

(RESEARCH ARTICLE)



## Health promotion through digital screening tools for adults with autistic phenotype

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Magna Scientia Advanced Research and Reviews, 2024, 10(02), 055–065

Publication history: Received on 03 December 2023; revised on 25 February 2024; accepted on 27 February 2024

Article DOI: <https://doi.org/10.30574/msarr.2024.10.2.0004>

### Abstract

Health promotion is related, in all people, to factors such as physical health, stress, mental clarity, financial status, mental resilience and social support. Undiagnosed adults with autism elements, compared to the rest of the population, are at greater risk of depression, anxiety disorders, mood disorders, and obsessive-compulsive disorders. These individuals often become dysfunctional in professional, social and family contexts, they also feel social and emotional dissatisfaction without even knowing the cause of their problems. The detection of autistic elements of adults is necessary for health promotion so that they receive appropriate support from health professionals, and to prevent serious mental, physical and mental health problems. The scope of this research through the systemic bibliographic review is the recognition of autistic elements diagnostic tools in adult population. There have been 14 trustworthy measuring tools for autistic elements. 12 of which are self-referential tools, one tool that requires a specialist to yield result and one diagnostic tool. The trustworthiness and the validity of all tools are above 0,70 rendering them both trustworthy and valid to be used. The results of the bibliographic review have proven that the majority of the tools rely on the measurement of social skills deficiencies, empathy levels and sensory dysfunctions of the respective adult population sample.

**Keywords:** Autism; Digital screening; Adults; Health promotion

### 1 Introduction

According to the UNCTAD, one in 100 children is autistic, but the reported prevalence between studies varies considerably (World Health Organization, 1992). A 2001 study in the USA found that the prevalence of autism had increased from 4 to 5 cases per 10,000 children in the 1980s to 30 to 60 cases in the 1990s (Bertrand et al., 2001). Furthermore, a study using a community sample of 7461 adults in England detected ASD in 9.8 per 1000 adults (Brugha et al., 2011). In a 2018 study by the United States Centers for Disease Control and Prevention (CDC), one in 38 boys and one in 152 girls aged eight were diagnosed with ASD (Baio et al., 2018). In the same study, the average prevalence of ASD in adult men and women was found to be 4 to 1 with men having average or above average IQ compared to women with ASD. Other studies have also identified gender differences in the prevalence of ASD, with typically developing males having more autistic traits (Holtmann et al., 2007); Lai et al., 2011) and females exhibiting fewer repetitive, restricted behaviors and interests (Cassidy et al., 2014); Additionally, females with ASD have been shown to “camouflage” (i.e., have learned to obscure) their autistic traits more than males (Hull et al., 2019). Based on the above findings, Schuck, Flores and Fung noted that due to camouflage the ASD symptoms may be more difficult to detect in women. Consequently, a significant proportion of women may be misdiagnosed, diagnosed after a significant delay or not fully diagnosed, this resulting in a lack of treatment and support (Schuck et al., 2019).

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## 2 Social-emotional profile of adults with ASD

