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RESEARCH ARTICLE

Validation of the social communication questionnaire amongst Nigerian adolescents

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Abstract

Few autism spectrum disorder (ASD) screening tools have been developed and validated in Africa. This study aimed to examine the psychometric properties of the Social Communication Questionnaire (SCQ) when used with Nigerian adolescents. Parents and caregivers of two hundred and five adolescents completed the SCQ Lifetime form while the adolescents were assessed for ASD using the Autism Diagnostic Observation Schedule, 2nd Edition (ADOS-2). Factor structure and convergent and discriminative validity were examined, along with the sensitivity and specificity of the SCQ in identifying participants with an autism spectrum disorder. The confirmatory factor analysis (CFA) was used to examine the factor structure, while logistic regression and Pearson's correlation coefficient were used to examine the validities. The SCQ had good internal consistency, discriminative, and convergent validity. A cut-off score of 10 revealed sensitivity = 0.81 and specificity = 0.88 for the identification of autism spectrum disorder. AUC was 0.83, $p < 0.001$, 95% CI [0.77, 0.90]. The results of this study provide evidence to support the retention of the original four factors of the SCQ. The SCQ has good psychometric properties when used with Nigerian adolescents.

Lay Summary

We sought to examine the Social Communication Questionnaire (SCQ) amongst Nigerian adolescents aged 11–26 years as a screening tool for identifying those who may have autism spectrum disorder (ASD). The SCQ displayed solid psychometric properties. Also, we offered for each age range, different cut-off scores for identifying people with ASD.

KEYWORDS
adolescent, Africa, autism, diagnosis, Nigeria, screening, social communication questionnaire (SCQ)

Autism spectrum disorder (ASD), a condition characterized by restricted and repetitive behaviors and social and communication deficits, has become increasingly common (Wing & Potter, 2002). ASD has no known cure and a series of studies have found that lifetime costs for individuals with ASD can run into 100 of 1000 of dollars (Horlin, Falkmer, Parsons, Albrecht & Falkmer, 2014; Penner, Rayar, Bashir, Roberts, Hancock-Howard & Coyte, 2015; Sampaio, Feldman, Lavelle & Skokauskas, 2022; Rosenberg, Landa, Law, Stuart & Law 2011). However, early diagnosis and intervention have been shown to produce progress in independent functioning levels, development rate and access to effective services (James & Smith, 2020; Delehanty, Lee, Hooker, Cortese & Woods, 2020; Nadel & Poss, 2007). Nevertheless, appropriate and prompt diagnoses are crucial for accessing such intervention services early in life to capitalize on these gains.

Screening and diagnosis of ASD are feasible in very young children and are recommended as best practice; however, this has not been the norm in Nigeria, as most individuals with ASD are not diagnosed until after 5 years of age, and many are never diagnosed (Franz, Chambers, von Isenburg & de Vries, 2017; Bello-Mojeed,

Bakare & Munir, 2013; Bello-Mojeed, Omigbodun, Bakare & Adewuya, 2017). Different factors, such as low level of awareness, limited availability of qualified professionals, cultural differences, and access to standardized tools, affect the early assessment and diagnosis of developmental disorders, such as ASD amongst African adolescents (Franz et al., 2017; Bello-Mojeed et al., 2013; Bello-Mojeed et al., 2017; Burkett, Morris, Manning-Courtney, Anthony & Shambley-Ebron, 2015). Therefore, adolescents with ASD in African countries such as Nigeria often go undiagnosed.

Currently, ASD diagnoses in Nigeria do not include the use of a standardized schedule (Oshodi et al., 2017; Bakare et al., 2022). Whereas a clinical assessment of autism spectrum disorder can be given based on history taking, observation and use of the DSM-5 criteria by healthcare professionals, a confirmatory diagnosis using an acceptable gold standard schedule is required for better certainty (Zeidan, Fombonne, Scorah, Ibrahim, Durkin, Saxena, et al., 2022; McCarty & Frye, 2020). The cost of acquiring such a tool is not only prohibitive, but the administration also requires trained professionals, both of which are scarce in Nigeria (Abubakar, Ssewanyana, & Newton, 2016). Therefore, level two screening tools can be used to save time and cost, and such screening would help with the immediate identification of individuals at risk of ASD. In the African context, in countries, such as Nigeria, however, limited availability of age-appropriate screening and validated screening tools, as well as low levels of awareness amongst parents and professionals, have been identified as barriers to assessment (Franz et al., 2017; Nwokolo, Langdon & Murphy, 2022).

