154	3.000	11.000
A2	14	0	1.571	0.646	-1.303	0.597	0.951	1.154	0.000	2.000
A7	14	0	1.643	0.633	0.433	0.597	-0.394	1.154	1.000	3.000
A8	14	0	1.571	0.756	-1.526	0.597	0.936	1.154	0.000	2.000
B1	14	0	1.714	0.726	-2.295	0.597	3.792	1.154	0.000	2.000
B3	14	0	1.143	0.663	-0.151	0.597	-0.310	1.154	0.000	2.000
B4	14	0	1.571	0.646	-1.303	0.597	0.951	1.154	0.000	2.000
B5	14	0	1.429	0.646	-0.692	0.597	-0.252	1.154	0.000	2.000
B9	14	0	1.571	0.514	-0.325	0.597	-2.241	1.154	1.000	2.000
B10	14	0	1.786	0.426	-1.566	0.597	0.501	1.154	1.000	2.000
B11	14	0	1.429	0.646	-0.692	0.597	-0.252	1.154	0.000	2.000
B12	14	0	1.500	0.519	0.000	0.597	-2.364	1.154	1.000	2.000
A3	14	0	0.429	0.514	0.325	0.597	-2.241	1.154	0.000	1.000
A5	14	0	0.21	0.426	1.566	0.597	0.501	1.154	0.000	1.000

			4							
D1	14	0	0.286	0.469	1.067	0.597	-1.034	1.154	0.000	1.000
D2	14	0	0.357	0.745	1.874	0.597	2.087	1.154	0.000	2.000
D4	14	0	1.071	0.829	-0.145	0.597	-1.509	1.154	0.000	2.000
Total_Score	14	0	19.214	4.726	-0.416	0.597	0.244	1.154	9.000	27.000
Compari_Score	14	0	7.143	2.033	-0.225	0.597	-0.318	1.154	3.000	10.000

4.2. EDA Module 2:

Data Distribution: Figure 9 illustrates the distribution of data in both qualitative and quantitative variables. The bar graph representing *ASD_Class* reveals that most individuals in the dataset are diagnosed with High ASD. In the Gender bar graph, it is evident that there is a higher number of males compared to females.

The analysis of the Age histogram shows that the data exhibits a positive skewness with a value of 2.2. This indicates that the data is concentrated towards the right side of the mean, which is 6.7 years. Additionally, the curve demonstrates a high level of leptokurtosis, as indicated by the value of 5.4. The values can be found in Table 3. These findings suggest that a significant portion of individuals diagnosed using module 2 of ADOS-2 are younger than 6.7 years.

Furthermore, the histograms of *Total_Score* and *Comparison_Score* indicate that the data is negatively skewed, with values of -0.9 and -1.08, respectively. Both graphs display a platykurtic distribution, characterized by negative kurtosis values of 1.15 and 0.85. This suggests that the total scores and comparison scores of individuals exceed the mean values of 15 and 6, respectively.

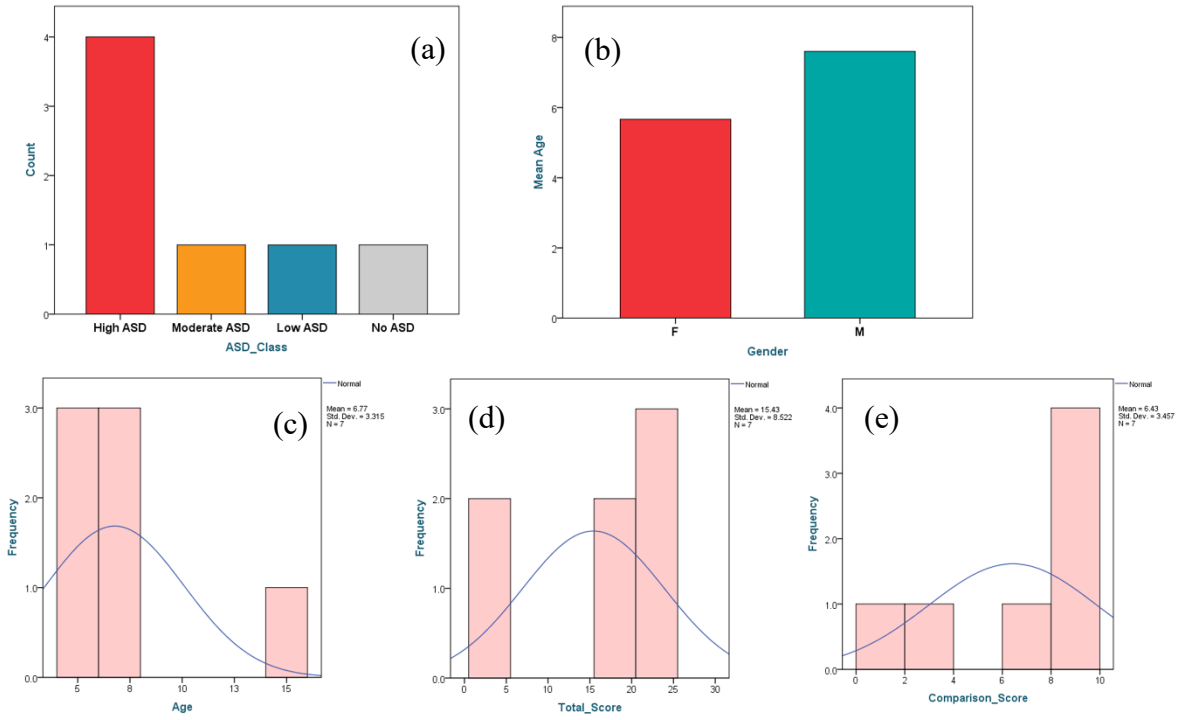


Fig. 9. Data Distribution Module 2(a) The Gender data distribution graph. (b) The *ASD_Class* data distribution graph. (c) *Total_Score* histogram. (d) *Comparison_Score* histogram. (e) Age histogram.

Relationships: Figures 10 and 11 present the relationships among qualitative variables, quantitative variables, and the combination of qualitative and quantitative variables. In Figure 10, the grouped bar chart of Gender vs *ASD_Class* reveals that females outnumber males in one of the *ASD_Class* category namely, High ASD.

The grouped scatter plots of Age vs *Total_Score* and *Comparison_Score* demonstrate that there is no linear relationship between these variables, indicating their independence from each other. However, the scatter plot of *Total_Score* vs *Comparison_Score* reveals a somewhat linear relationship initially, but at a *Comparison_Score* value of 8, the *Total_Score* becomes higher compared to higher values of Comparison_Score. This observation may suggest the presence of an outlier or indicate that the *Comparison_Score* is influenced by a combination of Age and *Total_Score* as per the scoring algorithm of ADOS-2.

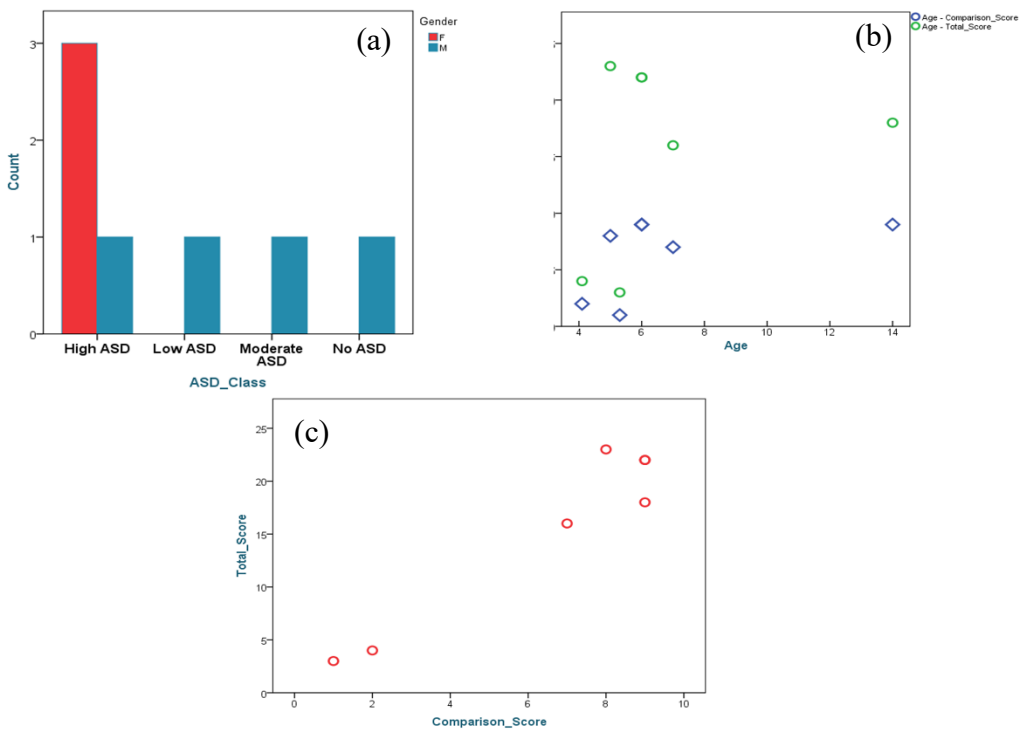


Fig. 10. Relationship Among Categorical Variables and Quantitative Variables of Module 2. (a) Grouped bar chart of *ASD_Class* vs Gender. (b) Scatter Plot of Age vs Comparison Score (blue diamonds) and Age vs *Total_Score* (Red Circles). (c) Scatter Plot of *Comparison_Score* vs *Total_Score*.

The analysis of quantitative vs quantitative variables is presented using bar charts in Figure 11. The ASD_Class vs Age graph indicates that individuals in the High ASD class tend to have higher ages compared to younger individuals, suggesting that delayed diagnosis is associated with more severe ASD symptoms.

The Bar graph depicting *Total_Score* and *Comparison_Score* vs *ASD_Class* illustrates that higher scores are associated with individuals falling into the High ASD category. This finding suggests a direct relationship between the Score variables and *ASD_Class.*

The Gender vs Age graph reveals that males have a higher average age compared to females, suggesting that males tend to receive a diagnosis at a later stage for unknown reasons, despite a higher occurrence of the disease in males.

Furthermore, the Gender vs Score variables bar graph indicates that females tend to have higher scores compared to males.

