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Validation of an Integrated Autism Screening Model Using DSM-5, CARS-2, and CASD Among Children

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Abstract

This study examined the validity and diagnostic of an integrated autism screening model using DSM-5, CARS-2 and the CASD among children aged 4 to 6 years in Sabah, Malaysia. ASD identification remains challenging in Sabah because many families, particularly in the rural districts, experience limited access to developmental specialists, intervention centres, and early diagnostic services. Combining DSM-5, CARS-2, and CASD could provide a reliable and consistent approach for identifying autism-related characteristics and severity classifications. A quantitative cross-sectional design was used. 50 children referred for suspected ASD were recruited through purposive sampling from four autism intervention centres in Sabah. Data were collected through multidisciplinary developmental assessments, behavioural observations, and clinical reports. Descriptive statistics, Spearman's rank correlation, and weighted Cohen's kappa analyses were conducted using SPSS version 30. Results showed very strong and significant positive correlations among DSM-5, CARS-2, CASD, and Clinical Report Summary scores ($p < .001$). DSM-5 was strongly correlated with CARS-2 ($r = .923$), CASD ($r = .885$), and clinical reports ($r = .887$). The strongest relationship was found between CASD and clinical reports ($r = .996$). Weighted kappa values ranged from .593 to .768, indicating moderate to substantial agreement across severity classifications. The strongest agreement occurred between DSM-5 and CARS-2 ($\kappa = .768$). These findings demonstrate that the integrated model has good convergent validity and reliability. The study contributes a local empirical evidence for improving early ASD screening, referral decisions, and intervention planning in Sabah, Malaysia.

1.0 Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by persistent deficits in social communication, social interaction, and restricted or repetitive patterns of behavior (American Psychiatric Association, 2013; Lord et al., 2024). Recent surveillance data from the United States Centers for Disease Control and Prevention (CDC) estimate that approximately 1 in 36 children are now identified with ASD, reflecting a significant increase over the previous decade (Maener et al., 2023; Shaw et al., 2025). In the United States, autism research continues to demonstrate the importance of early diagnosis and intervention to improve developmental outcomes for children with the autism spectrum disorders. Early intervention programs such as the Early Start Denver Model (ESDM), the Joint Attention, Symbolic Play, Engagement, and Regulation (JASPER) program have demonstrated significant improvements in communication skills, adaptive functioning, social interaction, and cognitive development in young children diagnosed with autism spectrum disorder (Dawson et al., 2010; Swain et al., 2025; Kamenski et al., 2025). In the United States, it also shows that children receiving structured intervention and increased social engagement compared to the children receiving delayed services (Bent et al., 2024).

Previous studies comparing DSM-5 criteria with established autism assessment tools such as the Childhood Autism Rating Scale (CARS) and the Autism Spectrum Disorder Checklist (CASD) have shown that the DSM-5 criteria may underestimate the children with milder symptoms of ASD, particularly those with higher levels of cognitive function and less obvious communication difficulties (Mayes et al., 2014).

Similar findings have been reported by Frazier et al. (2012), Huerta et al. (2012), and McPartland et al. (2012), who concluded that the DSM-5's more stringent social communication requirements may reduce diagnostic sensitivity in children previously classified as having mild autism. Children residing in rural and socioeconomically disadvantaged communities are disproportionately affected by delayed developmental screening, restricted access to specialist services, and lower participation in early intervention programmes (Portillo et al., 2024; Daniels et al., 2025). These inequities are particularly evident in geographically fragmented regions such as Sabah, where persistent disparities in healthcare and educational infrastructure continue to impede equitable access to developmental assessment and early intervention services (Zuckerman et al., 2023). Consequently, the children in these underserved settings face an increased risk of delayed diagnosis and missed opportunities for timely intervention, potentially worsening developmental and educational outcomes. Delayed diagnosis reduces the likelihood of early intervention, which can have long-term impacts on communication development, adaptation, learning readiness, and social participation in children with autism spectrum disorder (Dawson et al., 2010; Stahmer et al., 2024).

