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Screening tools for autism in culturally and linguistically diverse paediatric populations: a systematic review

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Abstract

Background Autism Spectrum Disorder (ASD) has varying prevalence rates worldwide, often higher in culturally diverse populations. Cultural differences can affect autism symptom recognition. Language barriers and differing healthcare attitudes may delay diagnosis and intervention. Most autism screening tools were developed in Western, predominantly Caucasian populations, and their appropriateness in culturally and linguistically diverse (CALD) contexts remains uncertain. There is a lack of comprehensive data on the accuracy of these tools in identifying autism in culturally and linguistically diverse groups. Consequently, it is unclear whether current screening tools are culturally sensitive and appropriate.

Methods A research protocol was registered in PROSPERO (CRD42022367308). A comprehensive search of literature published from inception to October 2022 was conducted using the following databases: PubMed, Medline Complete, Scopus, PsychInfo and CINAHL Complete. The articles were screened using pre-determined inclusion and exclusion criteria. Data extracted included participant demographics, screening tool psychometric properties (validity, reliability, accuracy) and acceptability. A narrative synthesis approach was used.

Results From the initial retrieval of 2310 citations, 51 articles were included for analysis. The studies were conducted in 32 different countries with screening tools in the following languages: Chinese, Spanish, Korean, Turkish, Arabic, Kurdish, Persian, Serbian, Italian, French, Sinhala, Taiwanese, Finnish, Northern Soho, Albanian, German, Japanese, Vietnamese, Farsi, Greek and English. There was no data on acceptability of the screening tools in CALD populations. Validity, reliability, and accuracy ranged from poor to excellent with consistently high performance by screening tools devised within the populations they are intended for.

Conclusions The review evaluated autism screening tools in culturally diverse populations, with a focus on validity, reliability, and acceptability. It highlighted variations in the effectiveness of these tools across different cultures, with high performance by tools devised specifically for the intended population, emphasizing the need for culturally sensitive screening tools. Further research is needed to improve culturally specific, reliable autism screening tools for equitable assessment and intervention in diverse communities.

Keywords Autism spectrum disorder, Culturally and linguistically diverse, Screening tools, Paediatric

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Background

Autism Spectrum Disorder (ASD) is a multifaceted neurodevelopmental condition marked by difficulties in social communication and the occurrence of repetitive, limited, and/or sensory behaviours and interests [1]. The prevalence of autism worldwide is approximately 1 in 100 [2]; however estimates vary, with some countries finding that as many as 1 in 36 children are on the autism spectrum [3]. Prevalence rates also exhibit some gender disparities in the latest Centers for Disease Control and Prevention (CDC) reports, with autism being diagnosed approximately four times more commonly among boys than among girls [3]. Recently, research has shown that, contrary to prior beliefs, autism prevalence is lower among Caucasian children compared to other racial and ethnic groups [3].

These groups are commonly recognised internationally as those of a "non-English speaking background" or NESB, however this review and its inclusion criteria followed the Australian definition of "culturally and linguistically diverse" (CALD) to refer to these populations, where they are defined as people born in non-English speaking countries, and/or who do not speak English in their home [4]. As such, the CALD terminology includes those who are NESB.

In this regard, although autism has been found to be more common among children from culturally diverse and non-English speaking backgrounds (NESB) [3], rates vary among geographic regions and ethnic demographics [5]. This variation may be due to both actual disparities in prevalence as well as a reflection of other factors indexing social vulnerability. These may include exposure to social risk factors, limited awareness and opportunities for early identification, influence of social stigma and/or variations in the services and methods used for screening, diagnosing and determining autism prevalence [6–8].

Another factor implicated in differences in prevalence, ansed a potential barrier to screening is cultural differences in symptom recognition. This may make it difficult to recognise symptoms of autism, particularly in non-Caucasian populations. A study by Matson et al. [9] discussed variation in autism symptoms between children from Israel, South Korea, the United Kingdom (UK) and the United States of America (USA). They found that in certain cultures, such as in Native American and East Asian cultures [10, 11] reduced eye contact and non-verbal communication, stereotypical ASD symptoms, are favoured and hence less likely to be considered a sign of concern and more so a sign of respect,[10, 11]. Additionally, pointing with the index finger is considered inappropriate in Chinese culture [12]. Other studies have also commented on cultural differences in displays of emotion and facial expression [13] as well as preference for increased interpersonal space in Japanese culture [14]. This may be interpreted as a lack of engagement in social communication by individuals from Western cultures affecting autism screening and evaluations [14].

Certain features also considered stereotypical of autism such as hand-flapping and rocking were uncommon among children who had been diagnosed in Africa [15]. Given that these are less noticeable, they become less reliable indicators of pathology. While certain symptoms may not manifest, there could be the emergence of behaviours that are less conspicuous within Caucasian populations. This highlights the potential difficulties that may arise during assessment for identification including the measures used, especially if the assessment is not culturally appropriate [16].

In addition to differences in what are considered to be signs of concern, it has been found that both language differences and variations in cultural attitudes and beliefs related to the role of healthcare services may contribute to delays in health-seeking efforts [17]. Ou et al. [18] found in a study on Australian infants that even if the mother spoke English proficiently, infants from culturally and linguistically diverse (CALD) communities were less likely to access health services and receive mental health interventions. A study by Hussain et al. [19] found a significant link between CALD status and delayed age at which developmental concerns were raised, as well as higher severity of autism symptoms at the time of professional input. In this regard, a multicultural cohort study found an inverse care law in that those from the most disadvantaged backgrounds with the highest risk for developmental problems were least likely to engage with developmental surveillance programs for early identification, thereby missing opportunities for early intervention [17, 20]. These barriers to identifying autism result in a reduced rate of identification and treatment and as such, failed opportunities to capitalise on a period of increased neuroplasticity [21]. Studies have shown, and it is now well-known, that early identification and intervention for autism is essential to enhance the developmental outcomes and quality of life for affected individuals as well as their families [22]. On the other hand, there are significant repercussions of a missed diagnosis. Lupindo et al. [23] found these not only resulted in missed opportunity to provide support and scaffolding during a critical period of development but also had serious implications for psychological well-being during childhood as well as into adult life.

To investigate differences in the rates and presentations of autism in non-Caucasian children tools used for screening children for autism must be scrutinised. Most autism screening tools originated in the USA or the UK, both high-income countries comprising of a

predominantly Caucasian population [24], and are now being extrapolated for use in cultures distinct from their places of origin [25].

Clinicians typically utilise the *Diagnostic and Statistical Manual's* criteria, recently in its Fifth Edition, Text Revision (DSM-V-TR) [26] to define a diagnosis of autism. For a diagnosis of ASD according to the DSM-V criteria, a child must have persistent deficits in all three categories of social communication and interaction as well as meeting two of four categories related to restricted, repetitive patterns of behaviour, interests or activities. Most available screening tools have been based on the earlier DSM-IV [1] criteria [27].

Although various tools have been validated for the identification of autism, their applicability and accuracy in diverse cultural and linguistic contexts remain relatively unexplored. While tools have often been adapted for use and assessed in specific cultures [28] – demonstrating they *can* be used – it is less clear whether these tools *should* be used to adequately capture autism symptoms among diverse populations. Despite the increasing number of autism screening tools, there remains a lack of comprehensive pooled data on their accuracy in identifying children with cultural or linguistic diversity. Given the acknowledged disparities in interpretation of signs and symptoms of autism among CALD groups, it is questionable whether the current screening tools are cross-culturally sensitive as well as appropriate.

This systematic review aimed to comprehensively assess the existing literature on screening tools for autism in CALD paediatric populations specifically regarding acceptability, reliability, validity, and accuracy. A narrative systematic review was used to evaluate and synthesise the literature and answer the following research questions:

1. What available autism screening tools have been used with culturally and linguistically diverse populations?
2. Are the autism screening tools acceptable to parents of and service providers working with culturally and linguistically diverse populations?
3. What is the reliability, validity and accuracy of the autism screening tools in culturally and linguistically diverse populations?