A systematic review was conducted to identify available brief and cost-efficient screening tools for use with Nigerian adolescents (Nwokolo et al., 2022), aiming to judge their cultural appropriateness and assess the psychometric properties of available tools. A total of 12 screening tools for ASD were identified through that review. The tools were the Social Communication Questionnaire (SCQ), the Childhood Autism Rating Scale (CARS), the Child Behavior Checklist (CBCL), the Pervasive Developmental Disorder in Mentally Retarded Persons Scale (PDD-MRS), the Autism Screening Quotient (AQ-10), the Autism Spectrum Screening Questionnaire-Revised Extended Version (ASSQ-REV), the Developmental Behavior Checklist-Autism Screening Algorithm (DBC-ASA), the Diagnostic Behavioral Assessment for Autism Spectrum Disorder-Revised (DiBAS-R), A DSM-5 teacher screening questionnaire for autism & social communication disorders (EDUTEA), the Autism Diagnostic Inventory-Telephone Screening in Spanish (ADI-TSS), the Adapted Autism Behavior Checklist (AABC) and the Mobile Autism Risk Assessment (MARA).

After evaluating the evidence for the 12 tools, two of them (SCQ and AQ-10) were selected for further review by a consensus group of Nigerian experts: both had been widely used for screening, including cross-culturally. The SCQ was the lifetime version, and the AQ-10 was the adolescent version. The group of experts examined the content and face validity of both tools for Nigeria (Nwokolo, Murphy, Mensink, Moonen & Langdon, 2023). The SCQ is a brief 40-item parent, or caregiver screening measure used widely in research (Berument, Rutter, Lord, Pickles & Bailey, 1999). Administration of the SCQ is time-efficient, requiring no costly or special training. The group agreed that the SCQ was more robust and comprehensive than the AQ-10, with questions that examined the relevant autism spectrum domains. So, the consensus group selected the SCQ after adjusting it slightly to contain more culturally relevant examples.

To establish the usefulness of the SCQ in Nigeria, this study aimed to (a) validate the structure of the SCQ in the Nigerian population using confirmatory factor analysis (CFA), (b) examine the internal consistency, discriminative, and convergent validity of the SCQ, (c) derive an appropriate cut-off score based upon sensitivity and specificity, in relation to the criterion measure (the ADOS-2) and (d) derive the positive and negative predictive values.

METHODS

Design

A single-group design was used, and the ADOS-2 rating was employed to divide the adolescents and young people into two groups – with and without suspected autism spectrum disorder, as judged by their ADOS scores.

Participants

The study occurred within three of Nigeria's geopolitical zones: Abuja, Enugu, and Lagos. Initially, a major urban area in each of the six geopolitical zones of Nigeria was to be visited; however, COVID-19 restrictions truncated the plan so that only three of the six areas were included.

An adolescent or young person was eligible to take part in this study if they were suspected of having an ASD, and if they were (a) between 11 and 26 years old, (b) identified by a doctor as having a clinical diagnosis of ASD, and/or (c) enrolled in a special education school or a special center and (d) had a parent, guardian, or caregiver with adequate lifetime information regarding the adolescent. Individuals who did not meet the eligibility criteria for 'suspected ASD' were also included. and they were recruited from the community and the main researchers' contacts by sharing relevant information

with parents, carers and guardians of persons within the study's age range. Some of the participants thought to be without ASD were healthy individuals with no other known disability or mental health problems, while some others had a co-occurring intellectual disability. Participants were recruited from day centers, special schools, child and adolescent mental health care services, local community organizations, religious organizations, and public advertisements via word of mouth. The centers included Child & Adolescent Mental Health Services, Therapeutic Day Care Centers, and a private school in Abuja (name withheld due to confidentiality agreements). The churches include various branches of Christian churches in several parts of Nigeria. The recruitment of participants from the relevant centers was purposive to allow the inclusion of some persons suspected to have autism spectrum disorder, and some thought not to have the disorder, given the study's aims.

As a result, two hundred and ten adolescents and young adults, 124 (59%) male and 86 (41%) female ($n = 210$, $M_{age} = 15.88$ years; $Mdn_{age} = 15.29$ years; SD = 3.69; range = 10.90–26.96 years) took part in this study. The age distribution was grouped as follows: 11–13-year-olds ($n = 76$; 36.2%), 14–15-year-olds (n = 42; 20%), 16–17-year-olds ($n = 51$; 24.3%) and 18 years and above ($n = 41$; 19.5%). Initially, 245 adolescents and young adults were invited to participate in this study, but 35 declined to participate due to time constraints or prior commitments ($n = 16$) or did not respond to further attempts to contact them to complete the assessments they had started ($n = 19$), so that finally, 210 took part. Out of the 210, a further 5 participants did not complete the SCQ and were excluded from the analysis leaving 205 as the total number of participants. Assuming a significance level of 0.01, power = 0.95, H_1 AUC = 0.80, H_o AUC = 0.50, and an allocation ratio of 10:1, the estimated sample size was 187.

Procedure

Ethics

A positive ethical opinion was obtained from the University of Kent, Tizard Center Ethics Committee, the National Health Research Ethics Committee (NHREC; NHREC/01/01/2007–16/09/2019) and the Federal Neuro-Psychiatric Hospital, Yaba, Lagos, Nigeria (FNPH/HREC/20/09). All participants were provided with written information about participating in this study, including easier-to-read versions of information sheets for those who might have or had an intellectual disability. Parental informed consent was sought for those aged under 18 years of age. To maintain confidentiality, screenings done in the church and similar settings were in separate rooms. Participants were encouraged to take breaks as needed during testing.

