**Table 1. Overview of available tools for the screening of autism spectrum disorders that met the study criteria.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Full name of the tool** | **Abbreviation** | **Administer time (in minutes)** | **Age of the tested child** **(in months)** | **Person completing the questionnaire** | **Country** | **Language** | **Reliability**  **(Cronbach’s alpha)** | **Sensitivity** | **Specificity** | **Positive predictive value** | **Negative predictive value** | **Population and subgroups size** | **Changes made in the questionnaire** | | | **References** |
| **Original version** | **Lingual changes** | **Cultural changes** |
| 23-Item Screener | **23Q** | NDA | 24-108 | parents | Uganda | Luganda | NDA | 0.8 | 0.77 | 0.23 | 0.98 | 1169 from general population | + |  |  | [51] |
| Autism Observation Scale for Infants | **AOSI** | 20 | 6-18 | health professionals | Canada | English | 0.68-0.94 | 0.84 | 0.98 | NDA | NDA | In first study 92 infants siblings of children with ASD for the assessment of reliability , in second - 150 infants siblings of children with ASD. | + |  |  | [52, 53] |
| Autism Parent Screen for Infants | **APSI** | 10-15 | 6-24 | parents | Canada | English | 0.77-0.92 | 0.67 | 0.87 | 0.43-0.79 | 0.87-0.99 | 283 in total (79 low risk, 204 high risk) | + |  |  | [54] |
| Baby and Infant Screen for Children with aUtism Traits | **BISCUIT** | 30 | 17-37 | parents or caregivers | USA | English | NDA | 0.67-0.94 | 0.74-0.89 depending on cut-offs | NDA | NDA | 3062 in total (499 with ASD, 383 with PDD-NOS and 2180 with non-ASD related atypical development) | + |  |  | [55] |
| Behavior Development Screening for Toddlers | **BeDevel** | 18-42 | 10-15 | parents or primary caregivers | South Korea | Korean | 0.87–0.96 | 0.83 | 0.81 | 0.80 | 0.83 | 155 in total (75 ASD, 55 TD, 25 DD). | + |  |  | [56] |
| Brief Autism Detection in Early Childhood | **BADEC** | 10-25 | 12-36 | observers | Australia | English | NDA | 0.81 | 0.78 | 0.81 | 0.78 | 270 in total (95 with ASD, 28 with PDD-NOS, 69 ODD, 78 TD). | + |  |  | [57] |
| Brief Infant Toddler Social Emotional Assessment | **BITSEA** | 15 | 12-36 | parents | Finland | Finnish | 0.75 | NDA | NDA | NDA | NDA | 50 from general population |  | Translated with some language changes. |  | [58, 59] |
| France | French | 0.65-0.79 | NDA | NDA | NDA | NDA | 589 from general population |  | Translated according to international guidelines. |  | [60] |
| Netherlands | Dutch | 0.61-0.76 | NDA | NDA | NDA | NDA | 3170 from general population |  | Translated according to international guidelines. |  | [61] |
| Turkey | Turkish | 0.72-0.82 | 0.83-0.90 | 0.88-0.91 | NDA | NDA | 462 from general population |  | Translated with “minimal corrections”. |  | [62] |
| USA | English | 0.79 | 0.67-0.95 | 0.68-0.95 | 0.74-0.93 | 0.75-0.93 | 1788 from general population | + |  |  | [63] |
| Chandigarh Autism Screening Instrument | **CASI** | 15-20 | 18-120 | parents | India | Hindi | 0.86 | 0.89 | 0.89 | 0.67 | 0.96 | 405 in total (75 with intellectual disability, 83 with ASD, 87 with DD and 160 TD). | + |  |  | [64] |
| Checklist for Autism Spectrum Disorders | **CASD** | 15 | 12-204 | observers | USA | English, Spanish | 0.97 | 0.86 | 1.00 | 1.00 | 1.00 | 2469 (1052 with ASD, 925 TD, 55 with typical autism and 437 nonautistic clinical children) | + |  |  | [65] |
