Alimentary Tract

Assessing gastrointestinal symptoms in people with autism: Applying a new measure based on the Rome IV criteria

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Abstract

Background: People with autism spectrum disorder (ASD) often struggle with gastrointestinal symptoms, implicating alterations of the gut-microbiota-brain axis, which has also been linked to sensory reactivity, pain, and gastrointestinal symptoms in ASD. To better understand the prevalence and impact of gastrointestinal symptoms among individuals with ASD, a measure is needed that adheres to the Rome IV criteria of gastrointestinal symptoms and is applicable to individuals with ASD. The Gastrointestinal Symptom Severity Scale (GSSS) is a new assessment tool designed to match this need.

Methods: In a diverse sample of 265 individuals with ASD (mean age = 9.44, SD = 4.99), we examined the psychometric properties of the GSSS, the prevalence of gastrointestinal symptoms and associations with ASD traits, sensory sensitivity, repetitive behaviors, and pain.

Results: A unidimensional factor structure of the GSSS was confirmed and the measure showed good internal consistency, adequate test-retest reliability and strong convergent validity. Around a third of the participants evidenced clear difficulties with gastrointestinal symptoms and gastrointestinal symptoms were strongly associated with more pronounced ASD traits, sensory reactivity, and repetitive behaviors.

Conclusions: The GSSS shows promise as a useful measure to analyze the prevalence, severity, and impact of gastrointestinal symptoms in individuals with ASD.

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1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder defined by two main criteria: 1) deficits in social communication and interaction skills, and 2) the restricted and repetitive patterns of behavior [1]. The restrictive patterns of behavior often involve repetitive motor phenomena such as stereotypies, circumscribed interests, compulsions and behavioral problems due to sensory alterations [1]. The global prevalence of ASD is around 1%, and it affects males more frequently than females [1]. The microbiota-gut-brain axis hypothesis of ASD postulates that there are links between gastro-intestinal symptoms, gut microbiota [2], and ASD symptoms [3]. The gut–microbiota–brain axis is a bidirectional communication system linking neuronal, immune, endocrine and metabolic pathways [4].

Functional gastrointestinal disorders (FGIDs) are a set of chronic or recurrent gastrointestinal symptoms which are not explained by structural or biochemical abnormalities and interfere significantly with quality of life. FGIDs are associated with more frequent healthcare visits [4] and psychosocial difficulties [5] and are diagnosed and classified using standardized criteria as recommended by the Rome Foundation. The Rome IV criteria (2016) advocate for considering these conditions as disorders of gut–brain interaction, acknowledging their complex pathogenesis [6].

Irritable bowel syndrome (IBS), functional dyspepsia, and functional constipation are FGIDs that are incompletely understood, but account for at least a third of all referrals to gastroenterology clinics [7]. Up to half of the general population may meet the criteria for FGIDs at any given time, and they are more prevalent in women than in men [4]. Between 9.9% and 29% of all FGIDs are found in typically developing children and adolescents [8], with the most common conditions being IBS (0–45.1%), cyclic vomiting (0.2–6.2%), infant regurgitation (24.1%), functional constipation (31.3–86.9%), and dyspepsia (11.5%) [6,8,9].

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In clinical samples, FGIDs are very common and prevalence rates as high as 87 % have been reported [8]. Among individuals with ASD, between 40 % and 70 % struggle with gastrointestinal symptoms [10,11] and two recent meta-analyses reported higher prevalence rates in ASD than in the general population [12,13]. Specifically, the prevalence of gastro-intestinal symptoms in ASD according to two recent meta-analyses was between 26.2 % and 87.5 % for constipation or hard stools, between 21.4 % and 75 % for abdominal pain, between 25.1 % and 75 % for vomiting or nausea, 75 % for abdominal distension/flatusulence/aerophagia/excess gas, between 19.9 % and 62.5 % for diarrhea or soft stools, 8.6 % for gastrointestinal reflex, and 59.4 % for food selectivity [12,13].

Gastrointestinal symptoms are related to restrictive or selective dietary patterns (e.g., picky eating) in individuals with ASD [10,14] and the symptoms are typically more severe than in non-ASD comparison groups [10]. Gastrointestinal symptoms have also been linked to anxiety, pain, and sensory difficulties in ASD (15–17). In other psychiatric conditions, gastrointestinal symptoms, emotional instability, and gut dysbiosis have been linked, with all three factors relating to the gut–microbiota–brain axis through the enteric nervous system [11–18,19,20].