Setting and procedure

Study details were shared with research assistants. The first author provided one full day of training to the research assistants on administering the consent forms, information sheets and the SCQ, followed by three days of demonstration. Following this, the assistant was observed while implementing the procedure. No procedural errors were observed. The ADOS-2 was administered to the adolescent by the first author, who has been trained to meet the ADOS-2 to clinical reliability.

Each participant was seen either in their school, place of worship, day or community centre, clinic or home and was invited to complete the Autism Diagnostic Observation Schedule, 2nd Edition (ADOS-2), while the SCQ, was completed independently by their parent, caregiver, or guardian.

Measures

Social communication questionnaire

The SCQ is a brief 40-item parent or caregiver-report screening measure modeled after the Autism Diagnostic Interview-Revised (ADI-R) and has been used widely in research (Berument et al., 1999; Rutter et al., 2003). It is a screening tool only and cannot be used for the diagnosis of autism. The SCQ is designed for anyone 4 years old and above, and it takes about 10–15 min to complete and about 5 min to score. Following a consensus group study prior to this study, minor adjustments were made to examples in the SCQ, to ensure that it was culturally relevant (see Nwokolo et al., 2023). The measure has two versions: the lifetime and the current versions. Both focus on symptoms of autism most likely to be observed by the individual's principal caregiver, who must be familiar with the individual's developmental history and current behavior. The lifetime version was used in this study, given the age range of the participants (11–26 years). In addition, Wei, Chestnut, Barnard-Brak & Richman (2015) reported that the lifetime version has better psychometric properties. Wei et al. (2015) examined the item-level characteristics, measurement equivalence, and factor structure of the SCQ Lifetime and Current forms using both the Classical Test Theory (CTT) and the Item Response Theory (IRT). Their results showed that the current form had measurement issues, such as lower item discriminations, weaker factor structure, and sub-scale measurement bias, suggesting that the Lifetime version was preferable.

Autism diagnostic observation schedule, second edition

The Autism Diagnostic Observation Schedule, 2nd Edition, is a very widely used tool for assessing the presence

of autism (Chojnicka & Pisula, 2017; Lebersfeld, Swanson, Clesi & O'Kelley, 2021). It is a semi-structured standardized clinician tool which uses a hierarchy of presses across a range of play-based activities to observe behavior, communication, social interaction and imaginative use of materials. An overall score is obtained with cut-offs for ASD. The ADOS-2 has five modules – toddler and modules 1 to 4. Modules 1, 2 and 3 were used in this study. To determine the applicable module for each participant, the suggested guidelines in the ADOS-2 manual was followed. The guideline includes evaluation of the individual's expressive language and determining the chronological age. The ADOS-2 takes between 60 and 90 min to administer and score.

According to National Institute for Health and Care Excellence (NICE) guidelines in the UK (NICE, 2017), the ADOS-2 should be used alongside the ADI-R or DISCO interview to make a certain diagnosis of autism. However, resources did not allow for the ADI-R or DISCO, so the ADOS-2 was used alone as the gold standard. Utilizing the ADOS-2 as a standalone measure is supported in the literature (Kamp-Becker et al., 2021). Additionally, no diagnosis was given during this study.

Data analysis

Overview

The Statistical Package for the Social Sciences – IBM SPSS version 26 and Jeffreys's Amazing Statistics Program (JASP) version 0.16.3, an open-source statistical package, were used for analyses. Except for the confirmatory factor analysis (CFA) done with JASP, all other analyses were done with SPSS. CFA was performed to confirm the applicability and validity of the original SCQ constructs to the Nigerian adolescent population. The SCQ's performance as a screening tool was compared to the ADOS-2 classification, while correlations between the 40 SCQ items and ADOS-2 were calculated using Pearson's *r*. The discriminative and convergent validities of the SCQ were examined. Internal consistency was calculated using Cronbach's alpha. Receiver Operating Characteristic (ROC) analyses were used to calculate the Area under the Curve (AUC) to examine how well the SCQ identified participants with and without an autism spectrum disorder, with reference to sensitivity and specificity to identify optimal cut-offs. The positive (PPV) and negative predictive (NPV) values were calculated from the results.

Missing data

A total of 5 participants did not complete the SCQ, and 6 did not complete the ADOS-2. Therefore 5 participants were excluded from the SCQ analysis and 6 from the ADOS-2 analysis.

Confirmatory factor analysis

The SCQ is a standardized measure used widely in research. It has been translated into a number of different languages and used in a variety of countries, for example, in South Africa (Bozalek, 2013), (Awadu, 2021) and China (Liu et al., 2022). Some studies have examined the structure (Uljarević, Frazier, Phillips, Jo, Littlefield & Hardan, 2021), psychometric properties (Wei et al., 2015) and its utility as a screening tool (Chestnut, Wei, Barnard-Brak & Richman, 2016). Whereas some Nigerian professionals are conversant with the SCQ, the applicability of the SCQ has not been examined there. Thus, a CFA was performed to evaluate the validity of the original SCQ constructs in the Nigerian adolescent population.