| Checklist for Early Signs of Developmental Disorders | **CESDD** | NDA | 3-39 | observers | Belgium | Dutch | NDA | 0.80 | 0.94 | 0.7 | 0.99 | 6808 from general population | + |  |  | [66] |
| Communication and Symbolic Behavior Scale-Infant and Toddlers Checklist | **CSBS-DP** | 5-10 | 6-24 | parents | Australia | English | 0.82 | NDA | NDA | NDA | NDA | 1725 infants already participating in a longitudinal study of language development |  |  |  | [67] |
| South Korea | Korean | 0.90 | NDA | NDA | NDA | NDA | 219 of TD children |  |  |  | [68] |
| Taiwan | Chinese | 0.77 | NDA | NDA | NDA | NDA | 171 from general population |  | Translation was made. | Substitution of English phonemes with suitable Chinese phonemes; replacement of frequently used words (for example “uh/oh” was replaced with “thank you”). | [69] |
| USA | English | 0.87 | 0.89 | 0.89 | 0.94 | 0.80 | 2454 in the reliability study, 3026 (3021 of children not previously identified, 5 with DD) in the study of diagnostic properties | + |  |  | [70–72] |
| Developmental Behavior Checklist‐Early Screen | **DBC-ES** | 5-10 | 18-48 | parents or teachers | Australia | English | 0.87 | 0.75 | 0.51 | 0.77 | 0.48 | 207 children with or suspected of DD | + |  |  | [73] |
| Early Screening Autistic Traits Questionnaire | **ESAT** | 10 | 14-15 | parents | Netherlands | Dutch | NDA | 0.68 | 0.96 | 0.10 | 0.99 | 31724 from general population | + |  |  | [74] |
| Norway | Norwegian | NDA | NDA | NDA | 0.07-0.3 | NDA | 12666 from general population |  | Translation only. |  | [75] |
| First Year Inventory | **FYI** | 30 | 12 | parents | China | Chinese | The study was aimed at determining the cut-off points for the study population | | | | | 518 from general population |  | Translation only. |  | [76] |
| Israel | Hebrew | 0.69 | The study was aimed at determining the cut-off points for the study population | | | | 471 from general population |  | Items were culturally and linguistically adapted | | [77] |
| Italy | Italian | The study was designed to test the stability of the cross-cultural measurement between American and Italian children | | | | | 657 from general population |  | Translation only. |  | [78] |
| USA | English | 0.81 | 0.44  (0.41 in sample of high-risk children) | 0.99  (0.81 in sample of high-risk children) | 0.31  (0.52 in sample of high-risk children) | 0.99  (0.73 in sample of high-risk children) | 1496 from general population for study of test reliability; 699 from general population for other properties; 121 in the study on high-risk sample | + |  |  | [79–81] |
| USA | Spanish | The study aimed to identify possible difficulties related to translating the ASD screening questionnaires to adapt them to other languages and cultures | | | | | 25 |  | Items were culturally and linguistically adapted | | [82] |
| INCLEN Diagnostic Tool for Autism Spectrum Disorder | **INCLEN-ASD** | 45-60 | 24-108 | observers | India | English, Gujarati, Hindi, Khasi, Konkani, Malayalam, Odia, Telugu, Urdu | 0.96 | 0.98 | 0.95 | 0.91 | 0.99 | In first round of the study – 266 in total (81 with ASD, 120 NDDs, 65 TD); in second round – 154 (90 with average and 64 with subnormal intelligence) | + |  |  | [83] |
| Joint attention-observation schedule | **JA-OBS** | 5-10 | 30 | nurses | Sweden | English, Swedish | 0.93 | 0.86 | NDA | 0.93 | NDA | 3999 from general population | + |  |  | [84] |