The most commonly used assessment tools in research on gastro-intestinal symptoms are the Gastrointestinal symptom rating scale (GSRS) and the Questionnaire on Pediatric Functional Gastrointestinal Disorders, Rome IV version (QPFS-IV) [21,22]. However, these instruments have not been adapted to suit individuals with ASD (23). The Gastrointestinal Severity Index (GSI) has been used in children with ASD, but it does not measure the severity of the gastrointestinal symptoms and its psychometric properties have not been analyzed [24]. Another measure is the Gastrointestinal Symptoms Severity Index (GSSI), but it has only been validated in adults with FGIDs [25]. There is a growing interest in the evaluation of gastro-intestinal symptoms in ASD, but we have found serious limitations in current assessment tools as they have not been designed by taking into consideration the perspectives of families with a family member with ASD. In fact, a recent meta-analysis indicated that 37.5 % of the studies used specific questionnaires to analyze gastro-intestinal symptoms that had not been validated [12]. Further, only one study used a validated questionnaire, while the rest of the studies created ad hoc items or consulted the national health records database [12,13]. Thus, to better understand the prevalence and impact of gastrointestinal symptoms among individuals with ASD, particularly children and adolescents, a measure is needed that adhere to the Rome IV criteria and is applicable to individuals with ASD. The Severity Scale of Gastrointestinal Symptoms (GSSS) was designed to meet these criteria. The aim of this study was to evaluate the utility of the GSSS and to examine the prevalence of and correlates of gastrointestinal symptom in individuals with ASD, particularly how these symptoms relate to ASD traits, sensory sensitivity, repetitive behaviors, and pain.

2. Methods

2.1. Participants

Caregivers of 265 individuals with ASD (mean age = 9.44, SD = 4.99, age range: 3–41 years) participated in the study. Table 1 shows the sociodemographic and diagnostic characteristics of the sample.

2.2. Measures

2.2.1. Gastrointestinal symptom severity scale (GSSS)

This GSSS is based on the Rome IV criteria [26] and consists of 7 items covering constipation, diarrhea, average stool consistency, stool odor, flatulence and gas, and abdominal pain. The instrument includes abdominal symptoms (abdominal pain, gas and constipation) and vomiting and defecation symptoms (vomiting, defecation in inappropriate places, diarrhea, rumination). Items are rated on a four-point Likert scale ranging from 0 (none/nothing or this symptom does not occur) to 3 (very frequent and troublesome symptom). The instrument was developed in two versions: one for caregivers/professionals and one self-reported version. The caregiver/professional version was used in this study and its psychometric properties were evaluated as part of the study.

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2.2.2. Gastrointestinal severity index (6-GSI)

Gastrointestinal symptoms were also assessed using a modified 6-item version of the GSI [27]. In accordance with Adams et al. [24], we excluded the items of “unexplained daytime irritability,” “nighttime awakening,” or “abdominal tenderness.” The internal consistency of the measure in the present sample was low (α = 0.51).

2.2.3. Clinical questionnaire on gastro-intestinal symptoms

We created an ad hoc questionnaire to assess gastro-intestinal disorders according to the Rome IV criteria (26). The questionnaire consisted of a series of yes/no questions about gastrointestinal conditions (e.g. diarrhea, abdominal pain, etc.).

2.2.4. Social communication questionnaire (SCQ)

The SCQ (28) Form B is a caregiver-reported instrument with 40 items determining the possible presence of ASD by assessing the absence/presence of traits and symptoms associated with ASD. The SCQ has been used in both children and adults (29). Only the overall score was used in the present study. The SCQ has shown adequate psychometric properties in previous studies (28) and showed adequate internal consistency in the present sample (α = 0.80).

2.2.5. Pain and sensitivity reactivity scale (PSRS)

The PSRS evaluates reactivity to pain and sensory reactivity using 50 items. It is composed of three dimensions/scales: pain, sensory hyporeactivity, and sensory hyperreactivity. Items are rated on
a four-point Likert scale ranging from 0 (the behavior does not occur) to 3 (the behavior occurs and is a severe problem). The PSRS comes in two versions: one for caregivers/professionals and a self-reported version. The dimensions of the PSRS have shown strong internal consistency in previous (15). The caregiver version of the PSRS was used in the present study and showed good internal consistency (Pain, $\alpha = 0.83$; Sensory hyperreactivity, $\alpha = 0.90$; Sensory hyporeactivity, $\alpha = 0.93$).