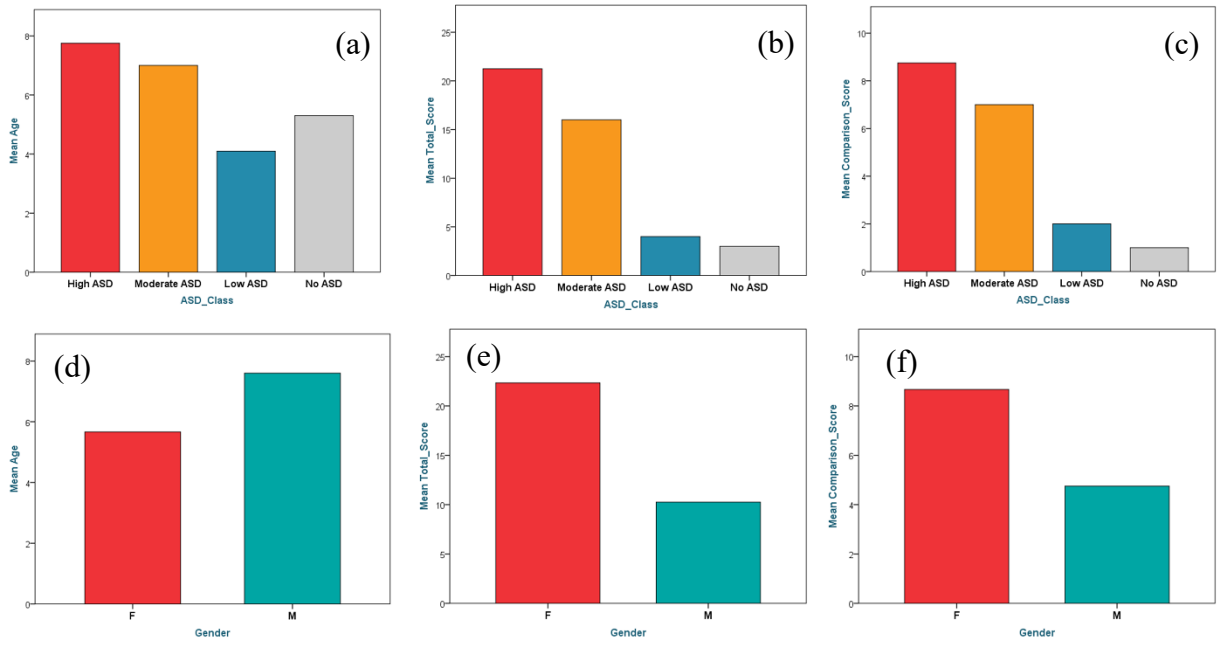


Fig. 11. Relationship of Categorical vs Quantitative Variables of Module 2. (a) *ASD_Class* vs Mean Age graph. (b) *ASD_Class* vs Mean *Total_Score* graph. (c) *ASD_Class* vs Mean *Comparison_Score* graph. (d) Gender vs Mean Age graph. (e) Gender vs Mean *Total_Score* (f) Gender vs Mean *Comparison_Score* graph.

TABLE 3 DESCRIPTIVE STATISTICS MODULE 2

	Valid	Missing	Mean	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
Age	7	0	6.771	3.315	2.235	0.794	5.407	1.587	4.100	14.000

	Valid	Missing	Mean	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
A6	7	0	1.571	1.134	-0.725	0.794	-0.743	1.587	0.000	3.000
A7	7	0	1.286	0.756	-0.595	0.794	-0.350	1.587	0.000	2.000
B1	7	0	1.429	0.976	-1.230	0.794	-0.840	1.587	0.000	2.000
B2	7	0	0.857	0.690	0.174	0.794	0.336	1.587	0.000	2.000
B3	7	0	1.286	0.951	-0.764	0.794	-1.687	1.587	0.000	2.000
B5	7	0	1.000	1.000	0.000	0.794	-2.600	1.587	0.000	2.000
B6	7	0	1.286	0.951	-0.764	0.794	-1.687	1.587	0.000	2.000
B8	7	0	1.286	0.951	-0.764	0.794	-1.687	1.587	0.000	2.000
B11	7	0	1.571	0.787	-1.760	0.794	2.361	1.587	0.000	2.000
B12	7	0	1.286	0.756	-0.595	0.794	-0.350	1.587	0.000	2.000
A4	7	0	0.857	0.900	0.353	0.794	-1.817	1.587	0.000	2.000
D1	7	0	0.571	0.787	1.115	0.794	0.273	1.587	0.000	2.000
D2	7	0	0.429	0.535	0.374	0.794	-2.800	1.587	0.000	1.000
D4	7	0	0.714	0.756	0.595	0.794	-0.350	1.587	0.000	2.000
Total_Score	7	0	15.429	8.522	-0.903	0.794	-1.154	1.587	3.000	23.000
Comparison_Score	7	0	6.429	3.457	-1.083	0.794	-0.858	1.587	1.000	9.000

4.3. EDA Module 3

Data Distribution: Figure 12 portrays the distribution of qualitative and quantitative variables within module 3. The bar graphs representing Gender and *ASD_Class* reveal a higher number of males compared to females and a larger proportion of individuals diagnosed with High ASD relative to other categories.

The histograms of the quantitative variables provide insight into the data distribution around the mean. The age histogram displays a slightly negative skewness (-0.45), indicating a slight concentration of data towards the right side of the mean age (11 years). This suggests that a greater number of individuals in the dataset are older than 11 years. Additionally, the histogram exhibits a slight platykurtic shape with a kurtosis value of -0.48. Since the values are close to zero, it can be inferred that the age variable approximates a normal distribution. The descriptive values are represented in Table 4.

The histograms of *Total_Score* and *Comparison_Score* reveal a moderate negative skewness, with values of -1.1 and -1.2, respectively. Furthermore, the *Total_Score* histogram displays moderate leptokurtosis, as indicated by the positive kurtosis value of 1.37. On the other hand, the *Comparison_Score* histogram exhibits a slightly leptokurtic distribution with a positive kurtosis value of 0.2. We can conclude that the *Comparison_Score* histogram represents a distribution with normal kurtosis or mesokurtic characteristics.

For detailed information on the mean, skewness, and kurtosis values of all the quantitative variables, please refer to Table 4.

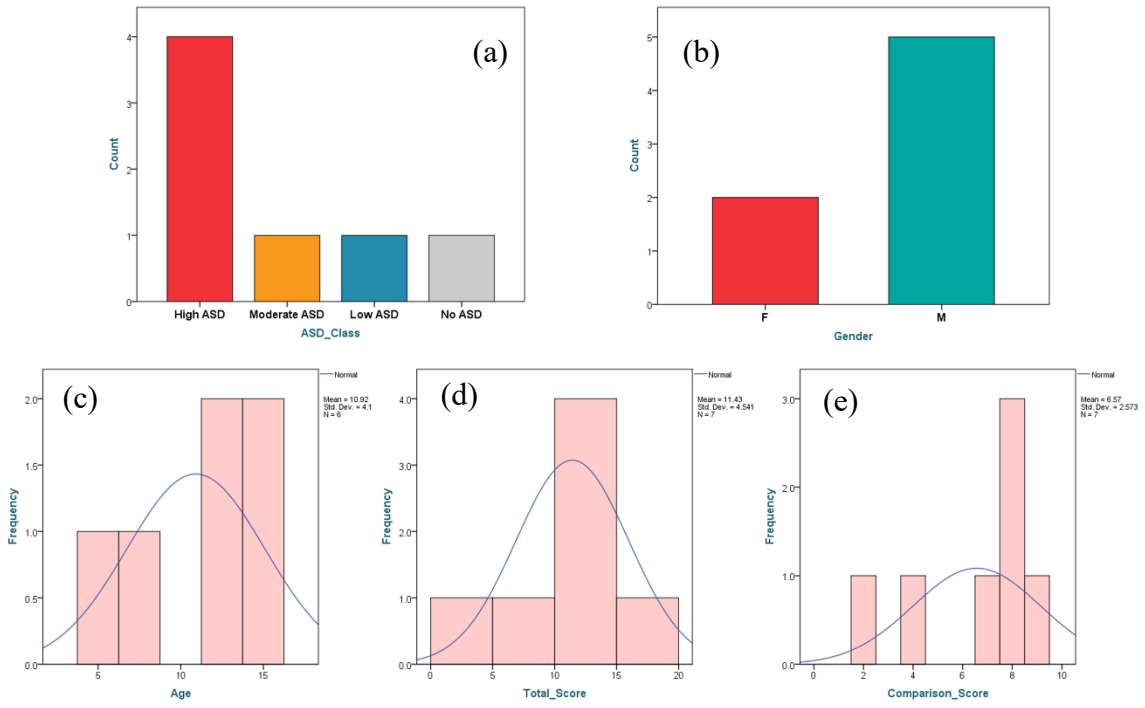


Fig. 12. Data Distribution Module 3(a) The Gender data distribution graph. (b) The *ASD_Class* data distribution graph. (c) *Total_Score* histogram. (d) *Comparison_Score* histogram. (e) Age histogram.

Relationships: Figures 13 and 14 present the relationships among qualitative variables, quantitative variables, and the combination of qualitative and quantitative variables. In Figure 13, the grouped bar chart of *ASD_Class* vs Gender reveals that within each *ASD_Class* category, males outnumber females.

The scatter plot of Age vs *Comparison_Score* and *Total_Score* indicates the absence of a linear relationship between Age and the scores. Furthermore, the scatter plot of *Comparison_Score* vs *Total_Score* reveals a somewhat linear relationship. However, at x-axis values of 7 and 8, the corresponding y-axis values remain the same, indicating that the x-axis value is not solely determined by *Total_score*.

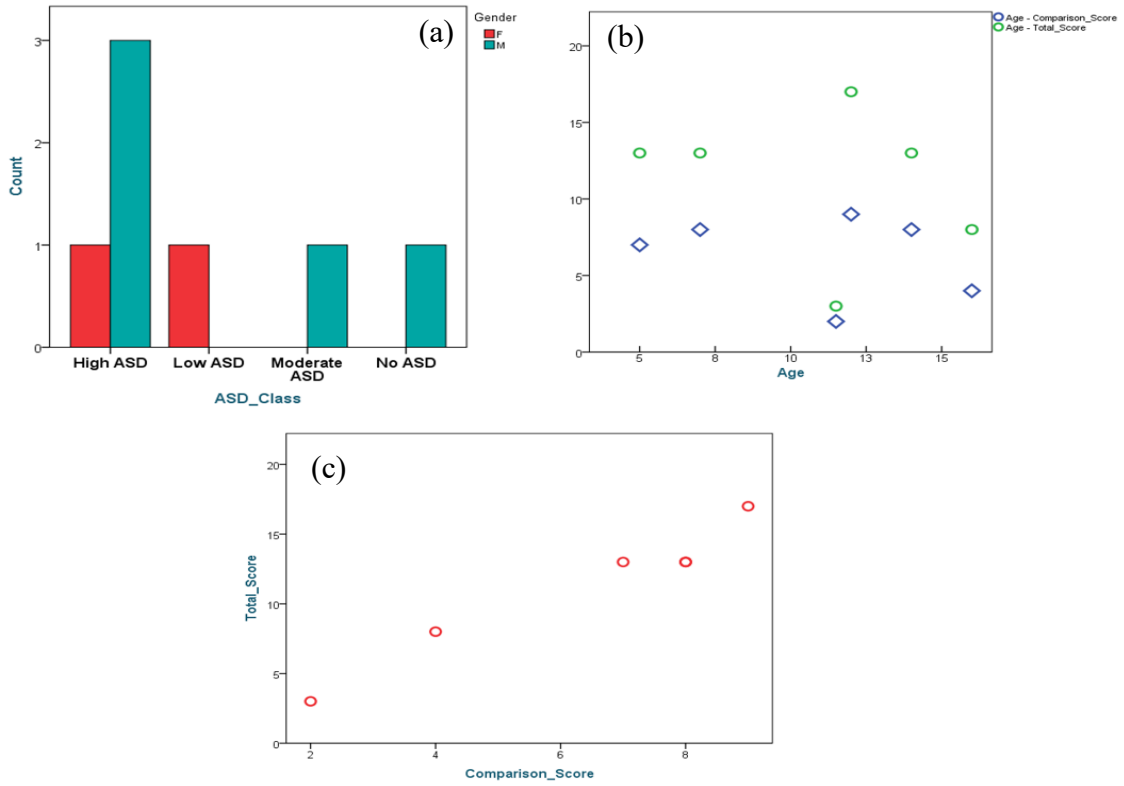


Fig. 13. Relationship Among Categorical Variables and Quantitative Variables of Module 3. (a) Grouped bar chart of *ASD_Class* vs Gender. (b) Scatter Plot of Age vs Comparison Score (blue diamonds) and Age vs *Total_Score* (Red Circles). (c) Scatter Plot of *Comparison_Score* vs *Total_Score*.

