

The Development and Acceptance of Autism Advisory Expert System

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Abstract: *This research paper aimed to develop an expert system designed to offer parents an initial diagnosis for Autism Spectrum Disorder (ASD). Such a system would benefit parents who fear taking their child to a psychiatric hospital despite their need to do so. The system covers five diagnoses: Autism in low, medium and high levels, Asperger's Disorder, and Child Disintegrative Disorder (CDD). Once the system gives the parents a diagnosis, it also offers them a set of general advice for parents to follow so their child's case won't worsen. The system was evaluated by a domain expert and a set of potential users who listed the benefits, limitations, and risks.*

Keywords: Autism Spectrum Disorder, ASD, Expert System, Knowledge, Knowledge-based System

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1. Introduction

Living in a community like ours can make it quite difficult for people to discuss certain illnesses that mainly affect their children's brains and mental health, as it returns to this perception that people with mental illnesses are "devalued as members of the society" [31]. However, it is quite important for people to understand exactly what is going on in their children's heads. Despite Autism Spectrum Disorder (ASD) not being diagnosed as a mental illness, many people still consider it to be one, and therefore, still maintain a fear of the stigma attached to the diagnosis.

From this perspective, this study aimed to develop an ASD diagnosis and advisory expert system prototype to serve as a knowledge hub for parents with doubts regarding ASD. Today, knowledge is mostly gained through the use of various technologies, including artificial intelligence (AI), a science that aims to develop systems that demonstrate 'intelligent' human-like behavior [5]. One of the commonly known types of AI technologies is an expert system, which is a system that encodes human expertise in specific domains by using If-Then rules, and accordingly advises and provide solutions to different problems [5]. With an expert system, parents can avoid having to go to a mental hospital just to relieve their doubts and receive a preliminary diagnosis. Once the system gives them an initial diagnosis based on a set of questions that needs to be answered regarding the child's age,

gender, and symptoms, the parents can move on to the next step and get an official diagnosis from the psychiatric hospital. One advantage of the expert system technology is its explanation facility, where the user can get an explanation and justification of the provided the conclusion [5]. This benefit can add value to an advisory system for a sensitive disorder such as ASD.

However, in a domain like ASD that is still subject to constant review and testing, the process of knowledge acquisition can be challenging. Extensive experience and expertise in the field of ASD is required and the experts are often unable to explicitly express their reasoning process [5]. Moreover, since the field of ASD is still under testing, the challenge to continuously update the knowledge base of the expert system rises. Nevertheless, the benefits of the expert system outweigh these challenges. This system will reduce the level of doubt parents have regarding their child's attitude. It will also increase the awareness of ASD and what should be observed in a child's behavior as well as what to do with a child suffering from any type of ASD.

2. Background Literature

2.1 Autism Spectrum Disorder (ASD)

Everyone has the skills to do something unique in their community, but those skills need to be adopted and developed by families first, and by schools and

communities second. The same is true for patients with ASD; they have the power and skills to build and create an impression on society, but they need some attention from their family and school to start the treatment at an early age [14]. The treatment starts with awareness; diagnosing the disease must obviously precede the treatment. Therefore, this study aimed to build a system to assess the existence and level of ASD in children.

ASD is a neuropsychiatric disorder that occurs between 12 and 18 months of age in boys more than in girls [13]. ASD is characterized by varying degrees by impaired verbal and nonverbal communication, social interaction, behaviors, and impaired mental or cognitive functioning [13], for example, such patients are often socially aloof, and it can be very difficult to interact or gain their attention. Also, such patients get anxiety in crowds, and struggle with eye contact, monitoring back and forth conversation, interpreting body language, and interacting with others in an age appropriate matter [22]. Moreover, patients with ASD tend to repeat certain behaviors that affect their day-to-day activities, become frustrated about communication with others, become very angry about changes in routine, and have a passionate interest in a single topic. Other symptoms include difficulty organizing time and some strange actions like rocking, hand flopping, walking on toes; and spinning in circles. Affected patients also have a degree of mental retardation, a challenge in self-care tasks, and difficulty making sudden decisions or changes to their regular routines [13]. The reasons behind ASD are still unclear, although it affects millions of individuals worldwide [6].