| Modified-Checklist for Autism in Toddlers (Revised) | **M-CHAT (R/F)** | 5-10 | 16-30 | parents | Albania | Albanian | 0.737 | NDA | NDA | 0.895 | NDA | 2594 from general population |  | Translation only. |  | [85] |
| Argentina | Spanish | 0.76 | NDA | NDA | NDA | NDA | 420 from general population |  | New translation was completed to adapt it to the Spanish used in Argentina, making slight changes to idiomatic turns of phrases and different expressions closer to Argentine vocabulary, for example: item “plaza” (square) was changed into “parque” | Throughout the entire questionnaire, the words “hijo/hija” (son/daughter) were replaced by “nino/nina” (boy/girl), so that the questionnaire could be administered in the case of another relative taking the child to a pediatric check-up | [86] |
| Brazil | Portugese | 0.95 | 0.94 | 0.91 | 0.86 | 0.97 | 303 from general population |  | The older version of the M-CHAT test was used in the study, no data available on cultural changes | | [87] |
| Chile | Spanish | 0.89 | 1.0 | 0.98 | NDA | NDA | 120 in total (20 with suspected ASD, 100 TD) |  | Semantic changes in 15 out of 20 items, grammatical changes |  | [88] |
| China | Chinese (Mandarin) | 0.57 | 0.96 | 0.86 | 0.07 | 1.0 | 7928 from general population |  | Translation in accordance with the principles semantic and linguistic of equivalence | Adapting children's behavior to culture: for example - “vacuum the rug” and “mow lawn” are not common activities in China, so we use “wipe the table” instead. | [89] |
| Egypt | Arabic | Version of the questionnaire during the assessment of psychometric values - only preliminary results are presented | | | | | 5546 from general population |  | Translation only. |  | [90] |
| Egypt, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Tunisia, | Arabic | NDA | 0.87-0.95 | 0.76-0.89 | 0.82-0.9 | 0.86-0.93 | 228 in total (122 with ASD, 106 TD). |  | Translators added the specific dialect of some words to the classical Arabic to clarify the meaning of a number of items of the questionnaire. |  | [91] |
| France | French | NDA | 0.67 | 0.94 | 0.14 | 0.99 | 1250 from general population |  | Translation only. |  | [92] |
| Iceland | Icelandic | NDA | 0.62 | 0.99 | 0.72 | 0.99 | 1585 from general population |  | Translation with minor changes. | Minor cultural adaptation in follow-up interview – “an action figure” was specified as a “Lego or Playmobil figure” | [93] |
| Indonesia | Indonesian | NDA | 0.89 | 0.95 | 0.76 | 0.98 | 168 from general population without severe sensory and communication disability or ASD diagnosed before |  | Translation only. |  | [94] |
| Iran | Kurdish, Persian | 0.61 | 0.90 | 0.82 | 0.05 (without FUI) | NDA | 2941 from general population |  | Translation only. |  | [95] |
| Israel | Hebrew | NDA | 0.70 | 0.98 | 0.20 | 1.00 | 1591 from general population |  | In this study the original version of M-CHAT was used. | | [96] |
| Japan | Japanese | 0.56 | 0.72-0.77 | 0.84 | 0.08-0.12 | NDA | 1851 from general population; in reliability study – 24 children |  | NDA | Authors added some illustrations in order to encourage caregivers to notice negative symptoms. | [97, 98] |
| Malaysia | Chinese, English, Malay | NDA | 0.18-0.64 | 1.00 | 0.26-0.78 | 0.99 | 19297 from general population |  | Translation only. |  | [99] |