In Figure 14, the bar chart depicting *ASD_Class* vs Mean Age shows that individuals in the low ASD category have the highest mean age. However, this contradicts the findings from modules 1 and 2. Further examination of the dataset reveals that there is only one instance of low ASD with an age of 16 years, which may suggest an outlier. Generally, our analysis and existing literature [58] suggest that individuals with lower age tend to exhibit less intense ASD symptoms. Therefore, this outlier instance requires further investigation.

The relationship between *ASD_Class* and both score variables indicates a dependent relationship. Higher score values correspond to more intense ASD symptoms, placing individuals in the Higher ASD class.

The Gender vs Age graph indicates that females have a higher mean age compared to males. However, this contradicts the behavior observed in the first two modules. A closer examination of the dataset reveals that out of the seven individuals in module 3, there are only two females in the dataset and have ages of 16 and 11 years. This finding suggests that females may have a higher age, and further investigation is needed to determine whether males with ASD are diagnosed at a higher age compared to females.

Furthermore, the analysis of Gender vs score variables suggests that males tend to have higher scores compared to females.

It is important to note that these findings are based on only seven instances from module 3. Therefore, while they provide insights into the trends observed in the data, they cannot be considered definitive conclusions.

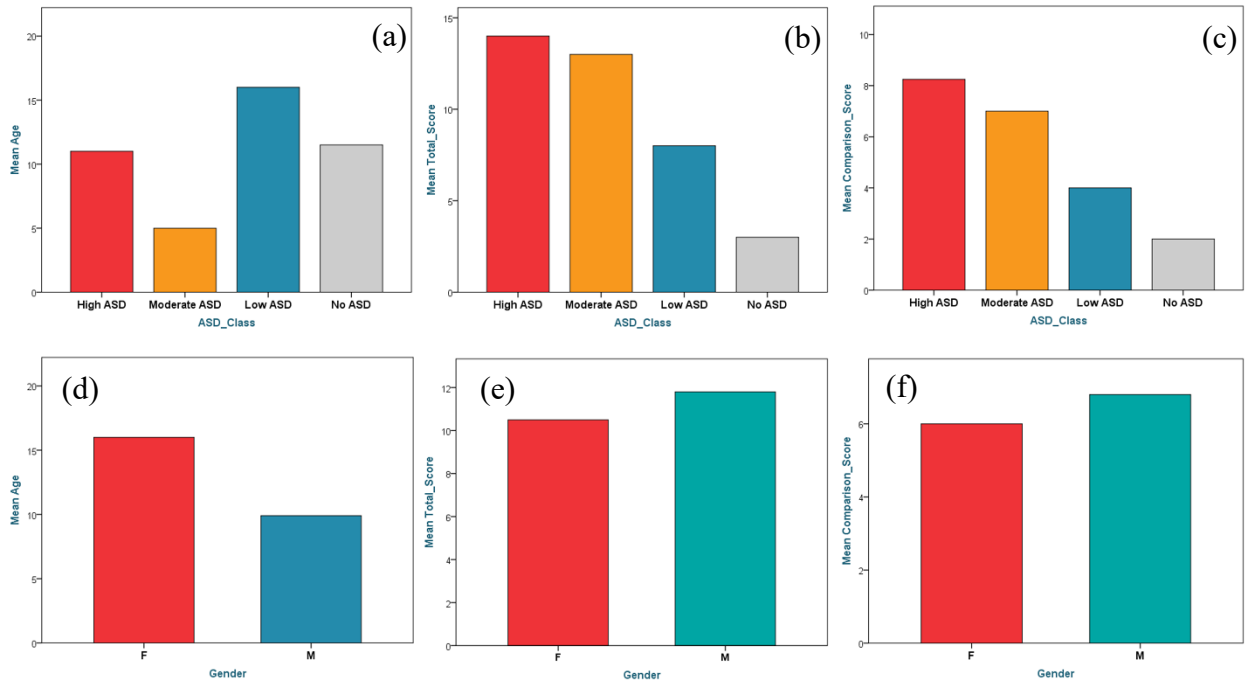


Fig. 14. Relationship of Categorical vs Quantitative Variables Module 3. (a) *ASD_Class* vs Mean Age graph. (b) *ASD_Class* vs Mean *Total_Score* graph. (c) *ASD_Class* vs Mean *Comparison_Score* graph. (d) Gender vs Mean Age graph. (e) Gender vs Mean *Total_Score* (f) Gender vs Mean *Compariosn_Score*.

TABLE 4 DESCRIPTIVE STATISTICS MODULE 3

	Valid	Missing	Mean	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
Age	7	0	10.929	3.813	-0.455	0.794	-0.485	1.587	5.000	16.000
A7	7	0	0.857	0.900	0.353	0.794	-1.817	1.587	0.000	2.000
A8	7	0	1.429	0.535	0.374	0.794	-2.800	1.587	1.000	2.000
A9	7	0	0.571	0.787	1.115	0.794	0.273	1.587	0.000	2.000
B1	7	0	1.714	0.756	-2.646	0.794	7.000	1.587	0.000	2.000
B2	7	0	1.000	0.816	0.000	0.794	-1.200	1.587	0.000	2.000
B4	7	0	1.000	0.816	0.000	0.794	-1.200	1.587	0.000	2.000
B7	7	0	0.857	0.378	-2.646	0.794	7.000	1.587	0.000	1.000
B9	7	0	0.714	0.488	-1.230	0.794	-0.840	1.587	0.000	1.000
B10	7	0	1.000	0.816	0.000	0.794	-1.200	1.587	0.000	2.000
B11	7	0	0.286	0.756	2.646	0.794	7.000	1.587	0.000	2.000
A4	7	0	0.143	0.378	2.646	0.794	7.000	1.587	0.000	1.000
D1	7	0	0.857	1.069	0.374	0.794	-2.800	1.587	0.000	2.000
D2	7	0	0.286	0.488	1.230	0.794	-0.840	1.587	0.000	1.000
D4	7	0	0.714	0.756	0.595	0.794	-0.350	1.587	0.000	2.000
Total_Score	7	0	11.429	4.541	-1.123	0.794	1.376	1.587	3.000	17.000
Comparison_Score	7	0	6.571	2.573	-1.225	0.794	0.222	1.587	2.000	9.000

4.4. Findings of the EDA

The summary of the findings from the exploratory data analysis (EDA) of all three modules is as follows:

1. Our analysis indicates that younger individuals tend to exhibit less severe symptoms of ASD compared to older individuals. This finding emphasizes the importance of early diagnosis and intervention for ASD, as early detection can potentially lead to better outcomes.
2. Consistent with existing literature, our analysis confirms that ASD has a higher occurrence in males compared to females. This supports the established understanding of gender differences in the prevalence of the disorder.
3. Furthermore, our analysis reveals that the mean age range for ASD diagnosis falls between 5 and 10 years. However, symptoms of ASD can start manifesting as early as 6 months of age, and a diagnosis can be made as early as 2 years of age. These findings suggest a potential lack of awareness among parents or guardians regarding early signs of ASD and the importance of timely diagnosis. Additionally, it raises the possibility of further investigation into the efficacy of the ADOS-2 tool used for diagnosis.

In conclusion, these findings shed light on the significance of early intervention, the gender-based differences in ASD prevalence, and the potential areas for improvement in early diagnosis practices.

4.5. Mapping of ADOS-2 Items

The content validation of the ADOS-2 items on DSM-5 sub-categories yielded the following results.

4.5.1. Module 1

In Module 1, all 17 items were categorized into two broad domains of DSM-5: Social Interaction and Communication, and Restricted and Repetitive Behavior. The distribution of these items across the two domains is illustrated in Tables V and VI, where it can be observed that 13 questions belong to the first domain, while the remaining 4 questions pertain to the second domain.

To further analyze the content, we proceeded with mapping the items onto specific sub-categories. The outcomes presented in Table 7 and 8 indicate that the items are distributed across five out of the seven available categories, with the highest number of questions falling under the domain of social emotional reciprocity. It is important to note that the ADOS-2 module 1 does not assess the domains of Developing and Maintaining Relationships and Restricted Behavior, as indicated by the content mapping.

It is important to note that two items, namely B-12 and D-4, defy clear categorization within a single sub-category. Their content encompasses multiple categories simultaneously, making it impossible to assign them to a single category. For a detailed understanding of the content of these items, please refer to [38].

TABLE 5 MAPPING OF MODULE 1 ON TWO DSM-5 DOMAINS

Sr. No	Main-Domains	A-1	A-2	A-7	A-8	B-1	B-3	B-4	B-5	B-9	B-10	B-11	B-12	A-3	A-5	D-1	D-2	D-4
1	Social Interaction and Social Communication																	
2	Repetitive or Restricted Behavior																	

TABLE 6 QUESTION COUNT OF MODULE 1 IN EACH DOMAIN

Domains	Questions	Percentages
1	13	76%
2	4	24%
Total= 2 domains	Total= 17	Total= 100%

TABLE 7 MAPPING OF MODULE 1 ON DSM-5 SUB-CATEGORIES

Sr. No	Sub-Domains	A-1	A-2	A-7	A-8	B-1	B-3	B-4	B-5	B-9	B-10	B-11	B-12	A-3	A-5	D-1	D-2	D-4
1	social-emotional reciprocity																	
2	Nonverbal Communicative Behaviors																	
3	Developing and maintaining relationships																	
4	Stereotyped or repetitive behavior																	
5	Unusual Fixated Interest																	
6	Restricted behavior																	
7	Hyper-or hypo-reactivity																	

TABLE 8 QUESTION COUNT OF MODULE 1 IN EACH SUB-CATEGORY

Sub- Domains	Questions	Percentages
1	5	29%
2	7	41%
1+2	1	6%
3	0	0
4	2	12%
4+5	1	6%
6	0	0
7	1	6%
Total = 17 domains	Total= 17	Total= 100%

4.5.2. Module 2

In Module 2, the 15 questions were initially categorized into two domains of DSM-5, followed by further classification into seven sub-domains. The initial mapping of these questions revealed that 11 questions belonged to the first domain, while the remaining 4 items were allocated to the second domain, as shown in Tables IX, and X

Upon examining the distribution within the sub-domains depicted in Tables XI and XII**,** it became apparent that the highest number of questions fell under two specific sub-domains: social emotional reciprocity and non-verbal communicative behavior. Notably, there were no questions pertaining to the sub-domains of developing and maintaining relationships and restricted behavior. This observation indicates that Module 2 of ADOS-2 does not assess children in these criteria.

It is important to note that in Module 2, there are four items, specifically B-8, B11, B12, and D-4, that are not distinctly categorized due to the general nature of their content.