Initial model fit using the original four factors (social interaction, communication, abnormal language, and stereotypic behavior, Berument et al., 1999) was examined using the JASP Version 0.16.3. This was followed by a bootstrapping with replacement (based on a sample size of 5000) and the diagonal weighted least squares (DWLS) estimator, which are appropriate for small sample sizes (Mîndrilă, 2010; DiStefano & Morgan, 2014; Koğar & Koğar, 2015). The model fit was first evaluated based on the chi-square (χ^2) goodness-of-fit statistics. Due to the sample size, literature and various opinions and criticisms about the chi-square (Hooper, Coughlan, & Mullen, 2008; Mîndrilă, 2010; McNeish, 2020), other indices were also examined: the chi-square/*df* ratio <3, the comparative fit index (CFI) ≥ 0.90, the Tucker-Lewis index (TLI) ≥ 0.90, the root mean square error of approximation (RMSEA) ≤ 0.08, the goodness of fit index (GFI) ≥ 0.90 and the standardized root mean square residual (SRMR) between 0.05 and 0.08 (Hu & Bentler, 1999; Prudon, 2014; Newsom, 2018a, 2018b; Mîndrilă, 2010).

Internal consistency

Cronbach's alpha, considered an adequate measure of internal consistency (Mokkink et al., 2018; Terwee et al., 2007), was used to assess the internal consistency of the SCQ. A Cronbach's alpha greater than or equal to 0.70 is acceptable (Tavakol & Dennick, 2011).

Criterion validity

The criterion validity of the SCQ was determined by assessing both the discriminative and convergent

validities. Terwee et al. (2007) and Mokkink et al. (2018) suggest a good correlation with the 'gold standard' tool if the correlation is ≥0.70 or AUC ≥0.70.

- Discriminative Validity. The discriminative ability of the SCQ was determined by examining the AUC.
- Convergent Validity. Convergent validity was assessed by examining the extent of correlation between the SCQ scores and the ADOS-2 classifications. The correlation was determined by using Pearson's correlation coefficient ***r***.

Sensitivity and specificity

The sensitivity of the SCQ refers to the probability of it correctly identifying individuals with ASD, while the specificity refers to its probability of correctly identifying those who do not have ASD (Trevethan, 2017). The optimal cut-off score for the SCQ was based on the ROC analysis, while specificity and sensitivity were determined from the AUC (Streiner & Cairney, 2007; Lasko, Bhagwat, Zou & Ohno-Machado, 2005). Sensitivity and specificity cut-off values were guided by Glascoe (2005).

Positive predictive value and negative predictive value

Positive predictive value and NPV determine those who genuinely have or do not have an ASD. The SCQ's PPV was determined using the formula [(true positives)/(true positives + false positives)]*100 and NPV as [(true negatives)/(true negatives + false negatives)]*100. Because both values relate to prevalence, there are no agreed cut-off values for PPV & NPV for a screening tool (Glascoe, 2005; Wong & Lim, 2011).

RESULTS

Descriptive statistics

SCQ scores for all 205 participants ranged from 0 to 30 points ($M = 8.42$; $Mdn_{score} = 6.00$; $SD = 6.89$; $IQR = 6.00–8.75$). Total SCQ scores did not differentiate by sex ($t_{205} = 0.34$, $p = 0.74$). Descriptive statistics for the SCQ scores per age group are in Table 1. The distribution of the 204 participants (one participant completed the SCQ but not the ADOS-2 and subsequently not included in the ADOS-2 analyses) with and without ASD (as defined by the ADOS-2 autism spectrum cut-off score for each module) is in Table 2.

Confirmatory factor analysis

Our CFA had an acceptable model fit, $CFI = 1.00$, $TLI = 1.03$, $SRMR = 0.08$, $RMSEA = 0.00$ and $GFI = 0.96$. Figure 1 shows the model plot and factor loadings in Table 3. The initial hypothesis was that the original four factors (social communication, social interaction, abnormal language, and stereotypic behavior) of the SCQ may not be applicable in the Nigerian context, but it transpired that the original four factor structure could be maintained. Items 5, 9, and 13 had factor loadings that were slightly below 0.3 (0.26, 0.20 & 0.20, respectively) but were retained in the SCQ as removing was not deemed impactful to the structure of the SCQ. Overall, the factor loadings indicated that all the items could be retained in the SCQ.

Internal consistency

The Cronbach's $\alpha = 0.88$ for the total sample and $\alpha = 0.86$ for the ASD group on all original four domains

TABLE 1 Descriptive statistics of SCQ scores by age groups (total $n = 205$).