However, according to [2, 12], there are several factors that may play a role in causing ASD, such as genetics and environmental surroundings that influence patients' development. ASD is rooted in very early brain development, so it needs early diagnosis to reduce the risk of any increase in the future. The diagnosis of ASD is conducted by a multidisciplinary team led by an expert following some information about the patient's health history, observing behaviors, testing cognitive function, and assessing language [13]. If early diagnosis was successful and treatment is immediately started, there is a big chance of recovery.

Some symptoms differentiate one type of ASD from the others. For instance, children with Asperger's have normal intelligence and near normal language development [11]. Furthermore, they tend to have specific rituals that they find impossible to switch. They also tend to have problems extracting visual information from the environment and translating what they see. Children with Asperger's tend to show low results in their physical test regarding where they tend to have low muscle tone and a brain based condition that makes it hard to plan and coordinate physical movement. In addition, their movement tends to be clumsy and awkward [3].

Children with Childhood Disintegrative Disorder (CDD) are most often distinguished by having specific skills and movements that suddenly disappear [28]. Furthermore, children with CDD suffer from epilepsy and seizures [28]. Another factor that helps in the diagnosis of ASD is the gender, where more than four times as many boys are diagnosed with ASD than girls [23]. In other words, ASD is four times more common among boys than girls. Furthermore, a history of ASD in the family can increase the risk of having children with ASD [18].

There are two common instruments to diagnose ASD: the Autism Diagnostic Interview – Revised (ADI-R), which is a semi-structured interview with parents, and the Autism Diagnostic Observation Schedule (ADOS) which is a system for monitoring patient behavior the using Childhood Autism Rating Schedule (CARS) to assess the strength of the ASD [29].

According to [7], the best treatment is social and educational interventions responsible for improving communication and enhancing social skills by giving patients academic subjects to learn and acquire knowledge. ASD experts also assign exercises such as solving puzzles, building toys, playing, drawing, and others to feed their minds and grab their attention. Furthermore, this expert advice gives the patient the freedom to act without constraints, which helps patients with ASD learn and discover their environment [7]. On the other hand, there is also medical treatment, which is responsible for calming and reducing their episodes. However, experts do not advise patients to go beyond this kind of treatment because of its negative impacts on the body.

2.2 ASD in Oman

The cases of ASD in Oman has been increasing. “A total 113 cases of ASD were enumerated nationwide, indicating an overall prevalence of 1.4 cases per 10,000 children aged 0-14 years. More prevalent cases were among boys (75%) and among low-income families” (Al-Farsi et al., 2011, pg. 821). According to [2], 3500 families in Oman have a child who suffers from a form of ASD. ASD ranges from high to low level and expands to cover Asperger's and CDD. ASD patients suffer from several challenges including the increasing cost of treatment, up to 50 OMR for one session [2]. Also, most centers are concentrated in Muscat City and most are private, meaning the cost of treatment is often very high. Moreover, the diminishing number of medical staff who specialize in ASD is another big challenge. According to Oman Daily (2016), the total number of ASD patients is 147, with a low presence of cadres. However, there are 153 cases of ASD on the treatment waiting list.

There are several centers and associations in Oman that care about ASD and work to increase the

awareness. Among these associations is the Oman Autism Society, which is a nongovernmental charitable association based in Muscat. It was founded on February 10th 2014 under the Ministerial Decree No.29/2014 [16]. This association deals with all elements of ASD and works to raise the awareness and understanding of ASD in Omani society. Therefore, this project aims to contribute to such work and support them in raising awareness of ASD amongst the people of Oman.

2.3 Existing IT Applications for ASD

There are numerous sites for parents to learn more about the different types and symptoms of ASD, but there aren't any interactive expert systems that could give them a preliminary diagnosis. Parents' only way of evaluating whether their children have ASD is by filling out a certified checklist called the Modified Checklist for Autism in Toddlers (M-CHAT) set up by the American Academy of Pediatrics (AAP). The checklist is aimed at assessing children from the age of 1-3 years by asking their parents yes/no behavioral questions, and then ordering the results in a set of ranges that go from low to high probability of autism [21], translated by [4]. Another available test is the Early Screening of Autistic Traits Questionnaire (ESAT), which is administered in two stages, for children aged 14 to 15 months [9]. This test is similar to the M-CHAT, except for the fact that it is performed in two stages, which might possibly bring better results [24].