A valid diagnosis of the autism spectrum in adulthood can prevent a collapse of family, social, and work relationships (Vaiouli & Panayiotou, 2021). According to the DSM as well as the ICD 11, when deficits are severe enough they can cause impairments in personal, family, social, educational, occupational, or other important functioning areas (American Psychiatric Association, 2013; ICD-11 for Mortality and Morbidity Statistics, 2022). Some adults with ASD may have fluent language ability, with relatively subtle impairment in eye contact, posture, and facial expression (World Health Organization, 1992). Additionally, many normal intelligence adults with ASD are able to find a job position that matches their special interests and skills, providing employment opportunities and mitigating the overall dysfunction associated with the disorder (Dell’Osso et al., 2017). However, even when diagnosis is delayed because of relatively good levels of interpersonal and occupational functioning, individuals with ASD retain a reduced ability to adapt to stressful life events. Consequently, they experience heightened sensitivity to stress, mood, trauma, and suicidal behaviors (Dell’Osso et al., 2015; Dell’osso et al., 2015; Lugnégård et al., 2011). In parallel, recent literature has focused on the comorbidity between ASD and other mental disorders, with some studies raising the question, whether psychiatric comorbidity could conceal ASD, especially in individuals with normal intelligence and moderate symptoms (Dell’Osso et al., 2015; Takara & Kondo, 2014). It has also been found that individuals with the Asperger syndrome were more likely to report depression, suicidal ideation, suicidal plans and attempts compared with both the general population, and individuals with medical or mental illnesses (Cassidy et al., 2014). It has also been shown that individuals with high autistic traits reported stronger feelings of loneliness (Jobe & Williams White, 2007; Lampion & Zlomke, 2014), depression and anxiety, as well as higher rates of bullying (Kunihira et al., 2006). In a study of newlywed couples, researchers found that higher levels of autistic traits in men were associated with lower satisfaction regarding the quality of their relationship (Pollmann et al., 2010).

## 3 Methodology

### 3.1 Purpose

The present research comprises a systematic literature review aiming to seek tools that detect autistic traits in the adult population and the specific criteria for diagnosing the autistic spectrum do these tools focus on?

### 3.2 Research method

The present study was based on the systematic literature review of articles published in peer-reviewed scientific journals. International studies related to the subject were studied. The finding and collection of articles was performed through an online search in the Scopus and PubMed databases. The time frame for the identification of the studies was between 2012 and December 2022. The search terms (keywords) of the articles were: “autism spectrum quotient” OR “autistic traits questionnaire” OR “autism screening tools” OR “autism diagnostic interview” AND “adults”.