| Mexico | Spanish | 0.76 | NDA | NDA | NDA | NDA | 456 in total (117 high-risk, 339 TD) |  | Translation with minor cultural adjustments. | Describing the “peek-a-boo” game (Mexican parents do not have a specific name for it). | [100] |
| Nepal (Bhutan/USA) | Nepali | The study aimed to demonstrate the need for further research on the cultural and linguistic adaptation of the screening questionnaires and the simplification of the wording used in | | | | | 13 pediatric Nepali refugee patients living formerly in Bhutan (from general population) |  | Translation only. |  | [101] |
| Netherlands | Dutch | NDA | NDA | NDA | 0.01-0.1 | >0.98 | 12102 from general population |  | Translation only. |  | [75] |
| Norway | Norwegian | NDA | 0.34 | 0.93 | 0.02 | NDA | 52026 from general population |  | Translation only. |  | [102] |
| Serbia | Serbian | 0.91 | NDA | NDA | NDA | NDA | 148 in total (128 from general population, 20 high-risk). |  | Slight adaptation of wording was required due to languages differences. |  | [103] |
| Spain | Spanish | 0.59 (without FUI), 0.62 (with FUI) | 0.79 | 0.99 | 0.39 | 0.99 | 6625 from general population |  | Translation only. |  | [104] |
| South Korea | Korean | Only item factor analysis was made | NDA | NDA | NDA | NDA | 2300 from general population |  | Translation with revision of ten Korean mothers living in Sothern California. |  | [105] |
| Sri Lanka | Sinhala | NDA | 0.25 | 0.71 | 0.13 | 0.85 | 374 from general population (28 with “red flags”) |  | Translation only. |  | [106] |
| Sweden | Swedish | NDA | 0.77 | NDA | 0.92 | NDA | 3999 from general population |  | A few minor adjustments of the Swedish language were done |  | [84] |
| Taiwan | Chinese | 0.8 | 0.77-0.88 | 0.53-0.72 | 0.63-0.72 | 0.77-0.82 | 236 of ASD high-risk sample |  | Translation only. |  | [107] |
| Thailand | Thai | NDA | 0.91 | 1.0 | 0.96 | 0.99 | 841 in total (109 high-risk, 732 low-risk) |  | To increase the suitability of the M-CHAT in a Thai cultural context, authors hypothesized that a screening process that includes both a parent-completed questionnaire followed by a semi-structured interview by trained clinicians, only for cases that initially screen positive that could improve overall sensitivity, specificity, PPV and NPV. | | [108] |
| Turkey | Turkish | 0.67 | 1.0 | 0.91 | 0.09 | 1.0 | 6712 from general population |  | Translation only. |  | [109] |
| USA | English | 0.85 | 0.91 | 0.99 | 0.11 (without follow-up interview (FUI))/ 0.65 (with FUI) | 0.99 | 3793 in total (3309 low-risk, 484 high-risk) | + |  |  | [110] |
| Vietnam | Vietnamese | NDA | NDA | NDA | 0.763 | NDA | 6583 from general population |  |  |  | [111] |
| Pictorial Autism Assessment Schedule | **PAAS** | 15-20 | 18-40 | parents | Sri Lanka | Sinhala, Tamil | 0.96 | 0.89 | 0.61 | 0.78 | 0.77 | 105 in total (45 with ASD, 30 DD, 30 TD) | + |  |  | [112] |
| Quantitative Checklist for Autism in Toddlers | **Q-CHAT** | 5 | 18-24 | parents | Iran | Persian | 0.89 | 0.96 | 0.90 | NDA | NDA | 100 in total (50 TD, 50 ASD) |  | Translation only. |  | [113] |
| Italy | Italian | 0.68 | NDA | NDA | NDA | NDA | 2400 from general population |  | Translation only. |  | [114] |
| Serbia | Serbian | >0.81 | 0.96 | 0.82 | NDA | NDA | 220 in total |  | No access to the full content of the article. | | [115] |
| Singapore | English | 0.53-0.60 | NDA | NDA | NDA | NDA | 514 from general population |  | NDA |  | [116] |
| South Korea | Korean | 0.66 | NDA | NDA | NDA | NDA | 104 in total (24 ASD, 80 unselected) |  | Translation only. |  | [117] |