	SCQ_Total_Score			
	11 to 13 years	**14 to 15 years**	**16 to 17 years**	**18 years & above**
Number	74	41	50	40
Median	6.000	6.000	6.500	6.500
Std. Deviation	7.337	7.753	6.008	6.337
IQR	7.000	7.000	8.750	6.000
Minimum	0.000	0.000	0.000	0.000
Maximum	30.000	27.000	24.000	30.000
25th percentile	4.000	3.000	3.000	4.000
50th percentile	6.000	6.000	6.500	6.500
75th percentile	11.000	10.000	11.750	10.000

TABLE 2 Descriptive statistics of the ADOS-2 classification for participants with & without autism spectrum disorder based on the autism spectrum cut-off score for each module.

		ADOS-2 classification					
		No ASD		ASD		Total	
		N	%	*N*	%	*N*	%
Age Groups	11 to 13 years	47	34.81	27	39.13	74	36.27
	14 to 15 years	26	19.26	14	20.29	40	19.61
	16 to 17 years	32	23.70	18	26.09	50	24.51
	18 years & above	30	22.22	10	14.49	40	19.61
Gender	Female	55	40.74	29	42.03	84	41.18
	Male	80	59.26	40	57.97	120	58.82
Total		135	100.00	69	100.00	204	100.00

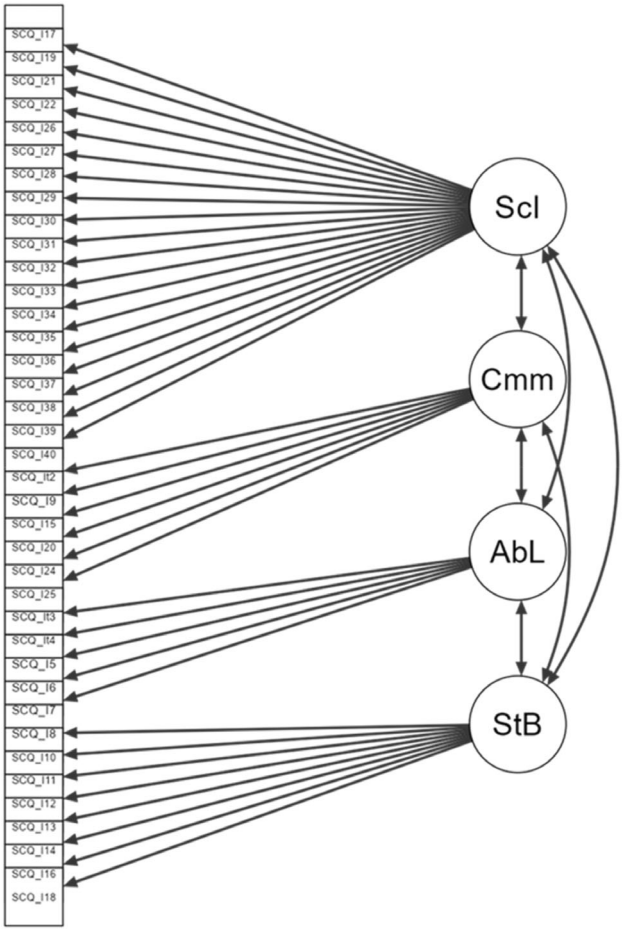

FIGURE 1 Model plot.

of the SCQ indicated adequate internal consistency of the SCQ items, while for the non-ASD group $\alpha = 0.59$. In the entire sample, Cronbach's $\alpha = 0.85$ for the social communication and interaction domain (SCI) and 0.66 for the restricted, repetitive and stereotypic pattern of behaviors domains (RRSB) – items 7, 8, 11, 12, 13, 14, 15 & 16. With the addition of the self-injurious items (17, 18 & 38) to the RRSB, Cronbach's $\alpha = 0.71$. The description of the internal consistency of the SCQ domains are in Table 4.

Criterion validity

Discriminative validity

The cut-off score of 10 on the SCQ showed that the SCQ could differentiate between those with and without ASD, (using the cut-off score for autism spectrum applicable for each ADOS-2 module). An AUC of 1 would indicate a perfect screening tool. At the cut-off score of 10, the AUC was 0.83.

Convergent validity

Overall convergent validity was indicated by a significant Pearson's correlation between the total SCQ scores and ADOS-2 scores for the 204 participants, $r = 0.71$, $p < 0.001$, showing a strong correlation and effect size (Cohen, 1992).

Sensitivity and specificity

At the recommended cut-off score of 15, ROC analysis revealed an overall AUC for the 204 participants as 0.76, $p < 0.001$, 95% CI [0.68, 0.84] with PPV = 0.54, NPV = 0.99, sensitivity = 0.95 and specificity = 0.81. While the specificity and sensitivity met the minimum requirements, the PPV did not meet the minimum standard (Glascoe, 2005). Lower cut-offs were explored by stepwise reduction to determine the best cut-off score. Lowering the cut-off score to 10, 11 and 12 improved the values; however, a cut-off score of 10 gave the best result overall, as shown in Table 5. With a cut-off score of 10, sensitivity = 0.81 and specificity = 0.88, applicable to the entire population.

TABLE 3 Factor loadings.