2.2.6. Repetitive behaviors scale-revised (RBS-R)

The RBS-R is a scale with 43 items completed by caregivers or mental health professionals designed to assess six dimensions of repetitive behaviors: stereotypic, self-injurious, compulsive, ritualistic, sameness, and restrictive behaviors (30). Responses are recorded on a 4-point rating scale ranging from 0 (repetitive behavior does not occur) to 3 (very severe repetitive behaviors). The RBS-R has been used in children and adults (up to 60 years of age) (31) and has demonstrated adequate psychometric properties (31–34). The internal consistency of RBS-R in the present sample was high ($\alpha = 0.95$).

3. Procedures

3.1. Development of GSSS

The GSSS was designed to measure the severity of gastrointestinal symptoms in non-autistic and autistic people, both children and adults. We adhered to the Rome IV criteria (functional nausea and vomiting disorders, functional abdominal pain disorders and defecation disorders). Fig. 1 shows the theoretical model of the scale.

Each item examines how often a sensation is experienced, the degree of discomfort, and to what extent the sensation is a problem. A problem is defined as a sensation that is either very intense or annoying, very frequent, negatively affects life activities (e.g., avoiding certain activities, people and/or places) and/or generates negative consequences for the person or others.

The GSSS was developed by a multidisciplinary team (pediatric specialist, psychiatrist, PhD level psychologist, and a doctor in chemistry specialized in gut microbiota). Initially, a pool of 10 common complaints to pediatricians (e.g., rumination problems, gas, etc.) was created. Initial items were generated from the Rome IV criteria, clinical experience, expert opinion, and review of existing literature and validated symptom questionnaires. First, an initial list of symptoms was made according to the Rome IV criteria. To assess content validity and understanding of the items, a pediatrician and child psychiatrist, a neuropsychologist, and two educators who completed the survey. Critical evaluation focused on content, completeness according to the Rome IV criteria, and clarity of the instrument. Then, the revised instrument was pilot tested with 10 caregivers of a child with ASD and 4 professionals for clarity of the questions and information on administration time. The 10 caregivers were families with children enrolled in special education centers and early care centers, while the two professionals were pediatricians from a referral hospital. These caregivers were aware of situations of pain in their children. Their life experience helped improve some examples and clarifications included in the GSSS. The questionnaire was further revised based upon this feedback with a definitive 7-item version, according to the Rome IV criteria (rumination, vomiting, gas, abdominal pain, constipation, diarrhea, and episodes of defecation in inappropriate places). Each item had a clinical description and a specified duration. Finally, the description of each item was reviewed and refined by two special education teachers who are experts in ASD, a pediatrician, a neuropsychologist, and a psychologist. No difficulties in understanding the final items of the GSSS were reported. The GSSS is found in the Supplementary.

3.2. Recruitment

In this study, the psychometric properties of the GSSS were analyzed in a sample of participants with autism. The characteristics of autism are very diverse, and the instrument was designed
in collaboration with families who have a child with autism with
the goal to suit this population. As one of the objectives of the
study was to contribute to the literature on the prevalence of GS
in autism, participants were not selected based on the presence
of gastrointestinal symptoms. Moreover, when examining psychome-
tric properties of a measure, it is preferable to have variance in
responses and observations across the full response scale, which
further makes it preferable to include a sample with varying lev-
eels of gastrointestinal symptoms. Families were recruited through
15 Spanish centers (Central part, northeast, south and south-east
of Spain). Two centers were specific special education schools; one
was a residence for people with ASD and ID; eleven were early
intervention centers; and one was regular school with open class-
rooms. The centers represented both rural and urban areas.

All participating families and caregivers had a child diagnosed
with ASD according to DSM-5 criteria (1). Individuals with ASD
with or without intellectual disability (ID) were diagnosed accord-
ing to DSM-5 criteria using standardized. The subjects were previ-
ously diagnosed by the mental health services and institutions in
charge of establishing each country’s degree of disability and de-
pendency. Families with children with another type of neurodevel-
opmental disorder were excluded from the study.

Almost all participating families or caregivers completed the
protocol at home, in a classroom or in an enabled room at the ed-
ucational center. Appropriate instructions were provided for each
scale. The researchers organized a training session for all partici-
pating centers to describe the purpose of the research study, the
instruments used, and instructions for administration. The tests
were administered by experienced psychologists or pediatricians
who gave instructions and provided individual assistance to fami-
lies who needed it.