Methods

Before initiating this review, a research protocol was formulated and officially registered with the University of York Centre for Reviews and Dissemination (PROSPERO; registration number: CRD42022367308).

Search strategy

Five databases (PubMed, Medline Complete, Scopus, PsychInfo and CINAHL Complete) were searched from inception to October 2022 to identify studies which reported on the psychometric properties and acceptability of autism screening tools delivered to CALD paediatric populations. The search terms included (autis* OR neurodevelop* OR asperg* OR developmental) AND (q-chat OR srs OR "quantitative checklist for autism in toddlers" OR "social responsiveness scale" OR m-chat OR "Modified Checklist for Autism in Toddlers" OR scq OR "social communication questionnaire" OR cars OR "Child Autism Rating Scale" OR "ASD screening") AND (immigran* OR migrant OR *lingual OR ethnic* OR cultur* OR cald OR *racial OR racial* OR linguistic OR multicultural OR refugee OR aborigin* OR native* OR "first nations" OR indigenous OR "children of color" OR "children of colour" OR "people of color" OR "people of colour" OR cross-cultural OR cross-country OR latin OR latin* OR hispanic OR spanish OR black OR asian OR chinese OR mandarin OR arabic OR african OR indian OR subcontinental OR hindi OR french OR vietnamese).

Inclusion and exclusion criteria

Articles were included in the review if they met the following criteria: (1) evaluated an autism screening tool, (2) study participants were aged 0–17 years and 11 months, (3) published in a peer reviewed journal and (4) the population of interest was predominantly (> 70%) from a CALD community (people of non-English speaking background, as well as people born outside of the studied country (if it is one of the main English speaking countries, as below) and whose first language is not English).

Articles were excluded if they (1) included a screening tool to evaluate an intervention outcome only (i.e., there was no evaluation of the screening tool itself); (2) were not data-based (e.g., books, theoretical papers, editorials, reviews); (3) were unpublished dissertations/theses; or (4) were populations (> 30% of sample) from the list of main English speaking countries: the main English speaking countries identified by the Australian Bureau of Statistics are Australia, Canada, Republic of Ireland, New Zealand, South Africa, UK (England, Scotland, Wales, Northern Ireland), and USA. Records were also excluded if the English translation or full text article could not be located, if they utilised secondary screening tools, if they did not report results of the ASD subscale of the relevant screening tool or if a diagnostic tool was evaluated in place of a screening tool. Given the limited number of studies on this topic, studies with tools that were used with children outside the recommended age range were also included.

The inter-rater reliability for title/abstract and full-text screening of database searches were 82% and 88%, respectively.

Data extraction

The Cochrane Effective Practice and Organization of Care Review Qualitative Evidence Syntheses guidelines were used to guide data extraction. Data extraction of included studies was performed primarily by author EH with review by authors AH and PH using Excel spreadsheet software (Microsoft Excel, Microsoft Corporation). Data items extracted included country-based, ethnicity, study setting, study design, aims, population (including number, age and gender), measure being evaluated and study outcomes relevant to the review.

Assessment of methodological quality

Two reviewers (EH and PH) conducted separate evaluations of the study quality using either the Quality Assessment of Diagnostic Accuracy Studies Tool (QUADAS-2) [29] or the Mixed Methods Appraisal Tool (MMAT) [30]. The MMAT was applied to assess the quality of non-randomised studies whereas the QUADAS-2 was utilised to appraise diagnostic accuracy studies. Applying the MMAT to the studies requires consideration of five questions that assess (1) if the participants represent the target population, (2) if the measurements are appropriate, (3) if there are complete outcome data, (4) if confounders are accounted for and (5) if the intervention/exposure occurs as intended. Each outcome is assigned "yes", "no", or "can't tell". The QUADAS-2 allows quality appraisal of diagnostic accuracy studies based on (1) patient selection, (2) index text, (3) reference standard and (4) flow and timing. Within each category, reviewers may rate the risk of bias and applicability as "low", "high", or "unclear". Appendix 1 defines the coding rules that were applied during the appraisal. Coding decisions were operationalised prior to performing the quality assessment. If any signalling question related to risk of bias resulted in a "no" response this was judged as "high risk". If there were no "no" responses the response "yes" or "unclear" that was more frequent determined the ultimate risk of bias. In this way, if the "yes" response was dominant the study was deemed to have a "low: risk of bias in that Domain. Concerns regarding applicability for Domain 1–3 was determined based on discussion between reviewers EH and PH. Disagreement between reviewers was solved by reaching a consensus over discussion. A third reviewer (VE) was available to settle unresolved disputes if necessary. See Appendix 1 for further details regarding the rules applied during QUADAS-2 application.

The results for the quality assessments using QUADAS-2 may be found in Fig. 1. Table 1 details the findings of the MMAT appraisal.

Data synthesis

Due to the high heterogeneity of the outcomes, a narrative synthesis approach was used in this review where results are consolidation from numerous studies primarily utilising textual descriptions to summarise and elucidate the synthesis findings.

Results

Literature search results

A total of 2310 citations were retrieved from the initial database search (674 from PsychInfo, 515 from PubMed, 507 from Scopus, 484 from Medline complete, and 130 from CINAHL Complete). Following the removal of duplicates, 1360 potentially relevant records remained. The articles were then screened using the inclusion and exclusion criteria. Title and abstract screening led to the exclusion of 1254 articles, resulting in 106 articles to undergo full text review. Following this, the full texts of 106 articles were reviewed, resulting in the exclusion of 55 articles, and ultimately, 51 articles were included and analysed in this review (Fig. 2).

Characteristics of included studies

The studies were conducted in 32 different countries. The delineation of number of studies per country studied and language studied are summarised in Tables 2 and 3 respectively. Table 4 presents the data extracted from each of the studies. It includes demographic data as well as reported classification measures and psychometric properties.

Psychometric properties of the screening tools

All studies provided psychometric evaluation of the screening tool utilised using varying parameters. The most common measure of validity was reporting of the sensitivity and specificity. Interpretation of these based on consensus of the reviewers was based on rule of thumb where ≥ 0.9 = high, 0.6- 0.89 = moderate, < 0.6 = poor. Some studies also reported positive predictive value (PPV) and negative predictive value (NPV).

Reliability was most frequently documented using Cronbach's α coefficient where ≥ 0.9 is excellent, 0.8–0.89 is good, 0.7–0.79 is acceptable, 0.6 -0.69 is questionable, 0.5–0.59 is poor and < 0.5 is unacceptable [79]. Less commonly reliability was reported using intraclass correlation coefficient (ICC), interrater reliability (r), omega (Ω) and theta (θ).

Fig. 1 Results for the quality assessments using QUADAS-2

Table 1 Results of quality appraisal for relevant studies using Mixed Methods Appraisal Tool (MMAT), version 2018

Studies	3. Quantitative nonrandomized Methodological quality criteria (Responses (yes, no, or inconclusive))				
	3.1. Are the participants representative of the target population?	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	3.3. Are there complete outcome data?	3.4. Are the confounders accounted for in the design and analysis?	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?
Carakovac, 2016 [31]	Yes	Yes	Inconclusive	No	Yes
Ruta, 2019 [32][a]	Yes	Yes	Yes	Yes	Yes
Seung, 2015 [33]	Yes	Yes	Yes	No	Yes
Sun, 2013 [34]	Inconclusive	Yes	Yes	No	Yes
Vorster, 2021 [35]	Yes	Yes	Yes	No	Yes

All studies met MMAT screening questions criteria S1, "Are there clear research questions?"; and S2, "Do the collected data allow to address the research questions?"

[a] Ruta, 2019 [32]

Screening tests

Thirteen different autism screening tools were found by this review to have been used with CALD populations.