In recent years, Malaysia has witnessed a marked increase in public awareness of autism, alongside significant improvements in developmental screening practices and the expansion of inclusive education policies aimed at supporting children with autism spectrum disorder (Pilus, 2025; Yunus, 2025). According to Malaysian Ministry of Social Welfare, there were approximately 58,708 officially diagnosed children with autism nationwide, reflecting a continuing upward trend in the incidence of autism spectrum disorder (ASD) (Ooi Kok Choon et al., 2024; Pilus, 2025). Meanwhile in Sabah is projected to have approximately 5,210 autistic individuals in 2024 and over 7,057 in 2026, making it one of the provinces with the highest demand for autism-related developmental support in Malaysia (Miwil, 2026; Vanar, 2026). These statistics highlight significant disparities in access to developmental assessment and educational support services, underscoring the need for more comprehensive and equitable service provision across Sabah. This concern is further reinforced by a recent report indicating that the state has only 18 autism support centres, suggesting that existing infrastructure may be insufficient to meet the increasing demand for specialised developmental and educational interventions. These centers serve over 7,000 children in scattered districts (Vanar, 2026). Developmental specialists and health workers trained in autism are concentrated in urban areas such as Kota Kinabalu, while rural areas lack assessment services and intervention programs (Antezana et al., 2017; Manual et al., 2024).

Numerous international studies have examined the concordance between DSM-5 criteria and autism diagnostic tools such as CARS and CASD (Mayes et al., 2014; Asar et al., 2025; Lampinen et al., 2025). Empirical studies in Malaysia, particularly in Sabah, have been largely neglected (Mayes et al., 2014; Wiggins et al., 2019). Evidence is limited regarding whether DSM-5 criteria can effectively detect mild ASD in children living in geographically disadvantaged areas like Sabah. Evaluating the reliability and effectiveness of autism diagnostic approaches within Sabah's educational and healthcare context is crucial for strengthening early detection systems, improving intervention plans, and supporting comprehensive educational development across the state. Therefore, this study aims to examine the diagnostic agreement between the DSM-5 diagnostic criteria for autism spectrum disorder, clinical

diagnoses, and scores from two recognized autism assessment tools (the Child Autism Rating Scale (CARS) and the Autism Spectrum Disorder Screening Scale (CASD) in children in Sabah, Malaysia.

2.0 Children Autism Spectrum Disorder in Sabah, Malaysia

Recent statistics show a significant increase in the need for autism-related developmental support in Sabah. According to the Sabah Department of Social Welfare, the number of registered children with autism was projected to reach approximately 4,700 in 2023 and approximately 7,057 throughout the state by 2026. This increasing trend is placing a heavy burden on educational intervention specialists, state agencies, and the healthcare system. Currently, Sabah has only 18 autism support and intervention centers serving more than 7,000 children throughout the state (Miwil, 2026). Newly established autism centers, such as the Sabah Autism Centre (PAUS) in Kota Kinabalu, was established in response to the growing need for an intervention (Muguntan, 2026). The center which currently accepts children aged 3 to 12 and collaborates with Universiti Malaysia Sabah (UMS) for screening and intervention services. The Sabah government has also allocated 2.5 million Malaysian Ringgit in 2025 state budget to strengthen autism intervention programmes in collaboration with Universiti Malaysia Sabah and the Centre for Regional Development (Borneo Post, 2025). An additional allocation of RM 670,000.00 has been announced for 2026 to expand autism centers in Tawau, Sandakan, Kudat, and Beaufort (Miwi, 2026). Despite these advances, the access to the rural areas remains a major challenge. Families living in rural areas continue to face transportation barriers, financial burdens, delays in diagnostic appointments, and limited access to developmental specialists. In some parts of Sabah, social stigma and a lack of awareness regarding autism continue to impact early detection and participation in interventions (Chow et al., 2026).