Factor	Indicator	Estimate	SE	95% confidence interval		Z	*p*	Stand. estimate
				Lower	Upper			
Social interaction	SCQ_Item17	0.1551	0.0254	0.1054	0.2049	6.11	< 0.001	0.427
	SCQ_Item19	0.1775	0.0330	0.1129	0.2422	5.39	< 0.001	0.380
	SCQ_Item21	0.2476	0.0317	0.1855	0.3098	7.81	< 0.001	0.529
	SCQ_Item22	0.2098	0.0622	0.0879	0.3317	3.37	< 0.001	0.244
	SCQ_Item26	0.1936	0.0252	0.1443	0.2429	7.69	< 0.001	0.523
	SCQ_Item27	0.0993	0.0158	0.0684	0.1302	6.30	< 0.001	0.439
	SCQ_Item28	0.2460	0.0248	0.1975	0.2946	9.93	< 0.001	0.648
	SCQ_Item29	0.2195	0.0293	0.1622	0.2768	7.50	< 0.001	0.512
	SCQ_Item30	0.2088	0.0243	0.1612	0.2564	8.59	< 0.001	0.577
	SCQ_Item31	0.2220	0.0289	0.1653	0.2787	7.68	< 0.001	0.522
	SCQ_Item32	0.1520	0.0236	0.1057	0.1983	6.43	< 0.001	0.447
	SCQ_Item33	0.2132	0.0203	0.1733	0.2530	10.49	< 0.001	0.673
	SCQ_Item34	0.3217	0.0250	0.2727	0.3708	12.86	< 0.001	0.782
	SCQ_Item35	0.3335	0.0295	0.2757	0.3914	11.30	< 0.001	0.714
	SCQ_Item36	0.2423	0.0234	0.1964	0.2882	10.35	< 0.001	0.665
	SCQ_Item37	0.1669	0.0195	0.1288	0.2050	8.58	< 0.001	0.573
	SCQ_Item38	0.1571	0.0240	0.1101	0.2040	6.56	< 0.001	0.455
	SCQ_Item39	0.3125	0.0294	0.2549	0.3702	10.63	< 0.001	0.682
	SCQ_Item40	0.2389	0.0240	0.1919	0.2858	9.97	< 0.001	0.646
Communication	SCQ_Item2	0.0574	0.0152	0.0276	0.0871	3.77	< 0.001	0.304
	SCQ_Item9	0.0688	0.0274	0.0151	0.1226	2.51	0.012	0.187
	SCQ_Item15	0.1451	0.0245	0.0971	0.1931	5.93	< 0.001	0.420
	SCQ_Item20	0.1711	0.0292	0.1139	0.2284	5.86	< 0.001	0.416
	SCQ_Item24	0.3350	0.0220	0.2920	0.3780	15.26	< 0.001	0.885
	SCQ_Item25	0.3412	0.0213	0.2994	0.3830	16.00	< 0.001	0.912
Abnormal language	SCQ_Item3	0.3014	0.0396	0.2238	0.3790	7.61	< 0.001	0.619
	SCQ_Item4	0.2010	0.0375	0.1276	0.2745	5.37	< 0.001	0.459
	SCQ_Item5	0.1284	0.0452	0.0398	0.2169	2.84	0.004	0.257
	SCQ_Item6	0.1757	0.0375	0.1022	0.2491	4.69	< 0.001	0.400
	SCQ_Item7	0.3082	0.0375	0.2347	0.3816	8.22	< 0.001	0.668
Stereotypic behavior	SCQ_Item8	0.1742	0.0397	0.0964	0.2521	4.39	< 0.001	0.362
	SCQ_Item10	0.2307	0.0332	0.1657	0.2958	6.95	< 0.001	0.534
	SCQ_Item11	0.2676	0.0317	0.2054	0.3297	8.43	< 0.001	0.640
	SCQ_Item12	0.2048	0.0329	0.1403	0.2694	6.22	< 0.001	0.485
	SCQ_Item13	0.1048	0.0408	0.0247	0.1848	2.56	0.010	0.212
	SCQ_Item14	0.1500	0.0338	0.0839	0.2162	4.44	< 0.001	0.353
	SCQ_Item16	0.1426	0.0272	0.0892	0.1960	5.24	< 0.001	0.421
	SCQ_Item18	0.1816	0.0324	0.1181	0.2452	5.60	< 0.001	0.449

For the specific age groups, using the cut-off score of 10, the following results were obtained: 11–13-year-olds, AUC = 0.83, $p < 0.001$, 95% CI [0.77, 0.90], $N = 74$, 14–15-year-olds, AUC = 0.84, $p < 0.001$, 95% CI [0.94, 0.99], $N = 40$, 16–17-year-olds, AUC = 0.84, $p < 0.001$, 95% CI [0.71, 0.97], $N = 50$, 18 years and above, AUC = 0.83, $p < 0.001$, 95% CI [0.67, 1.00], $N = 40$. Sensitivity and specificity with optimal cut-off scores for each group are shown in Table 4. Our study explored the usefulness of differentiated cut-off scores per age group since, to the best of our knowledge, no study specifying SCQ cut-off scores for age brackets has been done. From our study, a cut-off score of 10 is preferable for all those under 18 yrs, and a cut-off score of 12 is best suited for participants aged 18 and above, as all the psychometric properties met the minimum standard (Table 5).