Modified Checklist for Autism in Toddlers (M-CHAT)

The Modified Checklist for Autism in Toddlers (M-CHAT), created and validated in the United States by Robins et al. [80], is a 23-item questionnaire designed for screening children between the ages of 16–36 months for autism. It was used in 12 studies published between 2008 and 2021. It was translated into 8 languages and used in 10 countries. The M-CHAT is a modification of the original Checklist for Autism in Toddlers (CHAT) which was found to have poor sensitivity [81].

Twelve studies used a translated version of the M-CHAT. Five of these conducted the M-CHAT on children outside of the recommended age group, testing up to 10 years of age [36, 39, 41, 43, 67]. Three of these administered a Spanish M-CHAT [41–43] with varying translations appropriate to the region studied. Canal-Bedia et al. [42] reported some modifications made to increase acceptability in the setting of initial parental misunderstanding. This included the use of different toys and Spanish colloquialisms. The studies reported good validity scores with a sensitivity of 0.93–1, specificity of 0.63–0.98 and acceptable reliability $\alpha = 0.7$.

Two studies were conducted on Asian participants. Wong [37] implemented a Chinese M-CHAT in Taiwan with moderate validity scores, sensitivity 77% and specificity 72.4% and good reliability $\alpha = 0.8$. Seung [33] also found excellent reliability using the Korean M-CHAT $\alpha = 0.9$. Both of these studies found the parents' level of education to be relevant to their understanding of the screening tool. The latter reported that some parents had difficulty understanding some questions, answering "to the best of their ability". Baduel et al. [38] validated the French M-CHAT and reported a moderate sensitivity of 0.67 and good specificity of 0.94–0.99. They provided extra training to the paediatricians and day-care staff conducting the screening but did not comment on acceptability.

Eldin et al. [36] conducted a cross sectional study across 9 Arabic-speaking countries, resulting in moderate validity scores, sensitivity 86% and specificity 80%. Perera et al. [40] examined toddlers using a Sinhala M-CHAT and found a low sensitivity of 25% but moderate specificity of 70%. Samadi et al. [39] conducted the M-CHAT in Kurdish and Persian in Iran and found good sensitivity 90.3% and moderate specificity of 80.7%, commenting on extensive workshops and educational sessions for those completing the assessment including parents.

Most of the studies had a high risk of bias in the patient selection (50%) and flow and timing (75%) QUADAS domains. The majority showed a low risk (63%) of bias in terms of the index test but many (38%) had unclear details related to the conduction and interpretation of the reference standard tests. All studies had low concern regarding applicability. Of the relevant studies, Seung [33] was rated using the MMAT and met the criteria for all domains except accounting for confounding variables.

Modified Checklist for Autism in Toddlers, Revised with Follow-Up (M-CHAT-R/F)

The original authors of the M-CHAT developed a revised version, the Modified Checklist for Autism in Toddlers, Revised with Follow-Up (M-CHAT-R/F) [82] in 2009 to reduce the burden of follow-up interviews on the screening process. It involves 20 items and a revised scoring system. It was studied by 8 of the articles from 2016–2023 in 7 languages.

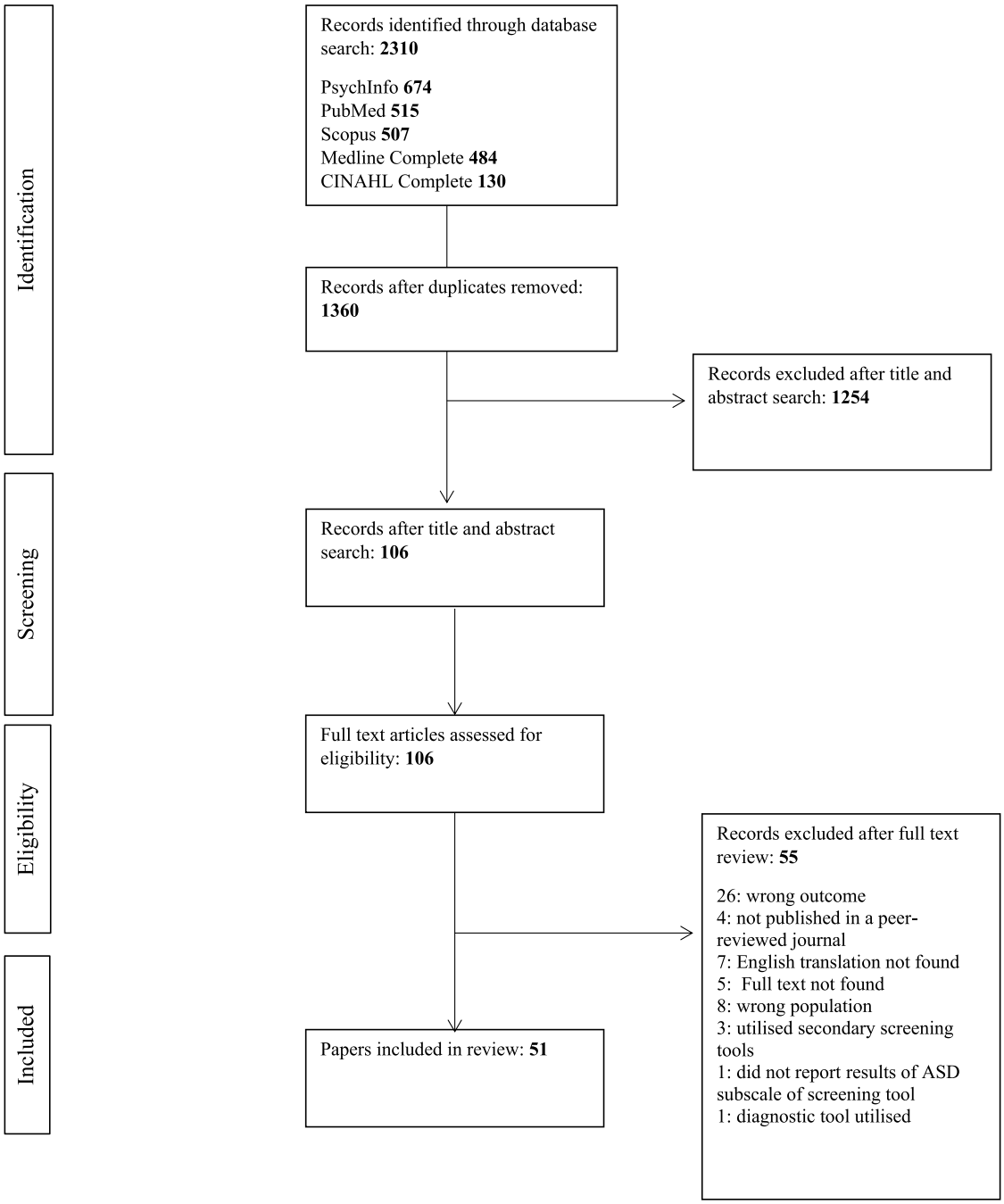

Fig. 2 PRISMA flow diagram of the literature selection process

Three studies on Turkish populations [50–52] all employed trained staff to administer the M-CHAT via interview increasing acceptability by parents using added explanations and demonstrations if necessary. They showed good validity, a sensitivity of 1 and specificity of 0.95 and reliability $\alpha = 0.84—0.96$.