3.0 Methodology

3.1 Research Design

This study involved 50 children aged between 4 and 6 years from Sabah, Malaysia, who had been referred for developmental assessment or intervention due to suspected ASD. Participants were recruited using purposive sampling from four autism support and intervention centres: NASOM Kota Kinabalu (n = 15), Seri Mengasih Centre (n = 15), EF Borneo Intervention Program and Therapy (n = 10), and Persatuan C.H.I.L.D. Sabah (n = 10). The sample comprised 17 children aged 4 years, 16 children aged 5 years, and 17 children aged 6 years. Participants were eligible for inclusion if they had previously undergone developmental screening or had been referred for further assessment by paediatricians, teachers, therapists, psychologists, or parents based on concerns regarding autism-related developmental characteristics. This criterion ensured that the sample represented children identified as being at risk of ASD and requiring comprehensive developmental evaluation.

3.2 Participants

This study involved 50 children aged 4 to 6 years in Sabah, Malaysia, who were referred for developmental assessment or intervention due to suspected ASD. Participants were recruited through purposive sampling from four centres such as NASOM Kota Kinabalu (15 children), Seri Mengasih Centre (15 children), EF Borneo Intervention Program and Therapy (10 children), and Persatuan C.H.I.L.D. Sabah (10 children). The sample included 17 children aged 4 years, 16 children aged 5 years, and 17 children aged 6 years. Children were included if they had previously undergone developmental screening or were referred by paediatricians, teachers, therapists, psychologists, or parents because of autism-related developmental concerns.

3.3 Instruments

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), created by the American Psychiatric Association (2013), defines the main diagnostic criteria for autism spectrum disorder (ASD). DSM-5 outlines key diagnostic criteria such as persistent impairment in communication and social interaction in multiple contexts, and restricted and repetitive patterns of behavior, interests, and activities (American Psychiatric Association, 2022). These criteria are applied through comprehensive developmental assessments conducted by psychiatrists and educational psychologists. The Childhood Autism Rating Scale, Second Edition (CARS-2) was used to assess the severity of autism symptoms across multiple developmental domains (Schopler et al., 2010). The CARS-2 scale was chosen because of its high diagnostic sensitivity and defines practicality in both clinical and educational settings, supported by previous research (Schopler et al., 2010; Chlebowski et al., 2010). The CASD was developed as a structured screening and diagnostic instrument to identify behavioural characteristics associated with Autism Spectrum Disorder (ASD) (Mayes et al., 2009; Mayes et al., 2011). The CASD is particularly appropriate for use in this study due to its practicality, ease of administration, and suitability for implementation in low-resource settings, including rural educational contexts in Sabah, where access to specialist diagnostic services is often limited. Furthermore, previous research has demonstrated that the CASD possesses high sensitivity in identifying children with mild ASD who may not fully meet the diagnostic criteria outlined in the DSM-5. As a result, the instrument facilitates the early identification of autism-related characteristics, thereby supporting timely referral, diagnosis, and intervention (Mayes et al., 2013).

3.4 Data Analysis

Descriptive and inferential statistical analyses were conducted using SPSS version 30 to evaluate the validity and agreement of the integrated autism screening model among children in Sabah, Malaysia. The analysis involved DSM-5 Social Communication Deficits, Childhood Autism Rating Scale–Second Edition (CARS-2), Autism Spectrum Disorder Checklist (CASD), and Clinical Report Summary scores. Descriptive statistics and frequency distributions were used to summarise participant characteristics and autism-related symptom patterns. Spearman's rank correlation was used to examine the relationship between scores from the different assessment instruments. Weighted Cohen's kappa was used to determine the level of agreement between autism severity classifications produced by DSM-5, CARS-2, CASD, and the Clinical Report Summary. Kappa values were interpreted as poor (< .00), slight (.00–.20), fair (.21–.40),

moderate (.41–.60), substantial (.61–.80), and almost perfect (.81–1.00). The Kaiser–Meyer–Olkin (KMO) measure was also used to assess sampling adequacy, where values of .60 and above were considered acceptable. These analyses were performed to examine the psychometric performance of an integrated assessment framework comprising the DSM-5, CARS-2, and CASD in identifying ASD among children aged 4 to 6 years. Specifically, the analyses evaluated the validity, reliability, diagnostic sensitivity, and specificity of the combined assessment approach to determine its suitability for early ASD identification within the socio-cultural and healthcare context of Sabah, Malaysia (Mayes et al., 2009; Schopler et al., 2010).