| United Kingdom | English | 0.67-0.83 | 0.44 | 0.98 | 0.28 | NDA | In first study – 795 in total (754 from unselected group, 41 ASD); in second study 3770 from general population | + |  |  | [118, 119] |
| Quantitative Checklist for Autism in Toddlers – 10-items | **Q-CHAT-10** | <5 | 18-24 | parents | Chile | Spanish | 0.85 | 0.93 | 0.77 | 0.48 | NDA | 287 in total (125 TD, 149 DD, 13 ASD) |  | Translation only. |  | [120] |
| Serbia | Serbian | >0.81 | 0.39 | 0.99 | 1.00 | 1.00 | 220 total |  | No access to the full content of the article. | | [115] |
| United Kingdom | English | 0.88 | 0.91 | 0.89 | 0.58 | NDA | 880 in total (754 control, 162 ASD) | + |  |  | [121] |
| Rapid Interactive Screening Test for Autism in Toddlers | **RITA-T** | 10 | 18-36 | doctors | Lebanon | Arabic | 0.91 | 0.96 | 1.00 | 1.00 | 0.96 | 48 in total (19 TD, 29 high-risk) |  | Translation only. |  | [122] |
| USA | English | NDA | 1.00 | 0.84 | 0.88 | NDA | 61 in total (23 ASD, 19 DD/non-ASD, 19 TD) | + |  |  | [123, 124] |
| Social Attention and Communication Study | **SACS** | 5 | 12-24 | nurses and other health professionals | Australia | English | 0.88 | 0.84 | 0.99 | NDA | NDA | First study - 20770 from general population, second study – 99 identified as “at risk” in first study | + |  |  | [125, 126] |
| China | Chinese | NDA | 0.53 | 1.00 | 0.42 | 1.00 | 10514 from general population |  | Translated and evaluated with English version to be comparable in meaning. |  | [127] |
| Screen for Social Interaction | **SSI** | 15 | 24-61 | parents or caregivers | USA | English | 0.756 | 0.58-0.94; 0.87-0.81 | 0.61-0.87; 0.70-0.71 | NDA | NDA | In first study – 111 in total (51 high-risk and 60 low-risk), in second study – 350 (168 from general population, 182 high-risk) | + |  |  | [128, 129] |
| Screening Tool for Autism in Two-Year-Olds | **STAT (T-STAT in Taiwan)** | 20 | 24 (12-24)  (18-24 in T-STAT) | examiner | Taiwan | Chinese | 0.90 | 0.93 | 0.74 | 0.94 | 0.97 | 107 in total; in first stage - 15 with ASD and 15 with DD or LI; in second – 77 with ASD, PDD-NOS or DD/LI. |  | Two items of the questionnaire were changed. | The toy that is shown to the child has been changed (from a dog to an elephant). | [130] |
| USA | English | 1.00 | 1.00 (0.95 for children <24 months) | 0.85 (0.73 for children <24 months) | 0.86 (0.56 for children <24 months) | 0.92 (0.97 for children <24 months) | In first research -104 in total (50 with ASD, 15 with PDD-NOS and 39 with DD/LI).  In second research – 77 with older sibling with ASD or had been referred for evaluation for concerns about ASD | + |  |  | [131, 132] |
| Three‐Item Direct Observation Screen | **TIDOS** | 15-20 | 18-60 | trained pediatric-oriented professionals | Turkey | Turkish | NDA | 0.8 | 0.74 | 0.6 | 0.87 | 259 in total (86 with ASD, 76 with DD without ASD, 97 with typical development) | + |  |  | [133] |
| Young autism and other developmental disorders checkup tool | **YACHT-18** | 10 | 18 | nurses | Japan | Japanese | NDA | 0.80 | 0.863 | NDA | NDA | 2814 from general population, without any recognized disease or disorder | + |  |  | [134] |

DD – development delay, LI – language impairment, NDA – no data available, NDDs – other neuro-developmental disorders, PDD-NOS - pervasive developmental disorder not otherwise specified, TD – typical development.