Two Spanish studies [48, 49] reported validity related to sensitivity ranging from 0.79 – 1 and specificity ranging from 0.98—0.99. Guo [45] tested a Chinese population of 7928 toddlers and found a sensitivity and specificity of 0.96 and 0.87 respectively. The Portuguese version conducted in Brazil by Losapio et al. [47] found

Table 2 Number of studies per country studied

Country Studied	Number of studies
Albania	1
Brazil	1
China	12
Chile	1
Egypt	1
Finland	2
France	1
Germany	1
Greece	1
India	2
Iran	2
Italy	2
Japan	1
Jordan	1
Kuwait	1
Lebanon	1
Mali	1
Mexico	2
Oman	1
Peru	1
Qatar	2
Saudi Arabia	2
Serbia	1
South Korea	3
Sri Lanka	1
South Africa	1
Spain	3
Syria	1
Taiwan	1
Tunisia	1
Turkey	3
Vietnam	1

Table 3 Number of studies per language studied

Language Studied	Number of studies
Chinese	12
Spanish	7
Korean	3
Turkish	3
Arabic	2
Italian	2
Kurdish	2
Persian	2
Serbian	2
Albanian	1
English	1
Finnish	1
Farsi	1
French	1
German	1
Greek	1
Japanese	1
Northern Soho	1
Sinhala	1
Taiwanese	1
Vietnamese	1

reasonable sensitivity but poor specificity (Table 2). Of note, this study extrapolated the use of the screening tool to children up to 6 years of age. The Malian study [46] found poor sensitivity but good specificity. Albanian and Serbian studies [31, 44] reported acceptable to excellent reliability (Cronbach's α) of their tools ranging from 0.74 – 0.91 respectively. Within these studies, the Spanish studies made comments related to increasing sensitivity by using culturally appropriate examples and rewording some of the questions to increase clarity. Vorster [35] commented that in a South African population where the participants were presented with a Northern Soho (local language) and culturally adapted English version of this tool, there was higher acceptability and preference for the latter.

Most of these studies showed a high risk of bias in the patient selection (78%) and flow and timing (100%) QUADAS domains. The majority showed a low risk (78%) of bias in terms of the index test, but many (44%) had unclear details related to the reference standard. Carakovac et al. [31] and Vorster [35] were rated using the MMAT and met criteria for all domains except accounting for confounding variables. It was unclear if the former had complete data.

Quantitative Checklist for Autism in Toddlers (Q-CHAT)

The Quantitative Checklist for Autism in Toddlers (Q-CHAT) is a 25-item questionnaire developed for toddlers aged 18 to 30 months [83]. It is a modification of the M-CHAT where dichotomous yes/no responses were altered to ordinal responses on a 5-point scale (0—4). It was translated to 2 languages and applied in 3 studies each between 2019 and 2021.

The Italian version of the Q-CHAT was conducted on a non-clinical sample [69] reporting acceptable internal consistency Cronbach's $\alpha = 0.68$. In a separate study on a clinical sample [32], they found higher internal consistency, Cronbach's $\alpha = 0.87$ and moderate sensitivity 83%

Table 4 Characteristics of included studies

Reference	Type of Study	Language	Country	Setting	N of children	Demographics		Reported Psychometric Parameters				
						Sex	Age	Sensitivity	Specificity	PPV	NPV	Other
Modified Checklist for Autism in Toddlers (M-CHAT)												
Eldin, 2008 [36]	Cross-sectional	Arabic	Kuwait, Oman, Qatar, Saudi Arabia, Jordan, Lebanon, Syria, Egypt and Tunisia	Child development centre General Paediatric Setting	228	185 M 43 F	18 m – 124 m	0.86	0.8	0.88		-
Wong, 2018 [37]	Case control	Chinese	China	Well Child Checks	236		18 m – 47 m	0.77	0.72	0.77	0.77	α = 0.8
Baduel, 2017 [38]	Cross-sectional	French	France	Well Child Checks, Daycare Centre	1250	663 M 587 F	24 m	0.67	0.94 – 0.99	0.14 – 0.6	0.99	-
Seung, 2015 [33]	Cross-sectional	Korean	South Korea	Daycare centres, Public Health Centres, Hospitals and private Paediatric Clinic	2300	1164 M 1136 F	16 m – 36 m	-	-	-	-	α = 0.9
Samadi, 2015 [39]	Cross- sectional	Kurdish and Persian	Iran	Pre-schools, Well Child Check, Private Neurology and Paediatric Clinics	2941		2y– 5y	0.9	0.8	0.05	-	α = 0.61
Perera, 2009 [40]	Cross-sectional	Sinhala	Sri Lanka	Primary healthcare clinics	374	172 M 202 F	18 m – 24 m	0.25	0.7	0.13	0.85	-
Albores-Gallo, 2012 [41]	Case control	Spanish (Mexican)	Mexico	Nurseries, Psychiatric Outpatient Unit	456	264 M 191 F	18 m – 6y	-	-	-	-	α = 0.76
Canal-Bedia 2011 [42]	Case control	Spanish (Spain)	Spain	Well Child Check, Psychiatry Unit	4535	2409 M 2126 F	18 m– 4y	1	0.98	0.19 – 0.35	1	-
Jensen, 2021 [43]	Case control	Spanish (Peruvian)	Peru	Educational centres, Private child development centres	101	61 M 40 F	36 m – 99 m	0.93	0.63	-	-	-
Modified Checklist for Autism in Toddlers, Revised with Follow-Up (M-CHAT-R/F)												
Brennan, 2016 [44]	Cross-sectional	Albanian	Albania	Well Child Check	2594	1300 M 1288 F	16 m– 30 m	-	-	0.14 – 0.89	-	
Guo, 2019 [45]	Cross-sectional	Chinese	China	Well Child Checks	7928	4391 M 3537 F	16 m– 30 m	0.96	0.87	-	-	α = 0.57 – 0.86 ICC = 0.76

Table 4 (continued)

Reference	Type of Study	Language	Country	Setting	N of children	Demographics		Reported Psychometric Parameters				
						Sex	Age	Sensitivity	Specificity	PPV	NPV	Other
Sangare, 2019 [46]	Cross-sectional	Malian	Mali	Community health care centres, ASD Clinic	947	492 M 455 F	16 m– 30 m	0.5	1	1	0.87	-
Vorster, 2021 [35]	Cross-sectional	Northern Sotho and culturally adapted English	South Africa	Community church, Daycare centres	21		18 m– 48 m	-	-	-	-	Wilcoxon signed rank test = 0.1
Losapio, 2023 [47]	Case control	Portuguese	Brazil	Social networks of authors	75		1y– 6y	0.88	0.56	-	-	α = 0.88
Carakovac, 2016 [31]	Case control	Serbian	Serbia	Primary healthcare, Psychiatric Institution	148	87 M 61 F	16 m– 30 m					α = 0.91
Magán-Maganto, 2020 [48]	Cross-sectional	Spanish	Spain	Well Child Checks	6625	3394 M 3231 F	14 m– 36 m	0.79	0.99	0.39	0.99	-
Coelho-Medeiros, 2019 [49]	Case control	Spanish (Chilean)	Chile	Outpatient clinics, Well Child Checks	120	77 M 43 F	16 m– 30 m	1	0.98	-	-	α = 0.89
Kara, 2014 [50]	Cross-sectional	Turkish	Turkey	Paediatric neurology clinic, Well Child Check	618	372 M 266 F	18 m – 36 m	-	-	0.75	-	-
Kara Uzun, 2019 [51]	Cross-sectional	Turkish	Turkey	University of Health Sciences	471	264 M 207 F	18 m – 30 m	1	0.95	0.75	1	α = 0.96
Kondolot, 2016 [52]	Cross-sectional	Turkish	Turkey	Well Child Checks	2021	1027 M 994 F	18 m – 30 m	-	-	0.12	-	α = 0.84
Social Responsiveness Scale (SRS)												
Cen, 2017 [53]	Case control	Chinese (Mandarin)	China	Child Behavioural Unit, Local schools	749	492 M 257 F	4y– 14y	-	-	-	-	α = 0.87 – 0.92 ICC = 0.81 – 0.94
Gau, 2013 [54]	Case control	Chinese (Mandarin)	China	Primary school, Outpatient clinics	1820	1015 M 805 F	4y– 16y	-	-	-	-	α = 0.94 ICC = 0.75 – 0.85
Wang, 2012 [55]	Case control	Chinese (Mandarin)	China	Kindergartens, Hospitals	307	198 M 109 F	4y– 6y	0.64 – 0.96	0.7 – 0.9	-	-	-
Zhou, 2017 [56]	Case control	Chinese	China	Clinics, Local Autism Rehabilitation Centres	1778	983 M 795 F	6y– 12y	0.97	0.82	0.39	0.99	-
Tehrani-Doost,2020 [57]	Cross-sectional	Farsi	Iran	Primary schools	533	191 M 342 F	7y– 11y	-	-	-	-	r = 0.44