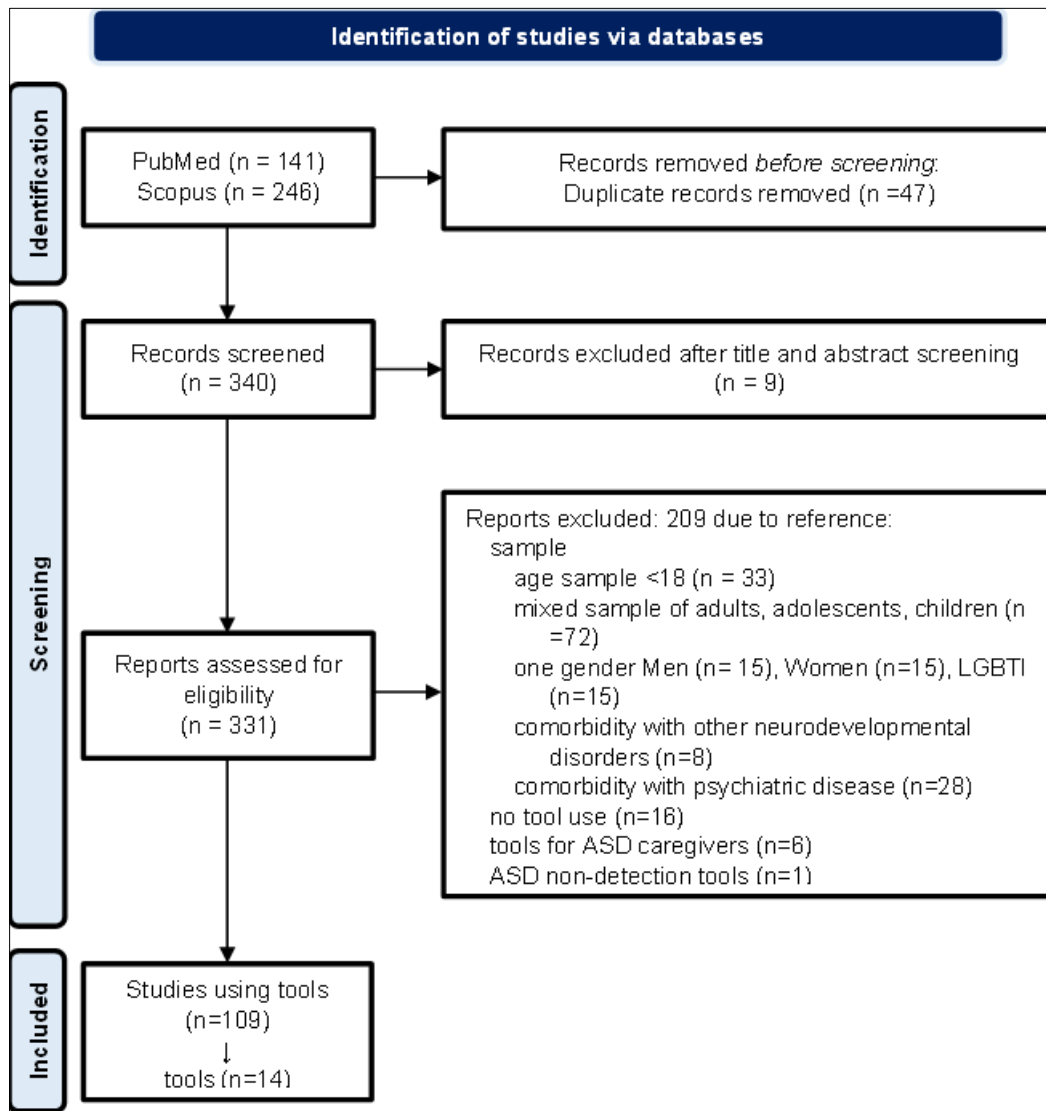
### 3.3 Inclusion Criteria

- Regarding the sample
  - Adults (over 18 years old)
  - Binary gender (male or female)
  - Studies that referred to tools aimed to adults themselves
- Studies that presented the psychometric properties of a weighted instrument applied to a large sample of autistic and non-autistic adults.
- Studies that used one or a combination of autistic trait detection tools to find epidemiological data on the autism spectrum.

### 3.4 Exclusion Criteria

- Regarding the sample
  - Age sample under 18 years of age as well as studies in a mixed sample (children – adolescents – adults).
  - Studies that used instruments that targeted either sex.
  - Studies where the sample consisted of people from the LGBTI community or included members of the LGBTI community in the sample.
  - Studies addressed to adult caregivers
- Studies where the sample presented comorbidity with other developmental disorders or mental disorders.

- Systematic reviews that did not make extensive reference to the presentation of an autism screening tool, but only referred to the results of a survey.



**Figure 1** Prisma flow diagram

## 4 Results

The tools used in the studies were the following:

AQ. It was used in 36 studies in its original English version and in 38 studies in a cultural adaptation. Additionally, it was used in two studies in both English and a culturally adapted version (Portuguese-English in the first case and Italian-English in the second), as these addressed to both native and English-speaking university students in Portugal and Italy. Two short versions of the AQ were also identified. The AQ10 English version was used in four studies (Adamson et al., 2018; Booth et al., 2013; Caine et al., 2021; Murray et al., 2019), while three studies used a cultural adaptation: one in Greek (Vaiouli & Panayiotou, 2021), one in Irish (Murray et al., 2022) and one in Norwegian (Orm et al., 2021). The second short version, AQ28, was used in its original English version in three studies (Cuve et al., 2021; Murray et al., 2017; Shah et al., 2019), and in an adaptation in Japanese (Kajitani et al., 2019).

EQ was found in nine studies; five studies in its original English version and four in cultural adaptations. (Cassidy et al., 2016) (Baron-Cohen and Wheelwright, 2004; Baron-Cohen et al., 2014; Vukusic et al., 2017; Sperandio et al., 2017; van Tiel et al., 2021; Massullo et al., 2020; Conson et al., 2020; Shalev & Uzefovsky, 2020; Paul et al., 2021).

- SQ appeared in six studies; two in the original English version and four in cultural adaptations.