Table 9 MAPPING OF MODULE 2 ON TWO DSM-5 DOMAINS

Sr. No	Main-Domains	A-1	A-6	A-7	B-1	B-2	B-3	B-5	B-6	B-8	B-11	B-12	A-4	D-1	D-2	D-4
1	Social Interaction and Social Communication															
2	Repetitive or Restricted Behavior															

Table 10 QUESTION COUNT OF MODULE 2 IN EACH DOMAIN

Domains	Questions	Percentages
1	11	73%
2	4	27%
Total= 2 domains	Total= 15	Total= 100%

TABLE 11 MAPPING OF MODULE 2 ON DSM-5 SUB-CATEGORIES

Sr. No	Sub-Domains	A-1	A-6	A-7	B-1	B-2	B-3	B-5	B-6	B-8	B-11	B-12	A-4	D-1	D-2	D-4
1	social-emotional reciprocity															
2	Nonverbal Communicative Behaviors															
3	Developing and maintaining relationships															
4	Stereotyped or repetitive behavior															
5	Unusual Fixated Interest															
6	Restricted behavior															
7	Hyper-or hypo-reactivity															

TABLE 12 QUESTION COUNT OF MODULE 2 IN EACH SUB-CATEGORY

Sub- Domains	Questions	Percentages
1	4	27%
2	4	27%
1+2	3	20%
3	0	0
4	2	13%
4+5	1	7%
6	0	0
7	1	7%
Total = 7 domains	Total= 15	Total= 100%

4.5.3. Module 3

Finally, in Module 3, the 15 items are distributed across two main domains, with 11 items allocated to the first domain and 4 items to the second domain, as illustrated in Tables XIII and

XIV. Upon validation of these items using DSM-5 sub-categories, it becomes evident that most of the questions align with the domain of social emotional reciprocity. The questions are distributed across 5 out of the 7 available domains, as depicted in Tables XV and XVI. ADOS-2 Module 3 does not include items specifically designed to assess the domains of developing and maintaining relationships, as well as restricted behavior.

During the mapping process of Module 3, we discovered that 5 items, namely B-7, B-9, B-10, B-11, and D-4, lack unique characterization due to the generality of their content. Consequently, these items are classified within multiple categories.

TABLE 13 MAPPING OF MODULE 3 ON TWO DSM-5 DOMAINS

Sr. No	Main-Domains	A-1	A-7	A-8	A-9	B-1	B-2	B-4	B-7	B-9	B-10	B-11	A-4	D-1	D-2	D-4
1	Social Interaction and Social Communication															
2	Repetitive or Restricted Behavior															

TABLE 14 QUESTION COUNT OF MODULE 3 IN EACH DOMAIN

Domains	Questions	Percentages
1	11	73%
2	4	27%
Total= 2 domains	Total= 15	Total= 100%

TABLE 15 MAPPING OF MODULE 3 ON DSM-5 SUB-CATEGORIES

Sr. No	Sub-Domains	A-1	A-7	A-8	A-9	B-1	B-2	B-4	B-7	B-9	B-10	B-11	A-4	D-1	D-2	D-4
1	social-emotional reciprocity															
2	Nonverbal Communicative Behaviors															
3	Developing and															

	maintaining relationships															
4	Stereotyped or repetitive behavior															
5	Unusual Fixated Interest															
6	Restricted behavior															
7	Hyper-or hypo-reactivity															

TABLE 16 QUESTION COUNT OF MODULE 3 IN EACH SUB-CATEGORY

Sub- Domains	Questions	Percentages
1	4	27%
2	3	20%
1+2	4	27%
3	0	0
4	2	13%
4+5	1	7%
6	0	0
7	1	7%
Total = 7 domains	Total= 15	Total= 100%

4.6. ADOS-2 Screening Guides

4.6.1. ADOScan1

Similarity Scores: The similarity scores between ADOScan1 and the reference questionnaires are depicted in Table 17. These scores provide insights into the degree of similarity between ADOScan1 and the reference questionnaires. Notably, ADOScan1 demonstrates the highest similarity with the SCQ (Social Communication Questionnaire) at 41.79%, while the AQ-10 (Adult Questionnaire) exhibits the lowest similarity at only 5.97%.

These results can be analyzed in the context of the ADOS-2 Module 1, which is primarily utilized for children with limited or minimal speech abilities. Typically, this module is applied to children between the ages of 3 and 11, based on our local dataset and corroborating literature

sources [22]. Consequently, ADOScan1 displays a lower degree of similarity with the AQ-10 Adult questionnaire, which is specifically designed for individuals aged 17 and above. On contrast, the SCQ, which encompasses a comprehensive set of 40 questions and is administered to individuals ranging from 4 to 40 years of age, exhibits a higher degree of similarity with our screening guide.

These findings lead to the conclusion that ADOScan1 aligns more closely with the SCQ questionnaire due to their shared focus on assessing individuals within a similar age range and encompassing relevant questions pertaining to social communication abilities.

Mapping on DSM-5: We have successfully mapped the items from our screening guide onto the relevant sub-categories within DSM-5. The category names and their corresponding matched keywords for each question can be found in Table 18. A comprehensive summary of the mapping results is presented in Table 19. As observed in Table 19, 10 questions are mapped within the Social Interaction and Communication domain (SIC), while 5 questions are mapped within the Stereotyped and Restricted Behavior domain (SRB). Within the Social Interaction and Communication domain, the highest number of questions (four) are mapped to the Social Emotional Reciprocity category, whereas the Developing and Maintaining Relationship category encompasses the least number of questions (two). In the Stereotyped and Restricted Behavior domain, two out of the five questions fall under the Restricted Behavior category, while the remaining three questions are distributed among three other categories.

TABLE 17 COMMON KEYWORDS AND SIMILARITY SCORES FOR ADOSCAN1

Questionnaires	Keywords	Similarity Index
SCQ	expressions, words, unusual, play, body, interest,?, name, ,, interests, respond, engage, facial, phrases, make, use, enjoyment, show, gestures, like, child, sounds, movements, pretend, actions, make-believe, pointing, questions	41.79%
QCHAT-25	his/her, words, unusual, unfamiliar, interest,?, name, ,, contact, upset, make, use, show, gestures,	34.33%

	child, sounds, movements, changes, pretend, eye, routine, simple, pointing	
AQ-10_Child	his/her, activities, sounds,,, make, new, others	10.45%
AQ-10_Adult	, sounds, others, like	5.97%
AQ-10_Adolescent	situations,,, make, new, like	7.46%
QCHAT-10	his/her, child,?, contact, words, upset, name, ,, pretend, interest, eye, use, simple, show, pointing, gestures	23.88%

TABLE 18 MAPPING OF ADOSCAN1 ITEMS ON DSM-5 SUBCATEGORIES

Sr. No	Question	Category	Keywords
1.	Does the child enjoy playing and interacting with other children?	Developing and maintaining relationships	playing
2.	Does the child respond to his/her name when called?	Social Emotional Reciprocity	called, name, respond
3.	Does the child show interest in sharing enjoyment or activities with others?	Social Emotional Reciprocity	enjoyment, show, sharing, interest, activity, interest
4.	Does the child make eye contact during interactions?	Nonverbal Communicative Behaviors	interaction, contact, interaction, eye
5.	Does the child imitate actions or gestures?	Nonverbal Communicative Behaviors	gesture
6.	Does the child use word or phrases to communicate needs or desires?	Social Emotional Reciprocity	need, word, desire, communicate, phrase, desire
7.	Does the child respond appropriately to simple questions or requests?	Social Emotional Reciprocity	respond
8.	Does the child engage in pretend play or make-believe?	Developing and maintaining relationships	engage, makebelieve, play
9.	Does the child use gestures or pointing to express needs or interests?	Social Emotional Reciprocity	interest, pointing, need, gesture, interest
10.	Does the child use facial expressions to express emotions?	Nonverbal Communicative Behaviors	emotion, facial, expression
11.	Does the child have repetitive body movements like rocking or hand-flapping?	Stereotyped or repetitive behavior	body, movement, repetitive, rocking

12.	Does the child have intense or unusual interests that they focus on excessively?	Unusual Fixated Interest	interest, interest, excessively, intense, focus
13.	Does the child become upset by changes in routine or transitions?	Restricted behavior	transition, routine, change
14.	Does the child have difficulty adapting to new or unfamiliar situations?	Restricted behavior	difficulty, unfamiliar, new
15.	Does the child demonstrate any sensory sensitivities, such as being bothered by certain sounds or textures?	Hyper or hypo reactivity	sensory, sensitivity, texture, sound

TABLE 19 SUMMARY OF ADOSCAN1 MAPPING

Domain	Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Social Interaction and Communication	Social Emotional Reciprocity															
	Nonverbal Communicative Behaviors															
	Developing and maintaining relationships															
Stereotyped and Restricted behaviors	Stereotyped or repetitive behavior															
	Unusual Fixated Interest															
	Restricted behavior															
	Hyper or hypo reactivity															

4.6.2. ADOScan2

Similarity Scores: The similarity scores between ADOScan2 and the reference questionnaires are provided in Table 20. A notable observation is the gradual decrease in the similarity percentages across the various reference questionnaires. Nevertheless, the highest similarity percentage is still observed with the SCQ (Social Communication Questionnaire), reaching 22%. This can be attributed to the extensive coverage and numerous items included in the SCQ, as well as its wide age range applicability.

Furthermore, the second highest similarity percentage, approximately 17%, is observed with the QCHAT-25 questionnaire. This can be attributed to the overlap in certain keywords and concepts, as Module 2 is designed for children who possess limited speech abilities, use short phrases, and fall within an age range approximately spanning 3 to 15 years. On the other hand, the QCHAT-25 questionnaire is specifically tailored for toddlers aged 18 to 24 months, although there are some shared elements that contribute to the observed similarity.

In contrast, ADOScan2 exhibits the lowest similarity with the AQ-10 Adult questionnaire, indicating a distinct divergence in their content and applicability.

Mapping on DSM-5: Mapping on DSM-5: We have successfully mapped the items from ADOScan2 to the corresponding DSM-5 criteria, as depicted in Table 21 and subsequently in Table 22. In Table 23, it is evident that a total of 10 out of 15 questions fall within the Social Interaction and Communication (SIC) domain, while the remaining 5 questions are mapped to the Stereotyped and Restricted Behavior (SRB) domain. Within the SIC domain, the Developing and Maintaining Relationship category contains the highest number of questions, in contrast to the findings from ADOScan1. Conversely, the Non-verbal Communicative Behavior category encompasses the least number of questions. This analysis suggests that Module 2 is specifically designed for older children with some speech ability, thus placing greater emphasis on assessing their social interaction and relationship-building skills rather than non-verbal communicative behaviors. In the SRB domain, the highest number of questions (2 out of 5) pertain to restricted behavior, while the remaining 3 questions are distributed across the other three categories.