Table 4 (continued)

Reference	Type of Study	Language	Country	Setting	N of children	Demographics		Reported Psychometric Parameters				
						Sex	Age	Sensitivity	Specificity	PPV	NPV	Other
Jussila, 2015 [58]	Case control	Finnish	Finland	Hospital Outpatients	88	88 M	7y – 16y	1	0.96	-	-	-
Bölte, 2008 [59]	Cross-sectional	German	Germany	Schools, Autism/Psychiatric Centre Outpatients	1436	823 M 613 F	10y	0.73	0.81	-	-	α = 0.91–0.97 ICC = 0.84 – 0.97
Kamio, 2013 [60]	Case control	Japanese	Japan	Schools, Paediatric Outpatient Clinics	130	90 M 40 F	4y – 17y	0.73 – 0.79	0.67	-	-	ICC = 0.87
Cheon, 2016 [61]	Cross-sectional	Korean	South Korea	Primary schools, Psychiatric Clinics, Epidemiological Sample	1095		7y– 12y	-	-	-	-	α = 0.81 – 0.88
Chun, 2021 [62]	Cross-sectional	Korean	South Korea	Outpatient clinics, Advertisements	563	379 M 184 F	10 m– 65 m	0.81—0.83	0.71—0.86	-	-	-
Fombonne, 2012 [63]	Case control	Spanish (Mexican)	Mexico	Autism and Developmental Disorders Clinic, Primary School	563	378 M 185 F	4y– 13y	0.93	0.93	-	-	α = 0.97
Nguyen, 2019 [64]	Case control	Vietnamese	Vietnam	ASD Centres, Communities	158	101 M 57 F	4y– 10y	0.93	0.98	-	-	α = 0.88 – 0.89 ICC = 0.82 – 0.83
Autism Spectrum Rating Scales (ASRS)												
Zhou, 2015 [65]	Case control	Chinese	China	Autism Rehabilitation Centres, Community	1625	830 M 795 F	6y– 18y	0.94	0.77	-	-	α = 0.59 – 0.93
Zhou, 2017 [56]	Case control	Chinese	China	Clinics, Local Autism Rehabilitation Centres	1778	983 M 795 F	6y– 12y	0.93	0.83	0.39	0.99	-
Zhou, 2018 [66]	Case control	Chinese	China	Kindergartens, Special Education Schools	2181	1056 M 1125 F	2y– 5y	0.89	0.85	-	-	α = 0.91
Social Communication Questionnaire (SCQ)												
Aldosari, 2019 [67]	Case control	Arabic	Qatar, Saudi Arabia	Autism Centres, Schools	412	304 M 108 F	5y– 12y	0.8	0.97	-	-	α = 0.92
Liu, 2022 [68]	Case control	Chinese	China	ASD Rehabilitation Centres, Schools, Hospitals	819	545 M 274 F	2y– 18y	0.93 – 0.96	0.95 – 0.98	-	-	α = 0.92 r = 0.56

Table 4 (continued)

Reference	Type of Study	Language	Country	Setting	N of children	Demographics		Reported Psychometric Parameters				
						Sex	Age	Sensitivity	Specificity	PPV	NPV	Other
Karaminis, 2022 [66]	Cross-sectional	Greek	Greece	Social media, Speech and Language Centres	311	197 M 114 F	7.5y	0.87 – 0.89	0.84 – 0.91	-	-	Ω = 0.92 – 0.95
Sangare, 2019 [46]	Cross-sectional	Malian	Mali	Community Healthcare Centres, ASD Clinic	120	74 M 46 F	4y– 20y	0.71	0.72	0.73	0.70	-
Quantitative Checklist for Autism in Toddlers (Q-CHAT)												
Ruta, 2019 [69][a]	Case control	Italian	Italy	Nurseries, Clinical facilities of Autism Centre	315	206 M 109 F	31.6 m	0.83	0.78	-	-	α = 0.87
Ruta, 2019 [32][b]	Cross-sectional	Italian	Italy	Well Child Check	2400	1267 M 1133 F	18 m– 24 m	-	-	-	-	α = 0.68
Stevanović, 2021 [70]	Case control	Serbian	Serbia	Nurseries, Preschool, Neurology and Psychiatry Clinic	220	93 M 127 F	15 m– 36 m	0.96	0.82	0.39	0.99	α = 0.81
Childhood Autism Spectrum Test (CAST)												
Sun, 2013 [34]	Cross-sectional	Chinese	China	Primary Schools	70	36 M 34 F	6y– 11y	-	-	-	-	weighted kappa = 0.53
Sun, 2014 [71]	Case control	Chinese (Mandarin)	China	ASD Rehabilitation Centre, Primary Schools	695	377 M 306 F	4y– 11y	-	-	-	-	θ = 0.89
Morales-Hidalgo, 2017 [72]	Cross-sectional	Spanish	Spain	Clinical Centres, Primary Schools, Birth data	1496	895 M 601 F	4y– 11y	0.84	0.93	0.63	-	α = 0.83
Autism Spectrum Quotient—Child (AQ-C)												
Sun, 2019 [73]	Case control	Chinese	China	Women and Children's Health Care Hospital, Primary Schools, Kindergartens	1154	637 M 517 F	4y– 10y	0.94	0.88	-	-	α = 0.77 r = 0.79
Indian Autism Screening Questionnaire/ Indian Scale for Assessment of Autism (IASQ/ISAA)												
Chakraborty, 2015 [74]	Cross-sectional	Hindi	India	Hospitals, National Institute for Mentally Handicapped	216	164 M 52 F	3y– 17y	-	-	-	-	r = 0.77 α = 0.93

Table 4 (continued)

Reference	Type of Study	Language	Country	Setting	N of children	Demographics		Reported Psychometric Parameters				
						Sex	Age	Sensitivity	Specificity	PPV	NPV	Other
Chakraborty, 2022 [75]	Cross-sectional	Hindi	India	Neurodevelopmental clinic, Institute for Disability and Rehabilitation, Community	285	177 M 108 F	3y– 18y	0.97	0.81	0.63	0.99	-
Autism Behaviour Checklist (ABC)												
Chu, 2022 [76]	Case control	Chinese (Mandarin)	China	Outpatient Clinic	474	407 M 67 F	1.5y– 14y	0.8	0.59	0.93	0.32	-
Autism Spectrum Screening Questionnaire (ASSQ)												
Mattila, 2012 [77]	Cross-sectional	Finnish	Finland	Local schools	4408		8y	0.89	0.82	0.62	0.96	-
HIVA												
Samadi, 2015 [39]	Cross- sectional	Kurdish and Persian	Iran	Pre-schools, Well Child Check, Private Neurology and Paediatric Clinics	2941		2y– 5y	1	0.97	0.38	-	α = 0.58
Toddler Autism Screening Questionnaire (TASQ)												
Tsai, 2012 [78]	Case control	Taiwanese	Taiwan	Well Child Check, Child Health Centres	77	46 M 31 F	18 m– 26 m	1	0.97	-	-	-

No studies looked at acceptability, *PPV* Positive Predictive Value, *NPV* Negative Predictive Value,—= data not reported, Sensitivity (0 = low sensitivity, 1 = perfect sensitivity), Specificity (0 = low specificity, 1 = perfect specificity); M-Male, F-Female

[a] Ruta, 2019 [69]

[b] Ruta, 2019 [32]

and specificity 78%. Both these studies collected extensive demographic data from the parents including education level. Stefanovic [70] tested Serbian toddlers with the Q-CHAT and found a high sensitivity of 96.2% and specificity of 81.9%. Ruta et al. [69] and Stefanovic et al. [70] were appraised using QUADAS-2 and showed a high risk of bias in the patient selection and flow and timing domains and unclear risk related to the index test. Ruta et al. [32] were more appropriately analysed using MMAT and rated "yes" in all domains.