- RAADS-R was used in five studies; four in original English version and one in a cultural adaptation.
- SRS appeared in five studies; three in the original English version and two in cultural adaptations.
- ADOS (module 4) appeared in five studies all in the English version.
- BAPQ was used in two studies; one in the original version and one in a cultural adaptation.
- CATQ researchers used it in one study in the English language
- SSQ researchers used it in one study in a cultural adaptation
- RMET appeared in one culturally adjusted study
- SPQ appeared in one study in its short version combined with the short version of the AQ.

All the tools mentioned above were used in combination with the AQ as well as other existing tools depending on which feature of the ASD the researcher wanted to focus on.

The tools identified in studies describing their original version (creation and weighting) are the following:

- AdAS Spectrum (Dell'Osso et al., 2017),
- ToM-HCAT (Aykan & Nalçaci, 2018)
- SPQ original version along with its short form used, as shown above, in one study.
- CATQ used in one study in its original version (Hull et al., 2019).

Among the studies using cultural adaptations, one tool, the GSQ, was found in its Japanese and French versions. The remaining studies involved:

- Four studies using a cultural adaptation of the AQ in Polish (Pisula et al., 2013), Chinese (Lau et al., 2013), Hebrew (Golan et al., 2023), and Swedish (Lundqvist & Lindner, 2017).
- One study using the Chinese version of the EQ (Zhao et al., 2018).
- Two studies using the CATQ in its Dutch (van der Putten et al., 2023) and Italian adaptation (Dell'Osso et al., 2022).

Regarding the reliability of the tools all the tools were found to have an index above 0.70. The highest validity reliability index was observed in the AdAS Spectrum tool (0.964) followed by SSQ (0.95), CATQ (0.94), GSQ (0.93), EQ and SPQ (0.92), ADOS (0.91-0.94), SQ (0.90), ToM-HCAT (0.84), BAPQ (0.80), RAADS (0.78-0.92), RMET (0.71), AQ (0.76), while, the SRS2 tool had the lowest reliability index in one category (0.61-0.92).

Finally, regarding diagnostic criteria, seven instruments (AQ, SQ, RAADS, SRS, ADOS, BAPQ, AdAS Spectrum) were identified, investigating deficits in social communication and interaction and persistent repetitive behavior patterns. Three instruments, i.e., SSQ, GSQ, SPQ, were identified strictly measuring sensory sensitivity, whereas two tools (RAADS and AdAS Spectrum) measured sensory sensitivity and hypo/hyper-sensory reactivity in their subscales. One tool, RMET, examined social understanding, while CAT-Q assessed social camouflage. In addition, a questionnaire, i.e., EQ, dealt exclusively with the measurement of empathy, while AdAS Spectrum studied it in one of its subcategories. Finally, ToM-HCAT examined the understanding and level of enjoyment of humor in order to detect possible ASD in adults.

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## 5 Discussion

Autism spectrum traits can be found in adults without a diagnosis having been preceded during the developmental period. Several adults may present autistic traits which were not a hindrance in their academic and professional career but a core of behaviors and social dysfunctions that they themselves could not explain. The purpose of this research was to find tools for identifying and evaluating autistic traits in an adult population. A sub-exploratory question in this research examined the specific criteria for autistic spectrum diagnosis these adult screening tools focus on.

In the last decades, there has been an increased interest in the identification and evaluation of autistic characteristics. This has contributed to the development of psychometric tools based on the precise identification of the clinical symptoms of autism as defined by the international diagnostic manuals DSM V and ICD 11. The results of the literature review proved that the majority of tools are based on measuring the deficit of social skills, empathy levels and sensory dysfunctions of the respective adult population sample. Also, through the studies, no correlation of these tools with cognitive functions was evident.