Positive predictive value and negative predictive value

Using the SCQ cut-off score of 10, PPV = 0.75 and NPV = 0.91, showing that the SCQ can correctly identify those with ASD and those without ASD.

DISCUSSION AND CONCLUSION

With the increased awareness of autism spectrum disorder in Nigeria, parents of younger children now seek screening and early intervention. However, the older children and adolescents who missed early screening and diagnosis need to be known. To detect ASD in these adolescents, a validated and easy-to-use screening tool is required. The SCQ was identified through a systematic review (Nwokolo et al., 2022) and agreed on as appropriate by a focus group (Nwokolo et al., 2023). Thus, the goals of this study were to (a) validate the structure of the SCQ in the Nigerian population using confirmatory factor analysis (CFA), (b) examine the internal consistency, discriminative, and convergent validity of the SCQ, (c) derive an appropriate cut-off score based upon sensitivity and specificity, and (d) derive the positive and negative predictive values.

Confirmatory factor analysis

While the SCQ is an established and widely used measure in both research and clinical settings, the accuracy and psychometrics of the SCQ have mainly been examined in North and South America, Europe, and Australia (Chesnut et al., 2017). Studies confirming its appropriateness in the African context, especially amongst adolescents, were non-existent. However, studies which examined the discriminative validity in young and older children aged between 2.5 and 17 years in South Africa (Bozalek, 2013) and Uganda (Awadu, 2021) were found. Based on existing literature, the scarcity of cross-cultural research in the African context and the aims of this study, a CFA was done. The CFA results revealed that the Nigerian population could retain the original four-factor structure, bearing in mind the limitations of the sample size.

TABLE 4 Internal consistency of the SCQ domains.

	Cronbach's alpha		
Domain	No ASD ($n = 135$)	ASD ($n = 69$)	Total ($n = 204$)
All 4 SCQ Domains	0.59	0.86	0.88
SCI	0.53	0.86	0.85
RRSB	0.52	0.69	0.66

Abbreviations: RRSB, restricted, repetitive and stereotypic pattern of behaviors; SCI, social communication and interaction.

Internal consistency

The SCQ's internal consistency was adequate, with a Cronbach's alpha of 0.88, indicating the tool's ability to capture the concept of autism spectrum disorder.

Criterion validity

Although at the published cut-off score of 15, the sensitivity, specificity and NPV met recommended criteria (Glascoe, 2005), the PPV was not optimal. With a reduction in the cut-off score to 10, all the properties met the minimum criteria, with the SCQ adequately discriminating between those with ASD and those without ASD. There was a strong positive relationship between the SCQ scores and group classification (with or without ASD), which showed that as the SCQ scores increased, the more likely an individual would have an ASD. The SCQ, as a screening tool, correlated well with the ADOS-2 ($r = 0.70$), showing that the SCQ is a valid screening instrument for use with the Nigerian adolescent population.

Sensitivity, specificity, positive predictive value, and negative predictive value

Based on the results of the ROC analyses, the sensitivity, specificity, PPV and NPV met the acceptable criteria of 70% for screening tools (Glascoe, 2005). Initially, at the

TABLE 5 Sensitivity and specificity for the various potential cut-off scores of the SCQ.

Cut-off score	PPV	NPV	Sensitivity	Specificity	AUC	Lower	Upper
10	0.75	0.91	0.81	0.88	0.83	0.77	0.90
11	0.68	0.94	0.85	0.85	0.81	0.74	0.88
12	0.65	0.96	0.88	0.84	0.80	0.73	0.88
15	0.54	0.99	0.95	0.81	0.76	0.68	0.84

TABLE 6 Sensitivity and specificity for the various potential cut-off scores of the SCQ per age group.

	SCQ cut-off score > 10					SCQ cut-off score > 11					SCQ cut-off score > 12				
	Total ($n = 204$)	11–13 years ($n = 74$)	14–15 years ($n = 40$)	16–17 years ($n = 50$)	18 years & above ($n = 40$)	Total ($n = 204$)	11–13 years ($n = 74$)	14–15 years ($n = 40$)	16–17 years ($n = 50$)	18 years & above ($n = 40$)	Total ($n = 204$)	11–13 years ($n = 74$)	14–15 years ($n = 40$)	16–17 years ($n = 50$)	18 years & above ($n = 40$)
PPV	0.75	0.74	0.71	0.78	0.80	0.68	0.67	0.57	0.72	0.80	0.65	0.63	0.57	0.67	0.80
NPV	0.91	0.91	0.96	0.91	0.87	0.94	0.94	0.96	0.94	0.93	0.96	0.96	0.96	0.97	0.93
Sensitivity	**0.81**	0.83	0.91	0.82	0.67	**0.85**	0.86	0.89	0.87	0.80	**0.88**	0.89	0.89	0.92	0.80
Specificity	**0.88**	0.86	0.86	0.88	0.93	**0.85**	0.83	0.81	0.86	0.93	**0.84**	0.82	0.81	0.84	0.93
AUC ($p < 0.001$, 95% CI)	0.83	0.83	0.84	0.84	0.83	0.81	0.80	0.77	0.83	0.87	0.80	0.79	0.77	0.82	0.87
Lower	0.77	0.72	0.94	0.71	0.67	0.74	0.68	0.59	0.70	0.71	0.73	0.67	0.59	0.68	0.71
Upper	0.90	0.69	0.99	0.97	1.00	0.88	0.92	0.94	0.97	1.02	0.88	0.91	0.94	0.96	1.02