Social Responsiveness Scale (SRS)

The Social Responsiveness Scale (SRS) is a 65-question screening measure for children aged 2.5 – 18 years [84]. The SRS was also popular and was used in 12 studies from 2008 to 2021 in countries. Four studies conducted in Chinese [53–56] showed good to excellent reliability scores with Cronbach's α =0.871 – 0.94, as well as good validity measures sensitivity 0.93 – 0.97 and specificity 0.7—0.82.

Several other translated versions were tested in Asian populations including 2 Korean studies [61, 62], 1 Japanese study [60] and 1 Vietnamese study [64]. Overall, these showed fair reliability α = 0.721 – 0.88 and moderate validity scores, sensitivity 0.725 – 0.93 and specificity 0.667 – 98%. Cheon et al. [61] specified some modifications made to allow culturally appropriate clarification. Both the Mexican [63] and German [59] adaptations reported high reliability with the former also showing good validity measures. Similarly, the Finnish SRS [58] had very high sensitivity [1] and specificity (0.96).

In the quality appraisal, 83% of these studies indicated a high risk of bias in the patient selection. Many had unclear details regarding the index testing (83%) and flow and timing (50%). One study raised concerns regarding the applicability of the reference standard used [57].

Autism Spectrum Rating Scales (ASRS)

The Autism Spectrum Rating Scales (ASRS) developed by Goldstein in 2009 [85] is relatively longer comprising of 70 questions and applicable to children aged 2 – 18 years old. Zhou [65] conducted this test in Chinese on 1625 participants and found variable internal consistency (Cronbach's α) of 0.585 to 0.929, high sensitivity of 94.2% and moderate specificity of 77%. In 2018, the team tested this on a Chinese kindergarten population and found a poorer sensitivity of 88.6% and better specificity of 84.5% (Zhou, 2018) [86]. This questionnaire was modified by Zhou 2017 and tested on different participants aged 6–12 years old resulting in similar sensitivity to their initial study of 93% but a high false positive rate with a PPV of 39.1% and specificity of 83.2%.

All studies indicated a high risk of bias in the patient selection and flow and timing domains as well as an unclear risk of bias related to the index test. There were low concerns related to the applicability within the studies.

Social Communication Questionnaire (SCQ)

The Social Communication Questionnaire (SCQ) is a 40-item yes/no response screening tool developed by Rutter et al. [87] aimed at children above the age of 4 years. The SCQ was translated to 4 different languages and studied from 2019–2022.

Four studies were found to use this test. Aldosari et al. [67] tested an Arabic version and found high reliability, moderate sensitivity (79.6%) and good specificity (96.6%). In the Greek population (Karaminis,2022) [66] the sensitivity ranged from 86.3%-88.7%, and the specificity ranged from 83.7% to 91.4%. Both of these studies mention removing references to English rhymes and making it culturally appropriate to increase acceptability. In a Chinese population, Liu et al. [68] found the test to be sensitive and specific in populations both under and over 4 years of age. This team collected data on parental education levels suggesting an impact on acceptability. Sangare et al. [46] also evaluated the SCQ in the Malian population and found similar sensitivity and specificity, 71% and 72% respectively.

All studies displayed a high risk of bias in the patient selection domain and 75% showed a high risk related to the flow and timing domains. They all indicated unclear details to ascertain risk related to the reference standard. There were low concerns related to the applicability among the various domains in all the studies.

Childhood Autism Spectrum Test (CAST)

The Childhood Autism Spectrum Test (CAST) is an instrument developed in the UK for screening for autism in children 4–11 years old [88]. It was translated to 2 languages and applied in 3 studies from 2013–2017.

Two studies [34, 71] tested the reliability of the Mandarin CAST on a Chinese primary school population, reporting it to be good with Spearman rho = 0.73 and theta = 0.89 respectively. A similar age group was tested using a Spanish translation [72] leading to a sensitivity score of 83.9%, a specificity of 92.5%, and an internal consistency (*a*) of 0.826. This study discussed some cultural adaptations such as changing unfamiliar games to culturally familiar descriptions.

During the quality appraisal, two studies [71, 72] indicated a high risk of bias in the patient selection. The study by Sun et al. [34] was analysed using the MMAT and deemed "yes" to all questions except for if they accounted

for confounders and also showed a lack of details regarding whether participants were representative of the target population.

Autism Spectrum Quotient (Child) (AQ-C)

The Autism Spectrum Quotient (AQ) (Child), AQ-C, is a 50-item parent-report questionnaire developed for children aged 4–11 years [89]. The Mandarin version completed on 4–10-year-old children [73] showed moderate reliability with an α coefficient of 0.765 and good validity with a sensitivity of 94% and specificity of 88.2%.

Indian Scale for Assessment of Autism (ISAA) and Indian Autism Screening Questionnaire (IASQ)

The Indian Scale for Assessment of Autism (ISAA) is described as a validated and mandated tool for autism assessment in India. The ISAA is a 40-item instrument with a 5-point rating scale [74]. All individuals, including health professionals, are required to undergo training prior to administration. It was studied by 2 of the publications [74, 75].

The Indian Autism Screening Questionnaire (IASQ) was derived from the ISAA and is a shorter, 10-question tool that requires comparatively brief training that can be done online. It was tested by 1 of the studies [75]. In a study population aged 3–17 years the ISAA was found to have a high validity score $r=0.77$, internal consistency and reliability Cronbach's $\alpha=0.93$ and good discriminant ability AUC = 0.93 [74]. The Indian Autism Screening Questionnaire (IASQ) on a similar aged population led to good sensitivity of 97% and specificity of 81% [75].

Autism Behaviour Checklist (ABC)

The Autism Behaviour Checklist (ABC) developed by Krug et al. [90], is a rating scale with 57 items for children aged 12 – 14 years. It was tested on a Mandarin population [76] aged 1.5–14 years leading to a moderate sensitivity of 80.45% but poor specificity of 58.67%.

Autism Spectrum Screening Questionnaire (ASSQ)

The ASSQ is a screening questionnaire developed by Ehlers and team in 1999 [91] with 27 different questions structured for carers of 7- to 16-year-old children. In a Finnish population of 8-year-old children in 2012, it showed sensitivity = 89% and specificity = 82% [77].

Hiva

Hiva (a word meaning "wish" in the Kurdish language) is a tool developed in Iran for its population consisting of the ten most commonly occurring autism symptoms identified by Iranian parents and professionals. It is based on the DSM-IV criteria and is aimed at children aged 3 – 11 years old. It was trialled in 1 study in 2015 in both Kurdish and Persian [39] in a population aged 2–5 years old. The scale had high validity measures (sensitivity = 100% and specificity 97%). The tool had poor internal consistency with Cronbach's $\alpha=0.58$.

Toddler Autism Screening Questionnaire (TASQ)

The Toddler Autism Screening Questionnaire was developed by Tsai and team [78] for Taiwanese children based on a qualitative study where a child psychiatrist interviewed families of children with autism. The tool includes 18 questions requiring yes/no answers. In their studied population aged 18 – 26 months, Tsai et al. found their devised screening tool to have high validity scores (sensitivity = 100% and specificity 97%).

For this review, the quality appraisals of the above once-studied screening tools were combined for the purpose of reporting and analysis. These studies (CAST [88], AQ-C [89], ISAA [74], IASQ [75], ABC [76], Hiva [39], TASQ [78]) demonstrated varied ratings on quality appraisal. They predominantly indicated a high risk of bias related to patient selection and flow and timing (75%). Most indicated an unclear risk of bias related to the reference standard (50%). However, there were mixed findings regarding the index test domain, with 50% indicating a low risk of bias, 37% rating unclear risk and 13% measuring high risk. All studies indicated low concerns regarding applicability.