The total time to complete all instruments included in the
study was approximately 45 min. Questionnaires previously vali-
dated in Spain were included in order to analyze convergent and
discriminant validity and associations between the GSSS and vari-
ables linked to the gut-microbiota-brain axis (e.g., sensory reac-
tivity, pain) and variables representing important characteristics of
ASD, such as repetitive behaviors. After one month, a random sam-
ple of 83 caregivers who had a child with ASD completed the study
instruments again. The objective of this analysis was to examine
the factorial stability of the GSSS. As we expected high tempo-
al stability, a smaller sample was needed for this analysis. In this
way, it provides information on the stability and temporal consist-
cy of the scale. The participants did not receive financial com-
ensation for their participation in the study. The study was con-
ducted between June 2020 and May 2022 and was approved by the
Ethics Committee of the University of Alicante in Spain (reference:
UA-2019-10-04). Caregivers provided informed consent. No clinical
work-ups were conducted in the present study (e.g., Pyrosequenc-
ing of the 16S rRNA gene pan-bacterial or PCR-based detection).

4. Statistical analysis

All statistical analyses were conducted in R Studio. Responses
on the GSSS items were zero-inflated and ordinal. Therefore, to
examine the psychometric properties of the GSSS, we computed
an item-level polychoric correlation matrix, which better respects
these types of distributions. We explored the correlation between
items using exploratory factor analysis in order to identify an em-
pirically supported factor model of the measure. To help exam-
ine whether the items were suited for factor analysis, we com-
puted the Kaiser-Meyer-Olkin (KMO) test values, both for the full
set of items and for each individual item. KMO values indicate
the proportion of variance in items that might be explained by
latent factors. Values above 0.60 are considered to indicate that
exploratory factor analysis may be suited and values above 0.80
that exploratory factor analysis is well suited. Factors were then
extracted using principal axis factoring and promax rotation. After
identifying a suitable factor structure, we used confirmatory factor
analysis to further understand the psychometric properties of the
measure and data from the first assessment were analyzed using
both exploratory and confirmatory factor analysis to maximize the
understanding of potential factor solutions. Data from the second
assessment was used to test all identified models in a confirmatory
fashion.

All confirmatory factor analyses were conducted using the R li-
brary lavaan using the diagonally weighted least squares estimator.
Model/data fit was evaluated by analyzing the Comparative Fit In-
dex (CFI), the Root Mean Square Error of Approximation (RMSEA),
and the Standardized Root Mean Square Residual (SRMR). An RM-
SEA around 0.06, an SRMR around 0.08, and CFI estimates greater
than 0.90 are indicative of acceptable model-data data fit (35). The
internal consistency of each factor was calculated using composite
reliability which is based on the factors loadings of confirmatory
factor analysis. We used this method because many items were
heavily zero-inflated.

Correlations between the GSSS and other measures were es-
timated using Spearman’s rho as well as by computing a partial
 correlation matrix using the R library BGGM and Copula gaussian
graphical model estimation, with credible intervals of 95 % for par-
tial correlations being used to control for false positive rate. Linear
regression models followed by dominance analysis were used to
to examine unique associations between GSSS and autism traits, pain,
sensory difficulties, and repetitive behaviors while accounting for
all other variables including age and sex. Dominance analysis es-
timates the unique contribution of each independent variable in a
regression model to variation in the dependent variable by running
all subsets of independent variables in relation to the dependent
variable.

5. Results

5.1. Presence of gastrointestinal difficulties

Caregiver-reported prevalence of gastrointestinal disorders were
23.4 % for infectious diarrhea, 20.6 % for abdominal pain, 11.4 %
for dyspepsia, and 10.9 % for gastroesophageal reflux. Scores on
GSSS, both for each item and the total score, are presented in
Fig. 2. Across items, most caregivers reported no symptoms, with
frequencies ranging from 55.5 % for constipation to 94.0 % for inap-
propriate defecation. For the total score, around a third (33.6 %)
of the caregivers reported no symptoms at the first assessment and
around a fourth (25.3 %) at the second assessment. Based on the
content of the measure, where a score of ≥2 indicates clear diffi-
culties, a cut-off-point of ≥2 was used. Using this cut-off, 30.9 %
(n = 82) of the sample was reported to experience clear diffi-
culties with some sort of gastrointestinal symptoms. Of these, 52
(19.6 %) reported difficulties within one domain, 22 (8.3 %) within
two domains, 6 (2.3 %) within three domains, 1 (0.4 %) within
four domains, and 1 (0.4 %) within five domains. Similarly, 39.2 %
(n = 104) of the sample scored ≥3 on the total score and a large
overlap was observed between scoring ≥2 on any domain and hav-
ing a score of 3 or higher on the total score: 86.6 % of those scor-
ing ≥2 on any domain also had a total score being 3 or above
while only 18.0 % of those without a score of ≥2 on any domain
having a score of 3 or above. This indicated that a cut-off score of
3 on the total score is justified.