TABLE 20 COMMON KEYWORDS AND SIMILARITY SCORES FOR ADOSCAN2

Questions	Keywords	Similarity Index
SCQ	friends, turns, expressions,?, taking, appropriate, movements, facial, people, ,, body, interests, use, age, show, rituals, social	22.08%
QCHAT-25	? contact, speech, upset, changes, people, movements, ,, follow, eye, understand, use, show	16.88%
AQ-10_Child	friends, conversations, people,,, feelings, good, others, social	10.39%
AQ-10_Adult	, others, people	3.90%
AQ-10_Adolescent	friends, conversations, time, people,,, good, social	9.09%
QCHAT-10	contact,?, upset, ,, follow, eye, use, show	10.39%

TABLE 21 MAPPING RESULTS OF ADOSCAN2 ITEMS ON DSM-5 SUBCATEGORIES

Sr. No	Questions	Categories	Keywords
1.	Does the individual have friends of their own age?	Developing and maintaining relationships	friend
2.	Does the individual initiate conversations with others?	Social Emotional Reciprocity	initiate, conversation
3.	Does the individual understand sarcasm or jokes in conversations?	Developing and maintaining relationships	conversation, sarcasm, joke
4.	Does the individual maintain appropriate eye contact during conversations?	Nonverbal Communicative Behaviors	conversation, contact, eye, maintain
5.	Does the individual show empathy or understanding of other people's feelings?	Developing and maintaining relationships	show, feeling, empathy
6.	Does the individual have good conversational skills, taking turns appropriately?	Stereotyped or repetitive behavior	turn
7.	Does the individual use facial	Nonverbal Communicative	interaction, social,

	expressions and body language effectively in social interactions?	Behaviors	language, expression, facial, body, interaction
8.	Does the individual understand non-literal language, such as idioms or metaphors?	Social Emotional Reciprocity	idiom, language, metaphor, nonliteral
9.	Does the individual adjust their speech based on the listener's comprehension level?	Developing and maintaining relationships	speech, comprehension, level, adjust, listener
10.	Does the individual have an age-appropriate vocabulary and grasp of grammar?	Social Emotional Reciprocity	vocabulary, grammar
11.	Does the individual have specific routines or rituals they follow consistently?	Restricted behavior	follow, specific, routine, ritual
12.	Does the individual have intense or focused interests that they spend a significant amount of time on?	Unusual Fixated Interest	interest, spend, interest, intense, focused
13.	Does the individual become upset by changes in plans or unexpected events?	Restricted behavior	event, change, plan
14.	Does the individual have any sensory sensitivities, such as being bothered by certain smells or textures?	Hyper or hypo reactivity	sensory, sensitivity, smell, texture
15.	Does the individual exhibit any repetitive or stereotyped movements or behaviors?	Stereotyped or repetitive behavior	behavior, movement, stereotyped, repetitive

TABLE 22 SUMMARY OF ADOSCAN2 MAPPING

Domain	Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Social Interaction and Communication	Social Emotional Reciprocity															
	Nonverbal Communicative Behaviors															
	Developing and maintaining relationships															
Stereotyped and Restricted	Stereotyped or repetitive															

behaviors	behavior															
	Unusual Fixated Interest															
	Restricted behavior															
	Hyper or hypo reactivity															

4.6.3. ADOScan3

Similarity scores: The similarity scores between the ADOScan3 and the reference questionnaires are presented in Table 23. Module 3 primarily targets individuals with regular and fluent speech abilities, typically ranging in age from 5 years onwards. The analysis reveals that the SCQ (Social Communication Questionnaire) attains the highest similarity score, with a similarity percentage of 22%.

Additionally, it is noteworthy that the QCHAT-25 questionnaire demonstrates certain shared keywords and concepts with our guide questionnaire. This partial overlap may be attributed to the targeted age group of the QCHAT-25 (18 to 24 months) and some common items considered within Module 3. Moreover, the AQ-10 Adolescent questionnaire, designed for children aged 12 to 15 years, also exhibits a modest similarity of 8% with our guide.

These findings shed light on the similarities and dissimilarities between the ADOScan3 and the reference questionnaires, indicating areas of convergence and divergence in their content and applicability.

Mapping on DSM-5: Lastly, we have conducted the mapping of ADOScan3 onto the subcategories of DSM-5, as illustrated in Table 24, with a summary provided in Table 25. Table 24 reveals that item 13 has been assigned to multiple categories by AutiMap. Specifically, it falls under the categories of Unusual Fixated Interest and Restricted Behavior. The keyword column displays five matching keywords. Upon examining these keywords in the database, we discovered that "highly" and "event" are associated with the Unusual Fixated Interest category, while "change" and "plan" pertain to the Restricted Behavior category. Additionally, the keyword

"distressed" is related to the "Hypo or hyperactivity" category. As the number of keywords is equal for both the Unusual Fixated Interest and Restricted Behavior categories, the application outputs these categories. However, based on the context, item 13 should be categorized under Restricted Behavior due to its emphasis on changes in routines. This analysis suggests that the database may require updates, or it may be beneficial to review the wording of such questions to avoid confusion.

Furthermore, in Table 25, it is evident that the highest number of questions (8 out of 10) are evenly distributed between the Social Emotional Reciprocity and Developing and Maintaining Relationship categories. This observation can be attributed to Module 3 being designed for individuals who are older and possess fluent speech abilities. Within the Stereotyped and Restricted Behavior domain, the highest number of questions pertained to the Restricted Behavior category.

TABLE 23 COMMON KEYWORDS AND SIMILARITY SCORES FOR ADOSCAN3

Questions	Keywords	Similarity Index
SCQ	friends, engage,?, words, appropriate, form, people, movements, ,, sentences, interests, use, using, rituals, social	20.55%
QCHAT-25	? words, movements, people, ,, understand, use	9.59%
AQ-10_Child	friends, conversations, people,,, social	6.85%
AQ-10_Adult	, people	2.74%
AQ-10_Adolescent	friends, conversations, time, people,,, social	8.22%
QCHAT-10	words,,, ?, use	5.48%

TABLE 24 MAPPING RESULTS OF ADOSCAN3 ITEMS ON DSM-5 SUBCATEGORIES

Sr. No	Question	Category	Keywords
1.	Does the individual have a close circle of friends they spend time with?	Developing and maintaining relationships	spend, friend, close
2.	Does the individual initiate and maintain conversations	Social Emotional Reciprocity	initiate, conversation, maintain

	effectively?		
3.	Does the individual understand and use appropriate humor in social interactions?	Social Emotional Reciprocity	interaction, social, humor, interaction
4.	Does the individual demonstrate empathy and understanding of other people's perspectives?	Developing and maintaining relationships	empathy, perspective
5.	Does the individual form and maintain reciprocal relationships?	Developing and maintaining relationships	reciprocal, maintain, relationship, reciprocal
6.	Does the individual demonstrate advanced language skills, using complex sentences and vocabulary?	Social Emotional Reciprocity	vocabulary, language, sentence, complex
7.	Does the individual understand and appropriately use nonverbal cues in communication?	Nonverbal Communicative Behaviors	communication, cue, nonverbal
8.	Does the individual interpret figurative language and understand multiple meanings of words?	Nonverbal Communicative Behaviors	word, language, meaning, figurative, interpret, multiple
9.	Does the individual adjust their communication style based on the context and social norms?	Developing and maintaining relationships	communication, social, context, norm, adjust
10.	Does the individual engage in meaningful and reciprocal conversations?	Social Emotional Reciprocity	conversation, reciprocal, engage, meaningful, reciprocal
11.	Does the individual have rigid routines or rituals that they struggle to deviate from?	Restricted behavior	rigid, routine, ritual
12.	Does the individual have intense or all-consuming interests that they dedicate a significant amount of time to?	Unusual Fixated Interest	interest, interest, intense
13.	Does the individual become highly distressed by changes in plans or unexpected events?	Unusual Fixated Interest, Restricted behavior	highly, event, change, plan, distressed
14.	Does the individual experience sensory sensitivities that significantly impact their daily life?	Hyper or hypo reactivity	impact, sensory, sensitivity
15.	Does the individual exhibit any repetitive or stereotyped movements or behaviors?	Stereotyped or repetitive behavior	behavior, movement, stereotyped, repetitive

TABLE 25 SUMMARY OF ADOSCAN3 MAPPING

Domain	Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Social Interaction and Communication	Social Emotional Reciprocity															
	Nonverbal Communicative Behaviors															
	Developing and maintaining relationships															
Stereotyped and Restricted behaviors	Stereotyped or repetitive behavior															
	Unusual Fixated Interest															
	Restricted behavior															
	Hyper or hypo reactivity															

CHAPTER 5

DISCUSSION

The primary objective of our study was to investigate the local diagnostic practices employed for individuals with ASD. The secondary objective was to evaluate the alignment between these methods, tools, and processes with the standardized DSM-5 guidelines. Our tertiary objective was to develop comprehensive and simplified guidelines for the relevant stakeholders to promote awareness and facilitate early intervention for ASD. Lastly, we aimed to create an application that automates the mapping of assessment questions to standard criteria, enabling analysis of areas in need of improvement. The following section presents our analysis.

5.1. Interpretation of the results

In the first sub-section of results, we have done the data analysis of three different modules of ADOS-2. The instances in each module were as follows, 15, 7 and 7. We have done the EDA to find the distribution of the data and finding the relationships between them. The findings suggested that the mean age of diagnosis of ASD individuals is 7.6 years. Then we found that the data have more males than females. Then we found that the older individuals are characterized in High ASD class as compared to the younger individuals. Then we found out that the mean age at which the males get diagnosis is higher as compared to females. Now we have made some interpretations based on these results of EDA.

As the mean age at which an individual is getting diagnosis in Pakistan is 7.6 years, despite of the ASD symptoms being shown in 1.5—2 years of age, and combined with our exploratory analysis of the psychological departments, there may be a lack of awareness among the parents about the disease and how to take steps in order to get early diagnosis and there may be an inefficient way of diagnosis procedures, like based on our observations one diagnosis session in a week, not properly implementing the diagnostic tools like ADOS-2 and giving subjective analysis based on just observations and experience. This may lead to missed cases, misdiagnosed cases, or late diagnosis cases. Additionally, the data tells us that the older individuals have severe ASD symptoms as compared to the younger individuals, this may point toward the importance of early ASD intervention. Furthermore, we observed that the males are higher than females, this

result was expected as the literature also suggests that males are more prone to the disease, but an unexpected result we observed from our available dataset was that the males were diagnosed at later ages as compared to females despite males having higher and severe occurrence of the disease. Therefore, the local dataset suggests many areas of improvements to provide ASD children with a quality life.

Based on our EDA and field observation we have selected a tool ADOS-2 to see its content validity on standardized criteria, to determine its efficiency in diagnosis of ASD as it is considered a global gold standard for diagnosis. After the item mapping of three modules of ADOS-2 we have observed that the tool does not cover all the criteria mentioned in DSM-5 standard criteria. Specifically, the developing and maintaining relationships sub-category of DSM-5 criteria was not covered by ADOS-2. Furthermore, the restricted behavior sub-category is also not distinctly covered in ADOS-2. While the DSM-5 suggests that all three subcategories of SIC domain namely, Social-Emotional Reciprocity, Non-Verbal Communicative Behavior and Developing and Maintaining Relationship should be covered in symptoms range of ASD individuals and 2 of the 4 sub-categories of RRB domain should be covered in the exhibiting symptoms of ASD individuals. Moreover, while studying ADOS-2 we have gained an insight that it is very complex and requires approx. an hour to administer, it is not open sourced, many of the items in ADOS-2 are general and not distinctively defined what they are trying to observe.

A study [27] like ours also mapped ADOS-2 along with two other tools 3di, and DISCO-11 to validate the content validity of these items. The study also observed three modules of ADOS-2 and mapped the items on DSM-5. The study suggested the similar results to ours that the subcategories mentioned above are not covered in ADOS-2. However, there is a lack of explanation, and clarity in the study that which items of which module are mapped on which sub-criteria. The study also claimed to provide detailed mapping content in their studies Appendix B, but there was no Appendix B mentioned in the study.