Adult screening tools are primarily based on assessing the difficulty of social reciprocity and how these individuals perceive the emotional complexity created in human relationships. The tendency of these individuals to build systems in order to control unforeseen reversals is another important detection indicator. Repetitive behaviors and obsession

with routine are a result of their tendency for *systematization* and contribute to the evaluation of autistic traits for the purpose of further diagnosis. Another critical parameter recorded in the adult instruments is the assessment of the Theory of Mind in relation to empathy. Social skills deficits manifested as a difficulty in interacting in a socially acceptable way are a significant parameter that, as mentioned in the studies, is involved in the identification of adults with autism spectrum disorders.

A total of 14 tools were identified, including:

- 12 self-report instruments
  - Autism Spectrum Quotient (AQ) and 2 short versions of it, the AQ10 and the AQ28,
  - Empathy Quotient (EQ),
  - Systemizing Quotient (SQ),
  - Ritvo Autism Asperger Diagnostic Scale (RAADS R),
  - Social Responsiveness Scale (SRS),
  - The Broad Autism Phenotype Questionnaire (BAPQ),
  - Camouflaging Autistic Traits Questionnaire (CAT-Q),
  - Sensory Sensitivity Questionnaire (SSQ),
  - Reading the Mind in the Eyes (RMET),
  - Sensory Perception Quotient (SPQ) and 1 short version,
  - Adult Autism Subthreshold Spectrum (AdAS Spectrum), and,
  - The Glasgow Sensory Questionnaire (GSQ).
- The Humor Comprehension and Appreciation Test (ToM-HCAT), which needs a specialist to produce the result
- The Autism Diagnostic Observation Schedule (ADOS) Module 4.

Regarding the 12 self-report tools in the literature, they were all described as screening tools. They are crucial in identifying individuals with a possible diagnosis of ASD so that they can be referred to qualified specialists for a full diagnostic evaluation. They are used in large-scale studies as well as in crowded medical settings where the scientific staff need an immediate diagnosis of the patient in order to make a referral. Additionally, they are easy to use, fast and without financial costs as the presence of an expert is not necessary for the result. In addition, the absence of an expert for their administration reduces his possible interpretative intervention in the final result. Finally, the fact that they are available on the internet allows for immediate access and an immediate result for a person wondering about the difficulties he is facing. This significant advantage of getting an immediate result through the use of digital forms can, however, lead to a disadvantage as there is no presence of an expert to advise and guide the individual directly. The person may feel insecure and be led to wrong interpretations. Another disadvantage could be the fact that the answers are based on the respondent's self-perception, who must have adequate cognitive skills and comprehension ability, which is why all the tools are aimed to people with normal or above normal intelligence (AdAS Spectrum).

All instruments were used in combination with the AQ, as previously mentioned, depending on the criteria the researcher wanted to focus on.

Of the self-administered autism screening tools identified, the AdAS Spectrum was the one with the highest reliability-validity index (0.96). It explores not only the basic manifestations of the disorder, but also weakened and atypical symptoms, personality traits, and behavioral manifestations that may be associated with ASD. It consists of seven domains, childhood/adolescence, verbal communication, nonverbal communication, empathy, repetitive behaviors/routines, restricted interests, hyper/hypo-sensory reactivity.

The AQ was the most important tool and the one identified in all studies. It has been one of the oldest tools since it was created in 2001, and it has been translated into 24 languages. It explores five areas – social skills, attention switching, attention to detail, communication, imagination. The Cronbach's index was 0.76 in the validation study the authors conducted when creating the tool. It is also the only one identified with two short versions, AQ10 and AQ28, with an excellent reliability index (0.85 and 0.86 respectively). Both short versions have been culturally adapted in four and in three languages respectively and their use was identified in 10 studies.

The SRS is a tool for autistic adults' relatives and includes a separate self-report form that measures deficits in social behavior and communication. It was found in five studies and consists of 65 items which are divided into five categories – social awareness, social knowledge, social communication, social motivation and restricted interests and repetitive behavior. Two SRS subcategories had the smallest (0.61) and maximum (0.92) Cronbach's a coefficient. The tool was also identified in many studies that were excluded due to the criteria established in this review as they addressed

autistic adults' relatives.