Acceptability

None of the studies included in this review presented data on the acceptability (parental and service provider) of the autism screening tools.

Discussion

This review examined the literature on screening tools used for autism in CALD populations. A total of 51 studies that examined 13 screening tools in CALD populations were used to ascertain the accuracy, reliability, validity, and acceptability. Although a variety of tools were identified, only some tools were implemented in more than one study. Of the total number of studies, 20 studies examined the reliability, validity and/or accuracy of the screening tool. Nineteen studies provided only validity scores and 12 studies presented only reliability measures.

The psychometric evaluations of the tools varied both in the properties evaluated and in the number of studies that assessed each screener. The performance varied from excellent to poor in terms of sensitivity and specificity. Table 5 highlights a description of the key findings. For example, the M-CHAT was studied in several different languages with good reliability and/or validity of the tool found when used in Spanish, Turkish, Chinese,

Table 5 Summary description of key findings

Finding	Screening Tool	Description
Variability in psychometric properties	M-CHAT	Good validity and reliability in various languages (Spanish, Turkish, Chinese, Korean, French, and Arabic) Sensitivity was low in the Sinhalese population
	M-CHAT-R/F	Good validity and reliability in various languages (Spanish, Chinese, Portuguese, Serbian, Malian, Northern Soho, and Albanian)
	Q-CHAT	Acceptable validity and reliability in Italian and Serbian
	SCQ	Good validity in some languages (Arabic, Greek and Malian) High sensitivity in Chinese language
	SRS	Good validity and reliability in Chinese, Mexican, Finnish and German. Moderate validity and fair reliability in various languages (Korean, Japanese and Vietnamese)
	ASRS	Good validity but variable reliability in Chinese
	CAST	Good validity in Spanish. Good reliability in Chinese
	AQ-C	Good validity and reliability in Chinese
	ABC	Moderate sensitivity but poor specificity in Chinese
	ASSQ	Fair validity in Finnish
Need for culturally sensitive approaches	Excellent sensitivity demonstrated by screening tools devised specifically for their culture. For example, the IASQ/ISAA for Indian populations, Hiva for Kurdish and Persian cohorts, and the TASQ for Taiwanese children The performance of tools created within their intended populations supports the need for comprehensive cultural adaptation beyond simple translation to improve the accuracy of autism diagnoses	

Korean, French, and Arabic populations indicating its potential utility in these groups. The M-CHAT-R/F, the updated version of the M-CHAT, appears to have similar results and was found to be valid and reliable in Spanish, Chinese, Portuguese, Serbian, Malian, Northern Soho, and Albanian communities.

However, the M-CHAT's performance was not universally robust. The tool's sensitivity was as low as 25% in a Sinhalese demographic [40]. It is worth noting that this study [40] was the only study that employed the M-CHAT within a South Asian nation. It was found that despite a "rigorous translation process" first to Sinhalese and then back to English to ensure validity, some behaviours significant for the diagnosis of autism were not recognised as abnormal by the Sinhalese mothers. This highlights a disadvantage of applying a tool designed for one population to another population where it might not align with the cultural context. The tool's contrasting accuracy in different settings underscores a critical research gap.

On the other hand Perera et al. [92] demonstrated that a pictorial autism screening tool yielded 88% sensitivity in differentiating autism from typical developing Sinhalese children. Hence, there may be merits of using alternative methods such as pictorial scales for identifying autism in diverse populations [93] where there is poor evidence base supporting conventional screening tools and presents an area for further studies.

Other factors may have also affected the success of the M-CHAT in some studies. Samadi et al. [39] reported good utility of the M-CHAT in Kurdish and Persian in Iran. However, this may be attributable to the conduction of extensive workshops and educational sessions for those completing the assessment including parents. This is additional to the standardised M-CHAT guidelines and can not only influence the extrapolation of these findings but also may not be feasible to replicate in ongoing clinical practice.

Importantly, the studies in this review did not consistently report cut-off scores for a positive screen, sensitivity, and specificity for these instruments. To ensure standardised screening efforts, it may be significant to establish and report culturally appropriate cut-off points as more studies are conducted in populations without screening histories. This may be an area where further research and validation studies are beneficial to determine the ideal cut-off for each population.

Various translations of the SCQ have proven reliable across populations and demonstrated validity specifically within Arabic, Greek and Malian populations and higher sensitivity within a Chinese demographic, despite the larger sample size ($n=819$) and wide age range (2 – 18 years). Liu et al. [68] analysed subgroups of various ages and found the validity scores to be consistent in <4 years and >4 years. This is clinically significant as there are limited options for autism screening between 30 and 48 months of age, with the M-CHAT-R/F being the only validated tool in China at the time but limited to toddlers up to 30 months of age. Thus, the SCQ demonstrates remarkable versatility across varying age groups in

addition to good reliability and validity. Further research would be beneficial to determine if these psychometric properties translate to other cultures.

Given the various autism screening tools analysed within a variety of countries in this study, an accurate comparison of the screening tools cannot be completed. Although generally it can be noted that the M-CHAT appeared to have the highest overall validity and reliability, its low sensitivity within Sinhalese populations highlights that CALD populations cannot be generalised.

This is furthered by the fact that the four screening tools included in this review that were devised specifically for their culture, namely IASQ/ISAA for Indian populations, Hiva for Kurdish and Persian cohorts and the TASQ for Taiwanese children demonstrated excellent sensitivity (0.97 – 1). This indicates not only the accuracy, but also the benefit of tailoring the screening tool for the particular culture. The methodologies behind the development of these tools vary. The ISAA [74] and IASQ [75] originated from a collaborative effort from a body of health professionals who devised questions based on the Indian population. Items in the TASQ [78] were based on a qualitative study where a child psychiatrist conducted interviews with Taiwanese families. The Hiva scale [39] was based on DSM 5 criteria but the questions were devised specifically for the Persian and Kurdish populations. This emphasises that the key factor is not only the method of tool development, which can vary, but the consistent element is that it was created in partnership with local stakeholders within the context of the specific population.

The performance of these tools created within their intended populations further supports the notion that the correct application of existing tools in different cultural and linguistic settings extends beyond just translation. It requires a comprehensive assessment of potential mismatches in language and concepts, followed by adjustments to ensure comprehension by the target population. A review by Soto et al. [8] emphasised that the objective of cultural adaptation is to achieve "functional equivalence" with the original version which, as demonstrated by the varying psychometric results in this review, is difficult to establish with only translation.

During the process of this review, some cultural adjustments were noted. Some examples include the replacement of the name "peek-a-boo" with a description of the game for Mexican families undertaking the Mexican M-CHAT [41] and the removal of references to British rhymes in the Arabic SCQ [67]. However, this review did not rigorously examine the cultural adaptation process for each study and its adherence to recommended guidelines [94]. This would be a beneficial area for further research as it may influence the quality of the psychometric outcomes. Soto et al. [8] did delve into this area and found that the details of adaptation methods were rarely reported with a notably large variation in the processes that were reported.

The ultimate diagnosis of autism is based on identifiable behavioural and social-emotional patterns highlighted in the DSM criteria. Nevertheless, the understanding of these behaviours can be shaped by diverse cultural contexts, leading to variations in identification [6]. Evaluating difficulties in social communication hinges on deviations from culturally defined norms, thus inviting differing interpretations. Consequently, assigning an impairment in this category to children across different cultures may lack uniformity, potentially disregarding significant cultural nuances in ASD assessments. Following from this arise questions regarding the cross-cultural sensitivity and validity of the DSM criteria which forms the basis of most screening tools. This may form a key area for future research and consideration of a revision of the criteria to reflect cultural differences.