One more study [28] suggested the difference of diagnosing with ADOS-2 and DSM-5. The study took four participants diagnosed autistic by ADOS-2, however when those participants were diagnosed using DSM-5 criteria all of them we labeled non-autistic. This suggested that there was a need for standardization of tools on DSM-5 criteria starting from the globally accepted and implemented tool ADOS-2.

Therefore, in the light of the above observations we may say that ADOS-2 needs to be revised to make it more efficient and comprehensive. Further, form our item mapping and EDA and literature search we observed that there is need of standardized level 1 screening tools for parents/guardians, school counsellors/ health care workers, pediatrics based on the globally implemented ADOS-2 tools, so that there will be a solution for lack of awareness, and streamline the diagnostic process to support early intervention. Hence, we developed three ADOS-2 screening tools called ADOScan for module 1, 2 and 3 respectively differentiated on the language skills and age of the ASD individuals. These tools will serve a great purpose to bridge the gap between the screening and Diagnostic procedure.

Lastly, we have encountered the need for an automated web-app that will help the researchers, professionals, tool setters etc., to standardize the available and the new generated methods/tools so that to make the ASD diagnosis an efficient and more effective process. Therefore, we developed a web-application called AutiMap that will serve the purpose.

5.2. Limitations and Recommendations

Our study has several limitations that should be acknowledged. Firstly, the scarcity of our dataset limits the extent to which we can draw definitive conclusions from our interpretations. A larger and more diverse data set would have provided a broader perspective, allowing for more robust and factual conclusions. Additionally, a larger dataset would have enabled us to support our mapping with data-driven evidence.

The second limitation stems from the unavailability of the complete ADOS-2 manual. As the ADOS-2 is a proprietary tool, we did not have access to a comprehensive review of its items. Instead, we relied on the score sheets available to us and the insights gathered through discussions with professionals. While this approach provided a general understanding of the nature of the items, having the full ADOS-2 manual would have facilitated a deeper and more detailed analysis.

Another limitation of our study is the lack of analysis regarding the psychometric properties of ADOScan1, 2, and 3. Due to limitations in resources, including cost, time, and labor, we were unable to conduct a comprehensive evaluation of the psychometric properties of these screening

tools. It is essential to acknowledge that a thorough assessment of these properties is critical in establishing the reliability and validity of the ADOScan instruments.

Furthermore, to ensure accessibility and effectiveness in providing guidance, it is imperative to make the ADOScan tools available in multiple languages. This approach would help overcome any potential bias related to specific populations and enable a broader range of individuals to benefit from the guidance and support offered by the ADOScan instruments.

Acknowledging these limitations is essential for a comprehensive understanding of the scope and implications of our study. Future research should strive to address these limitations to further enhance the validity and reliability of the findings.

5.3. Conclusion

This study aimed to comprehensively investigate and analyze both local and global ASD diagnostic methods, specifically focusing on their alignment with the standardized criteria outlined in DSM-5. Our analysis specifically focused on the widely implemented ADOS-2 tool and its compatibility with the DSM-5 criteria for ASD diagnosis. Through our investigation, we determined that the ADOS-2 does not fully cover all the criteria specified in DSM-5, highlighting the necessity for its revision.

During the analysis of the ADOS-2 tool and exploration of local practices, we identified a significant lack of awareness among key stakeholders, particularly parents/guardians, which often results in delayed diagnoses for individuals with ASD. Consequently, we developed screening guidelines intended to provide guidance and support to these stakeholders. Additionally, we recognized the need for automating mapping procedures to promote standardization in research on existing tools and the development of new tools. This approach represents a crucial step towards achieving homogeneity in ASD diagnostic and screening methods and tools.

The findings of this study lay the foundation for future efforts in standardization and early ASD interventions, aiming to improve the quality of life for individuals with ASD and their parents/guardians. By addressing the identified gaps and promoting awareness among

stakeholders, we aspire to facilitate timely and accurate ASD diagnoses and provide effective support to those affected by the disorder.

5.4. Appendix

5.4.1. Appendix A

TABLE 26 DIAGNOSTIC TOOLS FOR ASD

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
1. ADOS	Risi et al. [23]	12+ months	Autism = 0.87	Autism = 0.73	Autism = 0.80
	Klein Tasman et al. [24].		ASD = 0.87	ASD = 0.78	ASD = 0.82
	Tomanik et al. [25]		Autism	Autism	Autism
	Kleinman et al. [26]		M1 = 0.88	M1 = 0.80	M1 = 0.84
	Wiggins and Robbins [27]		M2 = 0.77	M2 = 0.92	M2 = 0.85
	Kim and Lord [22]		M3 = 0.89	M3 = 0.81	M3 = 0.85
	Lord et al. [28]		ASD	ASD	ASD
	Noterdaeme et al. [29]		M1 = 0.86	M1 = 0.71	M1 = 0.79
	Ventola et al.		M2 = 0.70	M2 = 0.83	M2 = 0.77

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
	[30]				
	Mazefsky and Oswald [31]		M3 = 0.67	M3 = 0.79	M3 = 0.73
	Chawarska et al. [32]		Autism	Autism	Autism
	Sikora et al. [33]		OA = 0.77	OA = 0.89	OA = 0.83
	Papanikolaou et al. [34]		RA = 0.87	RA = 0.84	RA = 0.86
	De Bildt et al. [35]		ASD	ASD	ASD
	Gotham et al. [36]		OA = 0.74	OA = 0.74	OA = 0.74
	Gray et al. [37]		RA = 0.75	RA = 0.75	RA = 0.75
2. AOSI	Bryson et al. [46].	6–18 months	NR	NR	NR
3. VISS	Absound et al. [47].	1–6 years	ASD 0.89	ASD 1	ASD 0.95
1. ADI-R	Chawarska et al. [32]	2+ years	Autism	Autism	Autism

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
	Ventola et al. [30]		<3years = 0.82	<3years = 0.75	<3years = 78
	Wiggins and Robins [27]		>3years = 0.91	>3years = 0.78	>3years = 0.85
2. ASD-DC	Matson et al. [58].	2–16 years	Autism = 0.72	Autism = 0.79	Autism = 0.86
	Matson et al. [59]		ASD = 0.88	ASD = 0.81	ASD = 0.84
3. ADS-DA	Matson et al. [62]	20+ years	NR	NR	NR
4. DISCO	Leekam [63]	35 months —40 years	0.98	0.57	0.78
	Wing et al. [64]				
	Nygren et al. [65]				
5. RAADS /RAADS -R	Ritvo et al. [66]	18+ years	0.97	1	0.99
6. 3Di	Skuse et al. [68]	2–21 years	Autism = 1	Autism = 0.97	Autism = 0.99

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
	Santosh et al. [69]		ASD = 1	ASD = 0.98	ASD = 0.99
1. ADI-R and ADOS	Chawarska et al. [32]	2+ years	Autism	Autism	Autism
	Ventola et al. [30]		<3years = 0.86	<3years = 0.85	<3years = 0.88
	Kim and Lord [22]		>3years = 0.83	>3years = 0.85	>3years = 0.84
	Le Couteur et al. [16]		ASD	ASD	ASD
	Bishop and Norbury [21]		<3years = 0.83	<3years = 0.79	<3years = 0.81
	Mazefsky and Oswald [31]		>3years = 0.86	>3years = 0.76	>3years = 0.80
2. CARS	Saemundsen et al. [48]	2+ years	Autism = 0.89	Autism = 0.82	Autism = 0.86
	Tachimori et al. [70]		ASD = 0.82	ASD = 0.80	ASD = 0.81
3. CASD	Mayes et al. [73]	1–16 years	0.87–1	0.87–1	0.87–1

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
1. GARS	South et al. [9] Lecavalier [75] Mazefsky and Oswald [31] Sikora Hall et al. [8]	3–22 years	0.53	0.54	0.54
2. PDDBI	Cohen [76] Cohen et al. [77]. Cohen et al. [78] Reel et al. [79]	18 months —12 years	0.92	0.69	0.8
1. GADS	Matson et al. [80] Mayes et al. [10]	3–22 years	0.84	0.84	0.84
2. ASDS	Boggs et al.	5–18 years	AS versus	AS versus	AS versus

Tools	Articles	Age	Sensitivity (sen)	Specificity (spe)	Correct classification (cc)
	[81]		non-AS 0.79	non-AS 0.98	non-AS 0.89
			AS vs autism 0.84	AS vs autism 0.93	AS vs autism 0.89
3. ASDI	Gillberg et al. [82]	6–55 years	NR	NR	NR
4. AAA	Baron Cohen et al. [83]	18+ years	NR	NR	NR

Adapted from [13].

TABLE 27 SCREENING TOOLS FOR ASD

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
ABC	Autism Behavior Checklist	Eaves and Williams (2006)	2–14 years	57 items, 10–20 min	√√
ADEC	Autism Detection in Early Childhood	Nah, Young, and Brewer (2014); Nah, Young, Brewer, and Berlingeri (2014)	1–3 years	16 items, 10–15 min	√√
AOSI	Autism Observation Scale for Infants	Bryson, Zwaigenbaum, McDermott, Rombough, and Brian (2008);	6–18 months	18 items, 20 min	

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
		Zwaigenbaum et al. (2005)			
AQ	Autism Spectrum Quotient (Child Version)	Allison, Auyeung, and Baron-Cohen (2012); Auyeung, Baron-Cohen, Wheelwright, and Allison (2008)	4–11 years	50 items, 20 min	√√
ASAS	Australian Scale for Asperger's Syndrome	Garnett and Attwood (1997)	5 years+	27 items, 5 min	
ASRS-SF	Autism Spectrum Rating Scales Short Form	Goldstein, Naglieri, Rzepa, and Williams (2012)	2–5 years	15 items, 5 min	√√
ASSQ	Autism Spectrum Screening Questionnaire	Mattila et al. (2009); Posserud, Lundervold, and Gillberg (2006, 2009)	7–16 years	27 items, 10 min	√√
A-TAQ	Autism–Tics, AD/HD, and other Comorbidities (A–TAC) Inventory	Hansson et al. (2005); Larson et al. (2010, 2014)	6–19 years	96 items	√√
BISCUIT	Baby and Infant Screen for Children with aUtism Traits	Matson, Fodstad, Mahan, and Sevin (2009); Matson et al. (2009); Matson, Boisjoli, Hess, and Wilkins (2010)	17–37 months	62 items (Part 1), 20 min	√√

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
BITSEA	Brief Infant Toddler Social Emotional Assessment	Briggs-Gowan, Carter, Irwin, Wachtel, and Cicchetti (2004), Briggs-Gowan and Carter (2007)	12–36 months	42 items, 7–10 min	√√
CARS-2*	Childhood Autism Rating Scale 2nd Edition	Breidbord and Croudace (2013); Perry, Condillac, Freeman, Dunn-Geier, and Belair (2005)	24 months+	15 items, 15 min	√√
CASD	Checklist for Autism Spectrum Disorders	Mayes et al. (2009); Mayes, Black, and Tierrney (2013); Murray et al. (2011)	1–16 years	30 items, 15 min	√√
CAST	Childhood Asperger's Syndrome Test	Allison et al. (2007); Scott, Baron-Cohen, Bolton, and Brayne (2002); Williams et al. (2005)	4–11 years	37 items, 20 min	√√
CESDD	Checklist of Early Signs of Developmental Disorders	Dereu et al. (2010)	3–36 months	12 items	√√
CHAT	Checklist for Autism in Toddlers	Baird et al. (2000); Baron-Cohen, Allen, and Gillberg (1992);	18–24 months	14 items, 5 min	√
DBC-ASA	Development Behavior Checklist-Autism Screening	Brereton, Tonge, Mackinnon, and Einfeld (2002); Witwer	4–18 years	29 items, 10–15 min	√