Furthermore, existing artificial intelligent (AI) systems that deal with ASD are mainly used for treatment and for assisting teachers in providing daily tasks to children with autism. One example is the AI robotic device called NAO. This robot was developed by Aldebaran Robotics, with the aim to understand whether it is easier for children with autism to interact with a robot rather than a human being [25]. Another robotic device with a similar aim is called Zeno. This robot has more human-like features and resembles a four-year-old child, making it more friendly and easy for children to interact with [19]. A less tech-savvy way that professionals treat children is through homemade videos that provide professionals with clinical proof of the child's behavior, making it easier to assess and treat [15].

The system proposed here combines aspects of the M-CHAT in a more comprehensive and digitalized way, allowing parents to get an early diagnosis of their children online or offline using the system's application.

3. Development of the Autism Diagnosis and Advisory Expert System

3.1 System Objectives

Having an expert system that gives parents an early

diagnosis can be quite beneficial, as it can provide an early, clear idea of what is happening with their children and, as stated, "early identification may better equip health care professionals to recognize, diagnose and respond to related difficulties in siblings or other family members", so this system would provide professionals a starting point for what is going on with such children and provide the proper medical and social intervention [27].

On the other hand, expert systems can be quite challenging to handle; information can be difficult to acquire from human experts, the technology might be limited, and the system may not provide as much detail as a domain expert would [26].

The main objective of this system is for parents to easily identify the level and type of ASD their child might have by answering a set of questions regarding family history; genetics; child's age and gender; and checking the symptoms that their child displays. Once this has been obtained, the system displays the type of ASD the child might have, the definition of it, and some general advice that parents should follow to reduce the effect of the disorder.

3.2 Knowledge Elicitation

To obtain the information required to solve particular problems, many techniques such as interviews, observations, focus groups, case studies, role playing, document analysis, conceptual graph, reporting grid and others are used to elicit the knowledge [8]. This study used two techniques: analyzing literature reviews related to ASD and how to diagnose it; and a many-on-one interview, which means a single expert with multi knowledge engineers (KEs). This latter technique helps to broaden the possible information, observe the expert carefully, and identify some issues that a single knowledge expert might overlook [10].

The domain expert for this project was Dr. Samar D. Badawi, who has been a pediatrician for more than three decades. She has a Bachelor's Degree in human medicine and a Master's in pediatrics from Halab University, Syria. She also has many certificates in ASD diagnosis and behavioral disorders. She has been working in the field of diagnosis and early intervention for about two decades. Furthermore, Dr. D. Badawi is a member of many international autism associations, the Syrian Red Cross, The Oman Autism Society, and many non-governmental associations in the United Nations Development Program. Last but not least, Dr. D. Badawi has worked in the Child Psychiatry Department at Al Massara Hospital in Oman in the field of Autism Diagnosis and Early Intervention since 2013.

3.3 System Analysis

3.3.1 Inputs

The system requires the following inputs to reach a

conclusion:

- “How old is your child?” (Age)
- “Male OR Female” (Gender)
- “Is there a history of autism in the family?” (History of Autism in the family)
- Symptoms “Please choose the behaviors that your child shows among this list”
- “Does your child suffer from low muscle tone and dyspraxia?”
- “Are the movements of your child clumsy and awkward?”
- “Has your child lost bladder control?”
- “Has your child lost play skills?”
- “Has your child lost control of bowel movements?”
- “Have your child’s self-care skills declined?”
- “Does your child suffer from recent speech impairments?”
- “Does your child suffer from seizures?”
- “Does your child suffer from epilepsy?”

The following example illustrates the gender, age, and symptoms prompts as programmed in the eXpertise2Go expert system shell:

PROMPT [Gender] ForcedChoice
 “What is your child’s gender?”
 “Male”
 “Female”

PROMPT [Age] Numeric
 “How old is your child?”
 “1”
 “10”