Note: Bold values indicate applicable properties at each cut-off score for the entire population and per age group.

recommended cut-off score of 15, PPV = 0.54, NPV = 0.99, sensitivity = 0.95 and specificity = 0.81. However, the discriminating ability improved by reducing the cut-off to 10, giving a sensitivity of 0.81 and specificity of 0.88. This cut-off score of 10 is like the results obtained by Bozalek (2013) in the South African sample (cut-off = 10, sensitivity = 1, specificity = 0.95) and by Awadu, (2021) in Uganda (cut-off = 10, sensitivity = 1, specificity = 0.93). Other studies (Kim et al., 2015; Snow & Lecavalier, 2008; Schanding, Nowell & Goin-Kochel, 2012) also recommended a reduction in the cut-off score from 15 for better outcomes. In assigning the cut-off, the distinctions between sensitivity and PPV and between specificity and NPV in a screening and clinical context were considered (Trevethan, 2017; Akobeng, 2007). Classifying participants solely on sensitivity and specificity values differs from classifying them in combination with the PPV and NPV. PPV and NPV are influenced by the prevalence and depend on the population being investigated. Participants identified by medical professionals as autistic were sampled in this study; as such, the PPV and NPV were considered in addition to sensitivity and specificity to determine the best cut-off score. Since the Lifetime version of the SCQ was used, it is possible that some of the respondents of the older participants may not have an absolute recollection of the early years of their wards. For this reason, the scores will be affected, and a lower cut-off ensures that persons who may have autism are not missed. Should the sample age in any study be homogenous, which is highly unlikely, specific cut-offs are recommended for the different age groups, as shown in Table 6. Overall, the results showed that the SCQ correctly identified adolescents with and without ASD.

Limitations

There are some limitations to this study. First, the sample size was relatively small for CFA, although our model was associated with a good fit. Second, the participants completing the SCQ were mainly from urban settings and had good literacy skills; thus, it cannot be assumed that the psychometric properties will be the same when used in rural settings, where questions may need to be read to respondents. Third, while we recognize that the use of the original English version of the SCQ may be judged insufficient for a validation study in an ethnic and culturally diverse setting as Nigeria, English is the official language in Nigeria, and we ensured the examples given were culturally appropriate. English as the official language, or pidgin (a variation of English) is widely spoken by most people especially the urban dwellers. Additionally, while urban populations may be similar, given that there is insufficient evidence of formal validation of any autism screening tool

for the Nigerian population, validation of English SCQ was deemed a viable start. Further studies to explore the translation and validation of the SCQ in the three major languages (Hausa, Igbo and Yoruba) is recommended. Fourthly, we categorized participants as autistic based upon the ADOS-2 only and we did not undertake an additional assessment such as the ADI-R, DISCO or generate a thorough developmental history. A similar criticism about the use of English may arise concerning the use of the ADOS-2, however, for the same reasons that the English SCQ was used, and in the absence of other available tools, the ADOS-2 was deemed appropriate for use with the Nigerian urban population. It is possible that in doing so, functional and stimulus biases may have been introduced in that the Nigerian participants may not have been offered the same opportunity to demonstrate knowledge while eliciting the intended response as participants in the original ADOS-2 study. A study examining the validity of the ADOS-2 in the Nigerian context is recommended. Despite these limitations, the SCQ appears to be a useful screening tool for ASD in Nigerian adolescents.

CONCLUSION

In conclusion, the SCQ Lifetime form's psychometric properties met acceptable screening tools standards across the entire sample and all age groups of Nigerian adolescents and young people. All items of the SCQ Lifetime version are relevant, with culturally relevant examples used as applicable. Based on available data, this study is the first to explore the usefulness of differentiated cut-off scores per age group for the SCQ. From this study, a cut-off score of 10 is recommended for all those under 18 years, and a cut-off score of 12 for participants aged 18 and above, as all the psychometric properties met the minimum standard. Further studies exploring these cut-offs are recommended. The SCQ Lifetime form can be used as a screening tool for identifying Nigerian adolescents likely to have autism spectrum disorder and help ensure referrals for further diagnosis. Using the suggested cut-offs for specific age groups will be beneficial in clinical settings.

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CONFLICT OF INTEREST STATEMENT

The authors do not have any conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical approval for the study was obtained from the University of Kent, Tizard Centre Ethics Committee, and the National Health Research Ethics Committee of Nigeria (NHREC; NHREC/01/01/2007-16/09/2019).

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