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
	Algorithm	and Lecavalier (2007)			
DBC-ES	Development Behavior Checklist-Early Screen	Gray and Tonge (2005); Gray, Tonge, Sweeney, and Einfeld (2008)	18–48 months	17 items, 10–15 min	√
ESAT	Early Screening of Autistic Traits	Dietz, Swinkels, van Daalen, van Engeland, and Buitelaar (2006); Swinkels et al. (2006)	14–15 months	14 items, 5 min	√
FYI	First Year Inventory	Turner-Brown, Baranek, Reznick, Watson, and Crais (2013); Watson et al. (2007)	12 months	63 items, 10 min	√
GADS	Gilliam Asperger's Disorder Scale	Campbell (2005); Mayes et al. (2009, 2011)	3–22 years	32 items, 5–10 min	√√
GARS-3	Gilliam Autism Rating Scale 3rd Edition	Samadi and McConkey (2014)	3–22 years	42 items, 5–10 min	√√
KADI	Krug Asperger's Disorder Index	Campbell (**2005**); Krug and Arick (**2003**)	6–12 years	32 items, 15–20 min	√√
M-CHAT	Modified CHecklist for Autism in Toddlers	Robins, Fein, Barton, and Green (2001)	16–30 months	23 items,	√√

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
				5–10 min	
M-CHAT R/F	Modified CHecklist for Autism Revised with Follow-Up	Robins et al. (2014)	16–30 months	20 items	√√
PDDST	Pervasive Developmental Disorders Screening Test	Siegel (2004)	12–48 months	22 items (St1), 14 items (St2)	√√
POSI	Parent's Observation of Social Interactions	Smith et al. (2013)	16–30 months	7 items	√√
Q-CHAT	Quantitative Checklist for Autism in Toddlers	Allison et al. (2008)	18–24 months	25 items, 5 min	√√
RITA-T	Rapid Interactive Screening Test for Autism in Toddlers	Choueiri and Wagner (2015)	18–36 months	9 activities, 5–10 min	√√
SCDC	Social and Communication Disorders Checklist	Skuse, Mandy, and Scourfield (2005)	5-17 years	12 items	√
SCQ	Social Communication Questionnaire	Allen et al. (2007), Chandler et al. (2007); Oosterling et al. (2010); Snow and Lecavalier (2008)	4 years	40 items, 10–15 min	√
SORF*	Systematic Observation of	Wetherby et al. (2004)	12–24 months	29 items,	√√

Screening tool		References	Age range (months/years)	Nr. of items/length of test	Sensitivity and specificity above 70
	Red Flags			30–40 min	
SSI	Screen for Social Interaction	Ghuman, Leone, Lecavalier, and Landa (2011)	Toddler: 24–42 months Preschool: 43–61 months	Toddler: 21 items Preschool: 26 items	√√
SRS-2	Social Responsiveness Scale	Hus, Bishop, Gotham, Huerta, and Lord (2013)	2.5–18 years	65 items, 15–20 min	√
STAT*	Screening Tool for Autism in Toddlers	Stone, Coonrod, and Ousley (2000); Stone, Coonrod, Turner, and Pozdol (2004); Stone, McMahon, and Henderson (2008)	24–35 months		

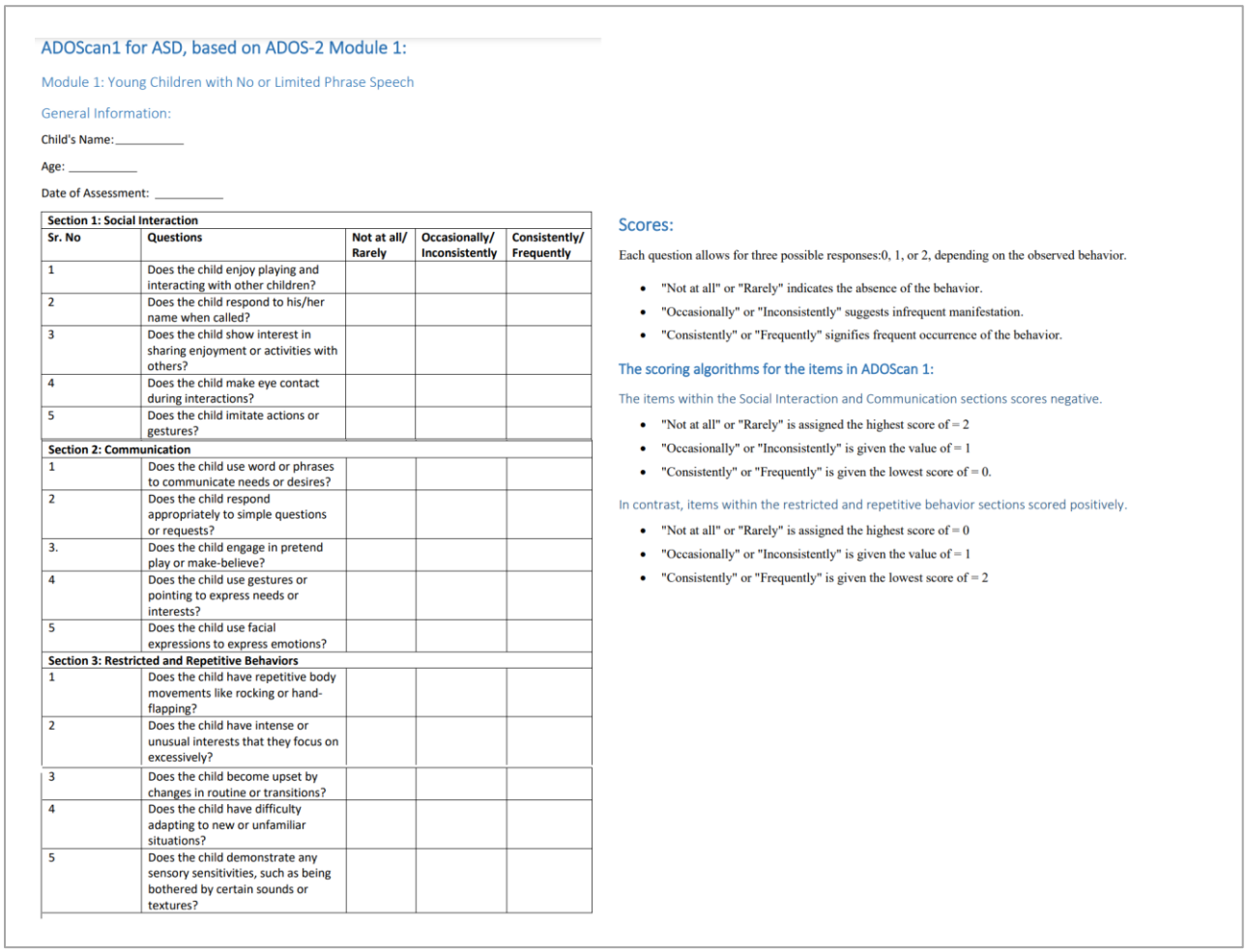
Adapted from [14].

5.4.2. Appendix B

TABLE 28 QCHAT-10 ANALYSIS ON DSM-5

Question Index	Question	Categories	Keywords
Q1	Does your child look at you when you call his/her name?	Social Emotional Reciprocity	call, name, look
Q2	How easy is it for you to get eye contact with your child?	Nonverbal Communicative Behaviors	contact, eye
Q3	Does your child point to indicate that s/he wants something? (e.g. a toy that is out of reach)	Social Emotional Reciprocity	point, want
Q4	Does your child point to share interest with you? (e.g. pointing at an interesting sight)	Social Emotional Reciprocity	point, pointing, share, interest, interest, sight
Q5	Does your child pretend? (e.g. care for dolls, talk on a toy phone)	No category found	No keywords found
Q6	Does your child follow where you're looking?	Social Emotional Reciprocity, Nonverbal Communicative Behaviors	follow, looking
Q7	If you or someone else in the family is visibly upset, does your child show signs of wanting to comfort them? (e.g. stroking hair, hugging them)	Social Emotional Reciprocity	comfort, show, sign
Q8	Would you describe your child's first words as:	Social Emotional Reciprocity	word
Q9	Does your child use simple gestures? (e.g. wave goodbye)	Nonverbal Communicative Behaviors	wave, gesture
Q10	Does your child stare at nothing with no apparent purpose?	Social Emotional Reciprocity	stare

5.4.3. Appendix C



ADOScan1 for ASD, based on ADOS-2 Module 1:

Module 1: Young Children with No or Limited Phrase Speech

General Information:

Child's Name:_____

Age: _____

Date of Assessment: _____

Sr. No	Questions	Not at all/ Rarely	Occasionally/ Inconsistently	Consistently/ Frequently
Section 1: Social Interaction				
1	Does the child enjoy playing and interacting with other children?			
2	Does the child respond to his/her name when called?			
3	Does the child show interest in sharing enjoyment or activities with others?			
4	Does the child make eye contact during interactions?			
5	Does the child imitate actions or gestures?			
Section 2: Communication				
1	Does the child use word or phrases to communicate needs or desires?			
2	Does the child respond appropriately to simple questions or requests?			
3.	Does the child engage in pretend play or make-believe?			
4	Does the child use gestures or pointing to express needs or interests?			
5	Does the child use facial expressions to express emotions?			
Section 3: Restricted and Repetitive Behaviors				
1	Does the child have repetitive body movements like rocking or hand-flapping?			
2	Does the child have intense or unusual interests that they focus on excessively?			
3	Does the child become upset by changes in routine or transitions?			
4	Does the child have difficulty adapting to new or unfamiliar situations?			
5	Does the child demonstrate any sensory sensitivities, such as being bothered by certain sounds or textures?			

Scores:

Each question allows for three possible responses:0, 1, or 2, depending on the observed behavior.

- "Not at all" or "Rarely" indicates the absence of the behavior.
- "Occasionally" or "Inconsistently" suggests infrequent manifestation.
- "Consistently" or "Frequently" signifies frequent occurrence of the behavior.