PROMPT [Symptoms] AllChoice
 "Select all of the symptoms your child displays"
 "Finds it difficult to communicate with words"
 "Repeated behaviours affect day-to-day activities (such as rocking, hand flapping, walking on toes, or other routines)"
 "Believe your child might be deaf"
 "Frustration about communication with others"
 "Very difficult to interact with"
 "Difficult to gain his/her attention"
 "Have a degree of mental retardation"
 "Over or under-sensitive to sounds and sights"
 "Has a challenge in self-care tasks"
 "Knows several different synonyms for some words"
 "Has passionate interest in a single topic (Ex: cars, toys, circular objects etc.)"
 "Senses (sight, hearing, touch, smell or taste) are too sensitive or too insensitive"
 "Difficult to organize time"
 "Struggle with Eye contact, maintaining back-and-forth conversation, Interpreting body language, Tone of voice"
 "None of the above"
 MAXVALS [Symptoms] 15

3.3.2 Outputs

The developed system aims to provide a conclusion about the following:

- Diagnosis (as in Table 2)
- Definition (as in Table 2)
- Additional advice

The following example illustrates conclusions (goals) as programmed in the eXpertise2Go expert system shell:

GOAL [Advice]
 GOAL [Definition]
 GOAL [Diagnosis]

3.3.3 Middle

The middle section represents the reasoning process that enables the system to reach a conclusion based on the user’s responses to the inputs questions; it is like a link between the inputs and outputs [5]. A decision table was used to illustrate this reasoning logic that links the inputs to the outputs based on the literature review and the human domain expert. For instance, Table 1 shows the common symptoms of autism disorder; which are also illustrated in Figure 1 of the developed system. Table 2 provides definitions for several ASD types. Figures 2-4 illustrate snapshots of the system conclusions.

Table 1 Common Symptoms

Common Symptoms Among the Autism Disorders
• Non-verbal communication.
• Repeated behaviours affect day-to-day activities.
• Very angry with a change in routine. (such as rocking, hand flapping, walking on toes, spinning in circles hand wringing or finger twisting or other routine)
• Frustration about communication with others.
• Very difficult to interact.
• Difficult to gain his/her attention.
• Have a degree of mental retardation.
• Over or under-sensitive to sounds and sights.
• Has a challenge in self-care tasks.
• Know several different synonyms for some words.
• Have a passionate interest in a single topic.
• Some sensory concern.
• Difficult to organize the time.
• Have difficulties to taking the perspective of others.
• Anxiety in crowds.
• Struggle with Eye contact, Maintaining back-and-forth conversation, Interpreting body language, Tone of voice

patient to diagnose the child. However, the system is great in regards of increasing the awareness of autism, its types, and the possible symptoms that are associated with each type. As a person who works in Al Masarra hospital, I get to see cases where parents don't know how to accept the child or know what ASD is, and through this system, I can see how it can help raise their awareness regarding ASD and what they should do."

Furthermore, one of the participants was also a pediatrician at Sohar Hospital. He liked the system so much that he wanted to implement it at the hospitals or upload it to the Internet to become a more permanent check for parents' potentially ASD children. Moreover, one critical piece of feedback was from a social worker who works at an elementary school; she deals with children every day and she knows when a child suffers from ASD and how to carefully handle such children. She approved of the system of symptoms and the advice included in the system. She said, "The system is so fast, cheap, saves time and flexible. It is very important for parents to use it at home before going to the hospitals for treatment".

Another participant was a biology teacher whose son suffers from medium level autism. He liked the idea of the system because it was very fast and gave useful advice regarding autism that he did not previously know. However, he also noted that prefers human experts to such a developed expert system because people are much more flexible, while the developed expert system is restricted to what information is already stored in it. In addition, the developed expert system may not function properly at certain times or crash. His opinion was similar to other feedback from a medical student at Sultan Qaboos University.

Furthermore, four of the respondents were housewives. All of them preferred the developed expert system to a human expert system because the system will save time rather than wasting time in a long queue at the hospital. Finally, two more participants, an architectural engineer and business man, preferred the developed expert system to the human expert system because they were too busy and using the technology helped them save time.

4.3 Inputs-Outputs-System Quality Evaluation

The survey asked participants to evaluate the inputs and the outputs of the Development of Autism Diagnosis and Advisory Expert System. The majority, about 92% of the users, agreed or strongly agreed that the system asked relevant questions, whereas 8% of them were neutral. About 80% agreed or strongly agreed that the questions were accurate, while 9% of them disagreed, and 11% were neutral. The majority, about 90%, also agreed or strongly agreed that the questions were complete, while 8% were neutral and only 2% strongly disagreed. Furthermore, the questions were understandable to 82% of the participants, while

10% were neutral, and 9% disagreed. For more details, see Figure 5.