5.2. Psychometric properties of the GSSS

The polychoric correlation matrix of the GSSS items is pre-
sented in the Supplementary Figure S2. Most items were moder-
ately to strongly positively correlated with rs among the total set of items ranging from −0.12 to 0.60. A high correlation was found between the symptoms of vomiting and regurgitation; abdominal pain and diarrhea; and abdominal pain and gas. A moderate correlation was found between constipation and gas; constipation and abdominal pain; diarrhea and inappropriate defecation.

The overall KMO value was 0.60 with all individual values being above 0.54. We extracted 1–3 factors using exploratory factor analysis and principal axis factoring with promax rotation and inspected the derived factor solutions. All models except the three-factor model (where a Heywood case was present) yielded adequate estimates, see the Supplementary Table S2 for factor loadings. We used confirmatory factor analysis to estimate the model/data fit of all three models using data from both the first and second assessment. Results indicated that the three-factor model had best model/data fit at the first assessment and the one-factor model best/model data fit at the second assessment.

To further explore the psychometric properties of the different models, we estimated the internal consistency of the factors of the unidimensional model and the three-factor model. The internal consistency of the unidimensional model (with all items loading onto a single dimension) was 0.75 at the first assessment and 0.88 at the second assessment. For the first factor of the three-factor model (items 1 & 2), the internal consistency was 0.75 and 0.61 at the first and second assessment, respectively. For the second factor of the three-factor model (items 3, 4 & 5), the internal consistency was 0.79 and 0.85 at the first and second assessment, respectively. For the third factor of the three-factor model (items 6 & 7), the internal consistency was 0.73 and 0.54 at the first and second assessment, respectively.

Based on results from both the first and second assessment and because of the principle of parsimony, we deemed a unidimensional model (i.e., a total score) was best supported by the data. The test-retest reliability of the total score was high (ICC [2] = 0.74 [0.65–0.80], n = 265; Spearman’s rho = 0.90, p < .001). The total score was also strongly correlated with the total score of the GSI (Spearman’s rho = 0.64, p < .001), indicating good external validity. We predicted individual scores using the unidimensional/total score model and proceeded.

5.3. The correlates of gastrointestinal symptoms

There was a small and barely statistically significant positive correlation between gastrointestinal symptoms and age (rho = 0.12, p = .05), indicating more symptoms in older participants. There was no statistically significant difference between those with and without ID (Mann-Whitney U = 7711.50, p = .17). There was a barely significant difference between males and females (Mann-Whitney U = 9021.00, p = .04), with females having more symptoms.
6. Discussion

The present study sought to evaluate a new measure used to assess gastrointestinal symptoms in people with ASD - the GSSS - and examine the prevalence and correlates of gastrointestinal symptoms. Using the GSSS, approximately 40% reported difficulties with gastrointestinal symptoms, which is in line with previous studies in ASD (12,13). The most frequent/severe symptoms were constipation and abdominal pain, which is also in line with previous studies (12). Our findings indicate that gastrointestinal symptoms are prevalent in ASD, which is important as such symptoms are related to reduced quality of life (36) and increased healthcare costs (37).

The diagnostic assessment of FGIDs can be challenging, and relies primarily on the published Rome criteria (38). There are several instruments available, particularly for the general pediatric population and for individuals with neurodevelopmental disorders. However, gastrointestinal symptoms can be present in both children, adolescents, and adults, as well as in clinical and non-clinical populations (7,8). Because no measure existed that suited all these populations, the GSSS was developed. The results of this first study are encouraging. For the clinical use of the GSSS, interpreting either the total score or each item separately is recommended. However, we found some evidence indicating that the instrument can be used as both a one-factor instrument assessing broad gastrointestinal symptoms and a two-factor instrument assessing 1) regurgitation and vomiting (i.e., expulsion of ingested food) and 2) symptoms related to the abdomen (e.g., abdominal pain, gas and constipation, etc.). A two-factor structure was supported by strong correlations between the items assessing vomiting and regurgitation, and gas and abdominal pain, while the correlation was negative and very low between constipation and vomiting and regurgitation. Further, exploratory factor analyses using the baseline data indicated that a two-factor solution could be derived. These results are consistent with clinical practice and with the Rome IV criteria (26).