The scoring algorithms for the items in ADOScan 1:

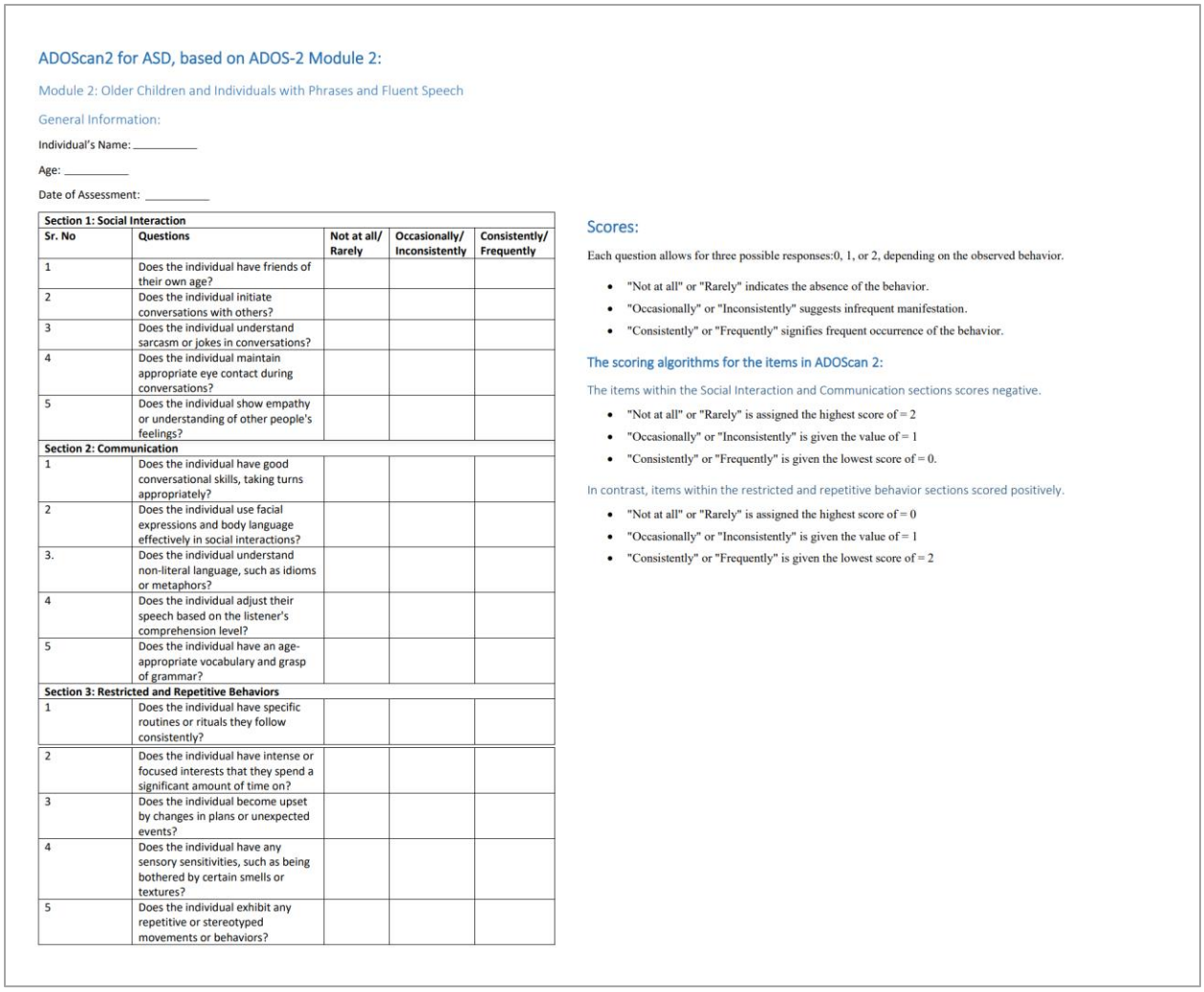
The items within the Social Interaction and Communication sections scores negative.

- "Not at all" or "Rarely" is assigned the highest score of = 2
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 0.

In contrast, items within the restricted and repetitive behavior sections scored positively.

- "Not at all" or "Rarely" is assigned the highest score of = 0
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 2

Fig. 15. ADOScan1 Screening Guide.



ADOScan2 for ASD, based on ADOS-2 Module 2:

Module 2: Older Children and Individuals with Phrases and Fluent Speech

General Information:

Individual's Name: _____

Age: _____

Date of Assessment: _____

Section 1: Social Interaction				
Sr. No	**Questions**	**Not at all/ Rarely**	**Occasionally/ Inconsistently**	**Consistently/ Frequently**
1	Does the individual have friends of their own age?			
2	Does the individual initiate conversations with others?			
3	Does the individual understand sarcasm or jokes in conversations?			
4	Does the individual maintain appropriate eye contact during conversations?			
5	Does the individual show empathy or understanding of other people's feelings?			
Section 2: Communication				
1	Does the individual have good conversational skills, taking turns appropriately?			
2	Does the individual use facial expressions and body language effectively in social interactions?			
3.	Does the individual understand non-literal language, such as idioms or metaphors?			
4	Does the individual adjust their speech based on the listener's comprehension level?			
5	Does the individual have an age-appropriate vocabulary and grasp of grammar?			
Section 3: Restricted and Repetitive Behaviors				
1	Does the individual have specific routines or rituals they follow consistently?			
2	Does the individual have intense or focused interests that they spend a significant amount of time on?			
3	Does the individual become upset by changes in plans or unexpected events?			
4	Does the individual have any sensory sensitivities, such as being bothered by certain smells or textures?			
5	Does the individual exhibit any repetitive or stereotyped movements or behaviors?			

Scores:

Each question allows for three possible responses:0, 1, or 2, depending on the observed behavior.

- "Not at all" or "Rarely" indicates the absence of the behavior.
- "Occasionally" or "Inconsistently" suggests infrequent manifestation.
- "Consistently" or "Frequently" signifies frequent occurrence of the behavior.

The scoring algorithms for the items in ADOScan 2:

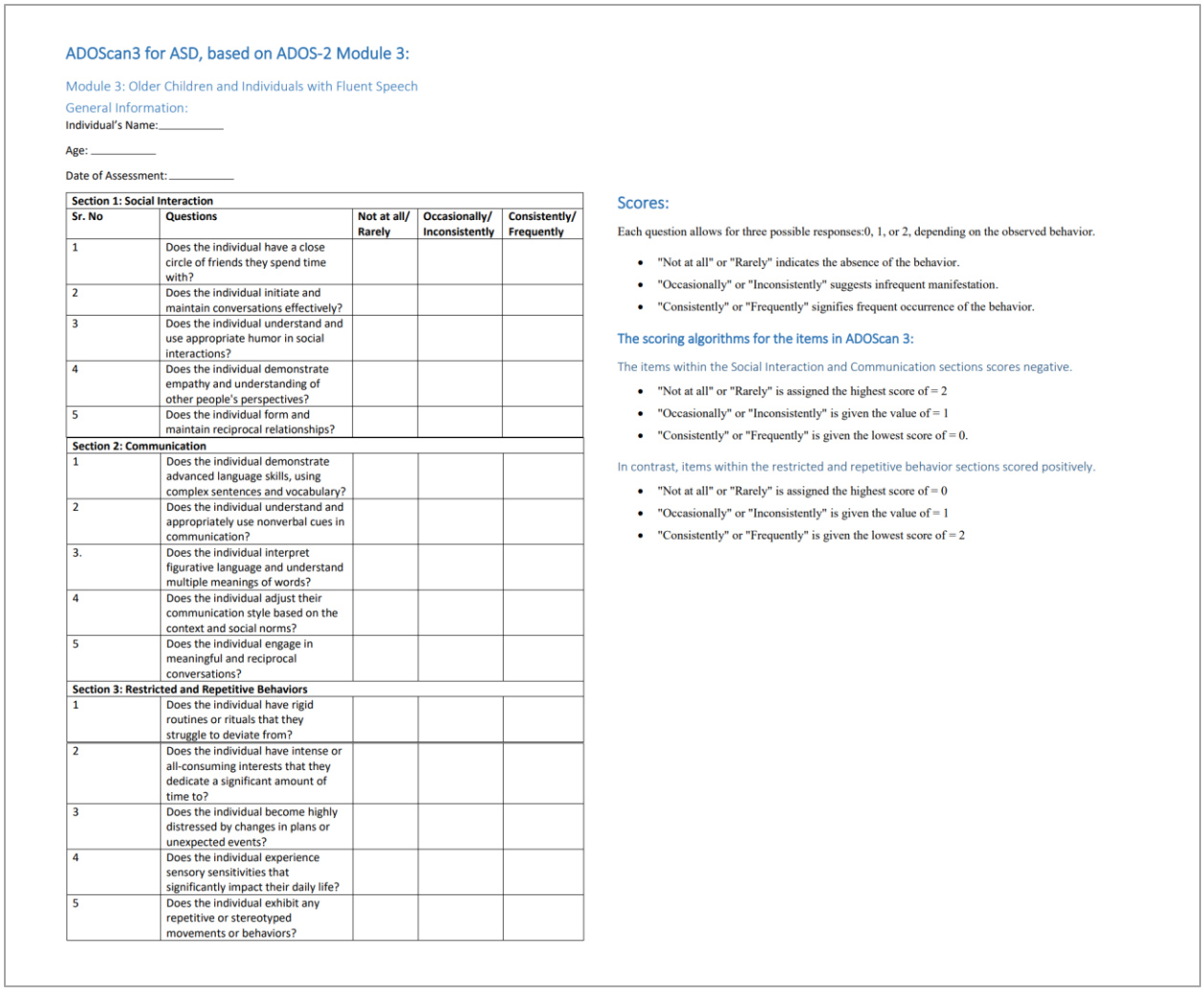
The items within the Social Interaction and Communication sections scores negative.

- "Not at all" or "Rarely" is assigned the highest score of = 2
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 0.

In contrast, items within the restricted and repetitive behavior sections scored positively.

- "Not at all" or "Rarely" is assigned the highest score of = 0
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 2

Fig. 16. ADOScan2 Screening Guide.



ADOScan3 for ASD, based on ADOS-2 Module 3:

Module 3: Older Children and Individuals with Fluent Speech

General Information:

Individual's Name:_____

Age: _____

Date of Assessment: _____

Sr. No	Questions	Not at all/ Rarely	Occasionally/ Inconsistently	Consistently/ Frequently
Section 1: Social Interaction				
1	Does the individual have a close circle of friends they spend time with?			
2	Does the individual initiate and maintain conversations effectively?			
3	Does the individual understand and use appropriate humor in social interactions?			
4	Does the individual demonstrate empathy and understanding of other people's perspectives?			
5	Does the individual form and maintain reciprocal relationships?			
Section 2: Communication				
1	Does the individual demonstrate advanced language skills, using complex sentences and vocabulary?			
2	Does the individual understand and appropriately use nonverbal cues in communication?			
3.	Does the individual interpret figurative language and understand multiple meanings of words?			
4	Does the individual adjust their communication style based on the context and social norms?			
5	Does the individual engage in meaningful and reciprocal conversations?			
Section 3: Restricted and Repetitive Behaviors				
1	Does the individual have rigid routines or rituals that they struggle to deviate from?			
2	Does the individual have intense or all-consuming interests that they dedicate a significant amount of time to?			
3	Does the individual become highly distressed by changes in plans or unexpected events?			
4	Does the individual experience sensory sensitivities that significantly impact their daily life?			
5	Does the individual exhibit any repetitive or stereotyped movements or behaviors?			

Scores:

Each question allows for three possible responses:0, 1, or 2, depending on the observed behavior.

- "Not at all" or "Rarely" indicates the absence of the behavior.
- "Occasionally" or "Inconsistently" suggests infrequent manifestation.
- "Consistently" or "Frequently" signifies frequent occurrence of the behavior.

The scoring algorithms for the items in ADOScan 3:

The items within the Social Interaction and Communication sections scores negative.

- "Not at all" or "Rarely" is assigned the highest score of = 2
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 0.

In contrast, items within the restricted and repetitive behavior sections scored positively.

- "Not at all" or "Rarely" is assigned the highest score of = 0
- "Occasionally" or "Inconsistently" is given the value of = 1
- "Consistently" or "Frequently" is given the lowest score of = 2

Fig. 17. ADOScan3 Screening Guide

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