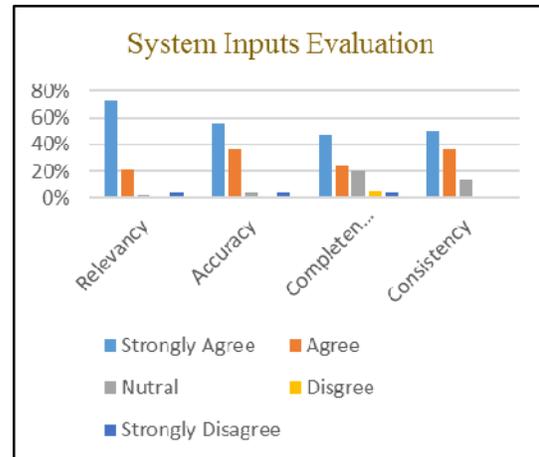


Figure 5. System Inputs Evaluation

Moreover, the survey also included questions related to the system's outputs. According to the responses, 94% agreed or strongly agreed that the system's conclusion was relevant, 2% were neutral, and only 4% strongly disagreed. Around 92% of the respondents agreed or strongly agreed that the conclusion of the system was accurate, while 4% were neutral, and only 4% strongly disagreed. Regarding the completeness of the output, 71% agreed or strongly agreed that the system's conclusion was complete, while 9% strongly disagreed, and the remaining 20% were neutral. Moreover, 86% agreed or strongly agreed with the consistency of the system's conclusion and the remaining 14% were neutral. About 84% of the participants agreed or strongly agreed that the system asked clear and easy to understand questions, while 16% were neutral. Finally, 62% of participants trusted or strongly trusted the outputs of the system, while 24% were neutral, and 14% disagreed, as shown in Figure 6.

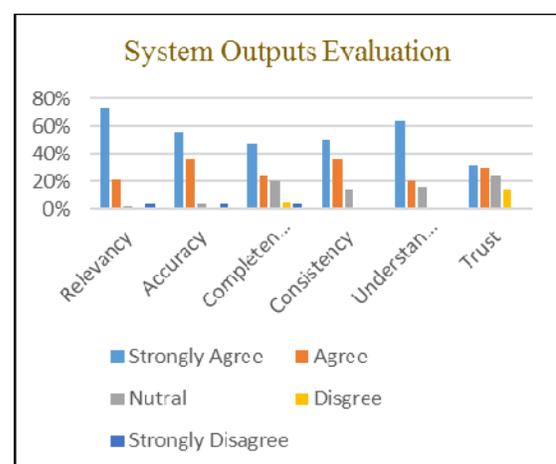


Figure 6. System Outputs Evaluation

Finally, the survey also asked participants to evaluate the overall system performance. Results showed that 68% of the participants agreed or strongly agreed that

the system was reliable, while 6% strongly disagreed, and 20% were neutral. About 88% agreed or strongly agreed that the system was friendly and easy to use, while 8% of them disagreed or strongly disagreed, and the remaining 4% were neutral. Actually, 84% of participants agreed or strongly agreed that they would use the system if they had access to it, while 16% disagreed or strongly disagreed that they would use the system. About 96% of participants agreed or strongly agreed that the system had a good response speed and that it was useful. In contrast, 4% of participants strongly disagreed with this finding. Moreover, 92% of the users agreed or strongly agreed that the system improved their awareness of ASD. About 80% agreed or strongly agreed that the system satisfied them, while 16% were neutral, and 4% strongly disagreed. Finally, about 66% of participants strongly trusted the system overall, while 27% were neutral, and 7% strongly disagreed with the system. Figure 7 shows a breakdown of these findings.