The SQ aims to measure a person's interest in systematization. It was found in six studies. Consisting of 75 items, its reliability is extremely high (0.90). After studying ASD-diagnosed and neurotypical individuals, the authors found that the combination of the EQ and SQ tools can detect autistic traits as successfully as the AQ tool.

The BAPQ was used in 2 studies. It has been designed to quantify autistic traits in three subscales - social deficits, stereotypic-repetitive behaviors, and social language deficits. Its reliability index is greater than 0.80.

The RAADS was created to identify autistic characteristics in the areas of social association, restricted interests, language deficits, and sensory and motor skills. Its reliability ranges between 0.78 and 0.92. We found this in five studies.

Three tools were also found to exclusively assess sensory sensitivity (SSQ, GSQ, SPQ). The SSQ has two versions; the first version is completed by parents, relatives, and friends who look after people with autism, while the second version is a self-report questionnaire for people with and without an ASD diagnosis. It consists of 13 items and explores the domains of touch, the presence of low pain/temperature thresholds, the presence of high pain/temperature thresholds, hearing, vision, taste, and smell. It has a high reliability index (0.95) and it was detected only once in the studies.

The GSQ was identified through the presentation of its cultural adaptations. It consists of 42 items and explores seven sensory domains – sight, hearing, taste, smell, touch, vestibular system and proprioception. It has extremely high reliability rates (Cronbach's  $\alpha=0.93$ ).

The last tool in this category is the SPQ. It consists of 92 items and explores deficits in the five senses, i.e., sight, hearing, touch, smell, and taste. The short version of the SPQ Short consists of 35 items with the same probe categories and was created alongside the full version. The Cronbach index of the full version is 0.92 and its short version 0.93.

Of all the tools in this category, the SPQ has the most items (92), which, however, explore fewer areas. The SSQ, which explores six areas, had the fewest items, while the GSQ had the most assessment areas consisting of 42 items and seven areas of inquiry. The reliability of all instruments was excellent ranging from 0.92 for the SPQ full version to 0.95 for the SSQ. Finally, two of the tools mentioned in the previous category, the RAADS and the AdAS Spectrum, examined deficits in sensory skills and sub/hyper-sensory reactivity respectively in their subcategories. Two tools, EQ and AdAS Spectrum, measure deficits in empathy. The second was described in detail above. The EQ, created in 2001, consists of 60 elements and has been translated into 24 languages including Greek. It has been the only tool that exclusively measures levels of empathy and has been combined both with the AQ and the SQ in studies. Combining all three tools gives a holistic diagnosis because, since autism is not the only disorder in which empathy is affected, EQ is unlikely to be useful as a diagnostic tool. For this reason, the authors advised that EQ should be accompanied by other instruments, such as the AQ, even for screening individuals diagnosed with ASD. Another tool identified was the RMET, a tool consisting of one domain, i.e., social understanding. It is one of the oldest tools along with the ADOS and AQ as it was created in 1997 and revised in 2001. It consists of 36 items and has been translated into 24 languages. However, it differs in its format from previous questionnaires as it includes photographs of the eye area of different actors' faces. The participant is asked to choose which of four words best describes what the person in the photograph is thinking or feeling. It has a reliability index of 0.71 and appeared in a cultural adaptation in one of the studies. Furthermore, it is accessible online; yet it was not found in many studies in this review. The CATQ is a different tool quantifying social camouflage. It consists of 25 elements which are divided into the following areas of compensation, masking, and assimilation. The tool was used in one study and its reliability and validity level was high (0.94). CATQ is an important tool as it is the only one that measures camouflage. All people in the general population have some level of autistic traits, but those with more autistic behavior traits try to camouflage it, not knowing that they may have ASD. According to the authors, when individuals fail to camouflage autistic traits, their social, emotional and psychological condition deteriorates. ToM-HCAT is the only tool that requires the presence of an expert. It is a tool that studies the loss of the ability to understand other people's emotional states, beliefs, desires, intentions, and feelings through humor. According to its creators, it can differentiate people with autistic traits from neurotypicals and has a high reliability index ranging from 0.84 to 0.94. This tool was not found to be used in the studies. Some reasons for this could be a) its recent creation (2018), b) the researchers' preference to weighted tools that exhaustively assess individuals on the DSM and ICD criteria, c) the ToM-HCAT differentiates individuals based on humor deficits, and d) its unavailability on the internet, which makes it inaccessible to the public. Finally, the ADOS is the only tool that can be used for diagnostic purposes and can only be administered by a qualified specialist. It explores communication, reciprocal social interaction, imagination/creativity, and restricted and repetitive behaviors. It is a reliable tool (Cronbach's  $\alpha=0.71$ ). In the studies, it was used to examine the current socio-communicative behavior of already diagnosed adults always in