When analyzed as a one-factor total score/unidimensional scale, internal consistency and test–retest reliability were adequate, which is in line with the psychometric properties of other instruments used in the general pediatric population [25]. However, most assessment tools that have been used in studies that include people with ASD have not been psychometrically examined, such as the GSI [39]. Thus, the GSSS is one of few instruments specifically designed for use with people with ASD that now also has psychometric support. Further, an important limitation in previous evaluations of similar instruments is the absence of convergent validity analysis, as discriminant rather than convergent validity is often prioritized [25]. The present study provides an improvement over previous studies as we analyzed and found evidence for both convergent and discriminant validity, with our results showing a clear association between the two scales used to measure gastrointestinal symptoms while lower correlations were found in relation to less clearly related constructs such as pain and sensory difficulties, although these correlations were moderate in size, which is expected based on the notion of common underlying mechanisms.

Our results indicated that older participants generally had more gastrointestinal symptoms, and that symptoms were more frequent in women. These results could suggest a pattern of gastrointestinal development according to age and sex in ASD. There is a lack of studies that analyze gastrointestinal symptoms longitudinally and this is a pending task for future studies.

The results of this study also strongly support that gastrointestinal symptoms in individuals with ASD are clearly associated with degree of autism traits, pain, sensory reactivity, and repetitive behaviors. This is in line with previous research that has shown an association between having restrictive eating behav-
iors due to hypersensitivity (e.g., being pickier with food) and increased gastrointestinal symptoms and pain in individuals with ASD [10-40,41,42]. In the present study, the correlation between pain and ASD traits was small, which indicates that pain is a factor that tends to be independent of the behavioral and emotional features of ASD. In addition, the pain scale of PSRS evaluates the severity of pain in objective situations (e.g., having a fever, behavioral manifestations of pain such as crying or touching the affected area, etc.). Definitely, these results are in line with our theoretical model and may imply that there is an interaction between these factors that show us the relationship between the gut-microbiota in the emotional and behavioral symptoms in ASD [19].

The present study has some limitations. First, while individuals across a wide age range were included, most were children and male. Future studies should evaluate the GSSS in predominantly adult samples and include more female participants. Second, while the GSSS correlated strongly with another measure of gastrointestinal symptoms, scores on the GSSS were not validated against a clinical examination, which would provide important information on the screening properties of the GSSS and known-group validity. Further, as no clinical work-up was included, it was not possible to analyze associations between gastrointestinal symptoms as measured with the GSSS and the gut-microbiota. Third, although a high correlation was found between abdominal pain (item 4, the frequency and form of bowel movements) and the frequency of gas (item 3) and diarrhea (item 6), it is still uncertain to which degree the frequency and form of bowel movements can be used as an indicator of pain in this population. Fourth, the largely cross-sectional design of the study precludes examinations of prospective associations between gastrointestinal symptoms and other prominent factors in ASD such as sensory difficulties, pain, and mental health symptoms. Fifth, we relied on ratings from carers who do not have direct access to the internal experiences (e.g., pain) of the people they rated. Professional and informal carers who work on a day-to-day basis with people who have ASD have the great challenge of trying to find out if a child with ASD has a negative emotional manifestation because of pain or for other reasons. It is known that limitations in communication can increase self-injury in individuals with ASD and that this type of behavior can be a way of expressing themselves [43]. The instruments designed so far have the same limitation as the GSSS (e.g., GSI) in that they depend on the subjective interpretation of the main caregiver of the emotional reaction of the child in a situation that causes pain. Although emotional reactions of persons with ASD have not been included in the design of the GSSS items, informant bias is something that can occur both in clinical interviews and when using psychometric assessment tools.

Despite these limitations, the GSSS is an instrument of practical application for a population little studied in the context of gastrointestinal symptoms: adolescents and young adults with ASD. Previous studies, and results from the present study, clearly indicate that gastrointestinal symptoms are common and possibly linked to gut-microbiota dysbiosis in individuals with ASD [10,20,41]. The GSSS can help improve research on the gut-microbiota-brain axis in ASD.

**Conflict of interest**

None.

**Supplementary materials**

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dld.2024.05.019.
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