Another finding of this review is a noticeable gap in the literature with a lack of studies exploring the acceptability of autism screening tools within CALD populations. The absence of acceptability studies impacts our understanding of the broader societal impact and is both academically and clinically relevant to ensure equitable and culturally competent screening [95]. Without a clear understanding of how these tools are received within CALD communities, there may be inadvertent use of methods that are linguistically inappropriate or culturally insensitive. This may lead to inaccurate diagnoses or delays in early intervention and support. It can also result in mistrust within the communities towards the healthcare system [96], exacerbating disparities.

Clinical implications

There are several clinical implications stemming from this review. While it appears to have been useful in several studies, the use of multiple stages of translation and explanation as well as the requirement of additional personnel, training and education in the assessment introduces an additional layer of complexity to the assessment process. This can increase the risk of misunderstandings between the healthcare provider and parent/carer, potentially affecting the accuracy of the diagnosis.

Moreover, the use of multiple stages within the screening (e.g., follow-up interviews and phone calls) and diagnosis process may lead to increased drop-out or decreased follow-up rate. This can potentially result in further delays in intervention. The additional steps are also relevant in terms of policymaking as they can

consume a considerable amount of time and resources with negative financial implications.

Based on this review, due to the heterogeneity of data, there was no currently available screening tool that appeared universally perfect for all CALD populations. This review did inform that the M-CHAT, and its updated version M-CHAT-R/F, as well as the SRS were the most frequently translated and utilised, all with good validity and reliability. Whilst the tools devised specifically for its culture (IASQ/ISAA, Hiva and TASQ) performed excellently, if it is not feasible to devise a novel measure, the community may consider one of the three available tools with appropriate culturally appropriate amendments.

Highlighting the potential positive impact of the findings of this review on clinical practice and policy is crucial. By recognising the importance of cultural sensitivity in screening and diagnosis, as emphasised in the review, clinicians and policymakers can prioritise the development and implementation of culturally appropriate assessment methods. This, in turn, can lead to more accurate diagnoses and early interventions tailored to the needs of children with autism in culturally and linguistically diverse communities. By involving local stakeholders in the research process, such as community leaders and healthcare providers, we can ensure that these efforts result in meaningful improvements in the lives of children with autism in CALD communities.

Incorporating cultural sensitivity and community engagement into the development and validation of autism screening tools is essential for ensuring their effectiveness across diverse populations. One approach is to involve community members, including parents, caregivers, and local healthcare providers, in the design and validation process. By soliciting input from culturally diverse perspectives, screening tools can be adapted to better reflect the cultural norms and expectations of different communities. For example, rather than relying solely on standardised behavioural criteria, as aforementioned this may have different interpretations in different cultures, screening tools could incorporate culturally specific behaviours and communication styles that may indicate autism in certain populations. Additionally, providing training and resources to healthcare professionals on culturally competent assessment techniques, may it be outside of the screening process, can help improve the accuracy of autism diagnoses in culturally diverse settings. Ultimately, by integrating cultural sensitivity and community engagement into the development and validation process, we can ensure that autism screening tools are more inclusive and reflective of diverse experiences.

Strengths and limitations

One of the strengths of this review lies in its inclusivity of a wide range of studies from diverse languages and cultural backgrounds, each of which is distinct from the others. This allows for a more rounded understanding of the complexities and variations in autism in CALD children across a variety of cultures. The strength is enhanced by the use of a systematic approach with broad inclusion criteria and the inspection by two independent reviewers.

This review has several limitations. First, the inclusion of a wide range of studies from diverse cultural backgrounds, while a strength, also introduces a potential limitation in terms of the heterogeneity of the data. The heterogeneity extends to the age groups studied by the screening tools. The various tools target different age groups however some studies extrapolated the use of the tool to outside of the recommended age range potentially affecting the validity and reliability. Moreover, within this review the analysis of single-stage studies was combined with that of studies utilising multiple stages of screening which may have affected the resulting psychometric parameters. Variations in research methodologies, sample sizes, and cultural contexts make it challenging to draw uniform conclusions and comparisons across all studies. Further research may group these studies into more specific categories.

Of significance is that the majority of the studies in this review exhibited a high risk of bias during quality assessment, using the QUADAS-2 and several studies lacked sufficient detail in their MMAT evaluations. This raises concern regarding the credibility of the findings and whether they can be generalised to other settings and contexts. Another limitation of this study is the absence of an examination of grey literature (defined as "literature that is not formally published in sources such as books or journal articles" [97]) and reference lists which may have allowed for more complete data on autism screening in CALD communities. Additionally, language barriers and the exclusion of studies not available in English may limit the comprehensiveness of the review, potentially excluding valuable research conducted in non-English-speaking regions. Furthermore, while the review highlights the cultural diversity within the selected studies, it focused only on reliability and validity which was demonstrated by psychometric parameters rather than the relevance of items to specific cultural contexts and as mentioned above, the adaptation process.

Conclusion

This review critically examined autism screening tools that have been employed in CALD populations, with a focus on their validity, reliability, accuracy, and acceptability. Notably, no studies have explored the acceptability

of these tools and further research is needed in this area. By systematically exploring how these tools are perceived, understood, and embraced by CALD communities, we can develop a better understanding of their effectiveness and potential limitations in these populations.

Nevertheless, the findings demonstrate the variability in psychometric properties across diverse populations. This highlights the diversity of the unique nuances, expressions, and interpretations of autism within different communities and the importance of recognising the heterogeneity in our approach to screening. Dependence on screening tools developed in Western contexts may result in biases and inaccuracies when applied to other settings.

The review illustrates the benefit of cultural sensitivity during screening and diagnosis as accuracy in these areas has profound implications for culturally appropriate assessment and early intervention with equitable access. Further research is needed to enhance the development of valid and reliable culturally specific autism screening tools with the involvement of local stakeholders.

Additionally, there should be continued efforts to address the ongoing stigma associated with autism in some cultural contexts. Cultural beliefs regarding neurodevelopmental disorders vary widely, leading to misconceptions and misunderstandings about autism often hindering discussion and support-seeking. Language barriers, limited access to culturally sensitive information, and disparities in healthcare resources further exacerbate the issue. To combat this stigma effectively, strategies must be tailored to specific cultural contexts. This may include community-based education programs, culturally sensitive awareness campaigns, and the involvement of community leaders and trusted figures in spreading accurate information about autism. Empowering individuals and families within CALD communities to openly discuss and seek assistance for autism can help reduce stigma and promote acceptance and inclusion, thereby facilitating earlier diagnoses and access to interventions.

Abbreviations

ABC	Autism behaviour checklist
ADI-R	Autism diagnostic interview - revised
ASSQ	Autism spectrum screening questionnaire
AQ-C	Autism spectrum quotient - child
ASD	Autism spectrum disorder
ASRS	Autism spectrum rating scales
CAST	Childhood autism spectrum test
CALD	Culturally and linguistically diverse
CHAT	Checklist for autism in toddlers
IASQ	Indian autism screening questionnaire
ISAA	: Indian scale for assessment of autism
MMAT	Mixed methods appraisal tool
M-CHAT	Modified checklist for autism in toddlers
M-CHAT-R/F	Modified checklist for autism in toddlers, revised with follow-up
PPV	Positive predictive value
Q-CHAT	Quantitative checklist for autism in toddlers
QUADAS-2	Quality assessment of diagnostic accuracy studies tool
SCQ	Social communication questionnaire
SRS	Social responsiveness scale
TASQ	Toddler autism screening questionnaire
USA	United States of America
UK	United Kingdom

Supplementary Information

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Supplementary Material 1.

Authors' contributions

EH, SC, PH, ADM, and JRJ assisted in the conceptualisation of the research question and design of the study; EH and PH conducted independent data extraction and quality assessment; EH drafted the manuscript under the supervision of SC, JRJ, and VE. All authors (EH, SC, PH, JRJ, AH, ADM and VE) reviewed and approved the final manuscript.

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The data generated and/or analysed during the current study may be available from the corresponding author upon reasonable request.

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Competing interests

The authors declare no competing interests.

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