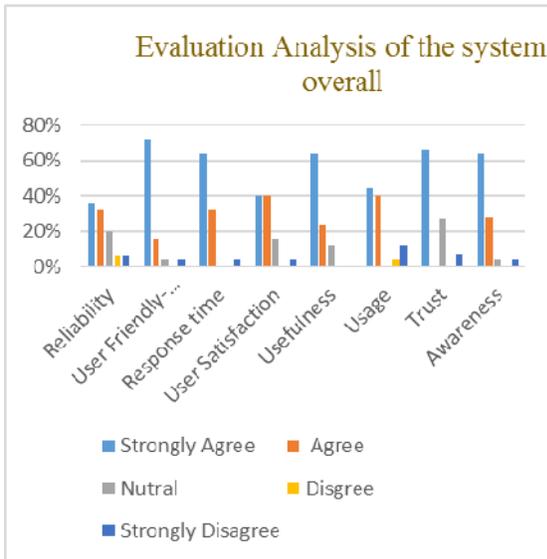


Figure 7. Evaluation Analysis of the system overall

4.4 System Benefits & Limitations Evaluation

Table 3 illustrates the benefits of the development of the Autism Diagnosis and Advisory Expert System. About 62% of the respondents thought the system was easy for getting a preliminary diagnosis and 89% identified the system as so easy to use. Also, 63% viewed the system as flexible, 56% said that the system was fast, and 46% indicated that the system would save time. Further, 50% of the participants said that the system was cheap and 44% of them indicated that it could provide useful advice. About 36% of participants saw the system as a powerful tool to increase awareness about ASD.

Table 3 Benefits of the Developed System

Benefits:	
Easy to use	89%
Flexible	63%
Easy to get a preliminary diagnosis	62%
Fast	56%
Cheap	50%
Save time	46%
Provide useful advices	44%
Increase awareness about Autism	36%

Table 4 identifies the limitations of the development of the Autism Diagnosis and Advisory Expert System. The results show that 44% of the participants had concerns about the accuracy of the system. Also, 38% needed more advice and details about the diagnosis. Moreover, about 21% noticed that there was no face-to-face interaction between the patient and the doctor.

Table 4 Limitations of the Developed System

Limitations:	
Accuracy	44%
No lots of details	38%
Non-existence of the face to face interaction between the patient and the doctor.	21%

Finally, the survey asked participants to express their opinions about whether they prefer a human expert or a developed expert system. About 59% of respondents preferred the developed expert system to the human expert because of the previously benefits mentioned. Nevertheless, 41% still preferred a human expert to the developed expert system.

Nevertheless, this system was unique, combining a variety of theories, symptoms, and tests related to ASD diagnosis to create a tool that can be used both online and offline. However, due to its new concept and the sensitivity and misconceptions of ASD as a topic among people in the sultanate, only one parent agreed to use this system to assess his child. When the father tried the system, the diagnosis of the system was the same as the diagnosis given in the clinic: Medium Level Autism.

4. Conclusion

Several studies have been conducted on ASD and some are still being conducted to get a clearer image of what it is, what causes it, and what symptoms are associated with it. The use of IT in the diagnosis and treatment of this disorder has also been discussed in several cases. However, due to its complexity, people

are hesitant to know about it or associate with it. Therefore, having an ASD Diagnosis Expert System that seeks to capture several inputs to produce an appropriate output will help raise the awareness of ASD, its symptoms, and additional advice that can help deal with the diagnosis. The system can be used by parents or any other interested individual or organization.

The system aims to help raise awareness of ASD, as it has become vital to know more about such disorders. Nevertheless, it also helps reduce any doubt that parents have about their child's behavior. Moreover, the system will reduce the time and effort needed to visit an expert to remove any lingering doubts. However, one limitation of this system is that it only provides an initial diagnosis; domain experts cannot be completely eliminated from the diagnosis process, as they play a significant role in the diagnosis of such disorders. Such a diagnosis still requires a face-to-face interaction between the patient and the doctor, for each child is unique. The final diagnosis must come from the domain expert, which can only happen after a long session with the doctor, so that the doctor can carefully observe and study the patient.

This paper illustrates the development process of an expert system for ASD diagnosis. Such development can be used by concerned individuals, social organizations, and clinics. The study also reported an evaluation by 25 potential users, from a conservative society, about the quality of system inputs and outputs, as well as the benefits and limitations of developing an Autism Diagnosis Expert System. Participants provided mainly positive responses to several indicators related to inputs, outputs, and systems quality. In addition, participants indicated that the system has several values in terms of ease of use; flexibility; fast access; saving time and money; providing useful advice; and increasing awareness about ASD. However, participants still expressed concerns about the accuracy of the system and the lack of face-to-face human interaction, and needed more information.

Future development might integrate other related disorders and provide more advice on treatments, nutrition, and exercises for children with ASD.

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