combination with the AQ.

It is important to underline the importance of all digital technologies in the health promotion domain. Digital technologies support assessment and screening for everyone, give new methods for efficient training and wellbeing, improve the retention every new information and encourage collaboration. Moreover, provide new tools for assessment, knowledge representation and endorse the education activities and methods via virtualization, mobilization, artificial intelligence, and through new learning environments-worlds. More specifically in autism screening, digital technologies are very successful, facilitating and improving assessment and reducing antisocial symptoms through Mobiles that bring educational activities everywhere (Drigas et al., 2020; Politi-Georgousi & Drigas, 2020; Stathopoulou et al., 2019) and through various ICT applications that are the current supporters of autistic children and adult (Bravou & Drigas, 2019; Drakatos et al., 2023b, 2023a; Drigas & Petrova, 2014; Drigas & Theodorou, 2016; Ioanna et al., 2023; Stahopoulou et al., 2023; Stathopoulou et al., 2022, 2023; Vouglanis & Driga, 2023a, 2023b; Xanthopoulou et al., 2019). The exploitation of AI, STEM & ROBOTICS raise educational procedures into new levels of adaptability, innovation, and performance for autistic person (Bravou et al., 2022; E. Chaidi et al., 2021; I. Chaidi & Drigas, 2022; Demertzi et al., 2018; Lytra & Drigas, 2021; Ntaountaki et al., 2019). Additionally, the adoption, enhancement, and combination of ICTs with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation (Bamicha & Drigas, 2022; I. Chaidi & Drigas, 2020; Drigas et al., 2017, 2022b, 2022a; Drigas, Mitsea, et al., 2021; Drigas, Papoutsi, et al., 2021; Drigas & Papoutsi, 2021; Drigas & Sideraki, 2021; Galitskaya & Drigas, 2021; Karyotaki et al., 2022; Karyotaki & Drigas, 2016; Mitsea et al., 2022a, 2022c, 2022b) brings the mental abilities to the core of the education procedures and policies, and as a result accelerate and improve even more the educational practices and results, like assessment and intervention especially for autistics children and adults.

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## 6 Conclusion

Concluding, health promotion is related, in all people, to factors such as physical health, stress, mental clarity, financial status, mental resilience and social support. Undiagnosed adults with autism elements, compared to the rest of the population, are at greater risk of depression, anxiety disorders, mood disorders, and obsessive-compulsive disorders. These individuals often become dysfunctional in professional, social and family contexts, they also feel social and emotional dissatisfaction without even knowing the cause of their problems. The detection of autistic elements of adults is necessary for health promotion so that they receive appropriate support from health professionals, and to prevent serious mental, physical and mental health problems.

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## Compliance with ethical standards

### *Acknowledgments*

The Authors would like to thank the SPECIALIZATION IN ICTs AND SPECIAL EDUCATION: PSYCHOPEDAGOGY OF INCLUSION Postgraduate studies Team, for their support.

### *Disclosure of conflict of interest*

The Authors proclaim no conflict of interest.

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