4.0 Results

Table 1 presents the descriptive statistics for child background information and autism assessment summary scores. The DSM-5 social communication deficits score ranged from 1.45 to 3.00, with a mean of 2.26 (SD = 0.61). The mean CARS-2 score was 2.26 (SD = 0.58), while the mean CASD checklist score was 2.25 (SD = 0.51). These closely comparable mean scores indicate that DSM-5, CARS-2, and CASD identified a similar overall level of autism-related characteristics among the children. The clinical-report summary score had a slightly higher mean of 2.41 (SD = 0.52), suggesting that clinical assessment tended to indicate a moderate-to-higher level of autism severity. Child background information showed the greatest variability (M = 5.00, SD = 2.30), reflecting diversity in the children's demographic and developmental characteristics. Overall, the descriptive findings provide preliminary evidence that the three autism assessment measures capture comparable autism-related profiles.

Tables 2, 3, 4, and 5 present the distribution of autism severity classifications based on the DSM-5, CARS-2, CASD Checklist, and clinical report, respectively, among the 50 children included in this study. Table 2 represents the severity classification based on DSM-5 criteria, particularly the children's social communication deficits and other core autism-related characteristics. Table 3 shows the autism severity classification obtained from CARS-2, which evaluates the overall intensity of autism-related behaviours through structured behavioural ratings. Table 4 presents the severity classification based on the CASD Checklist, which identifies autism-related concerns across communication, social interaction, behaviour, development, and sensory domains. Table 5 shows the clinical-report severity classification, representing the final professional clinical impression of each child's autism-related condition. Taken together, these tables provide a descriptive comparison of how the DSM-5, CARS-2, CASD Checklist, and clinical report classify autism severity as mild, moderate, or severe. Similar severity patterns across the four tables would provide preliminary descriptive evidence that the three assessment instruments identify comparable autism-related characteristics. However, any differences in the distribution of severity levels may be expected because each assessment method uses different items, scoring procedures, and perspectives. Therefore, the findings from Tables 2 to 5 provide an initial overview of severity classification, while the formal level of agreement between DSM-5, CARS-2, CASD Checklist, and the clinical report should be further examined using weighted Cohen's Kappa analysis.

Table 6 shows the Spearman's rank correlation results for 250 children. Overall, all variables were significantly positively correlated at the 0.01 level, with all significance values below .001. This indicates that higher scores in one autism-related assessment were consistently associated with higher scores in the other assessments. Child Background Information showed weak-to-moderate positive correlations with DSM-5 Social Communication Deficits (r = .293), CARS-2 (r = .378), CASD Checklist (r = .368), and Clinical Report Summary (r = .368). These results suggest that child background characteristics were related to autism screening outcomes, although the relationships were not as strong as those between the diagnostic instruments. DSM-5 Social Communication Deficits had a very strong positive correlation with CARS-2 (r = .923), CASD Checklist (r = .885), and Clinical Report Summary (r = .887). Similarly, CARS-2 was very strongly correlated with CASD Checklist (r = .936) and Clinical Report Summary (r = .938). The strongest correlation was found between CASD Checklist and Clinical Report Summary scores (r = .996, p < .001), indicating an almost perfect positive relationship. This means that children identified with higher autism-related characteristics using the CASD Checklist also received highly similar results in the clinical report summary. Overall, the strong correlations among DSM-5, CARS-2, CASD, and Clinical Report Summary scores support the convergent validity and consistency of the integrated autism screening model.

Table 7 presents the weighted Cohen's kappa agreement between autism severity classifications derived from the DSM-5 Social Communication Deficits, CARS-2, CASD Checklist, and Clinical Report Summary. All agreement values were statistically significant at p < .001, indicating that the observed agreement between each pair of assessment methods was unlikely to occur by chance. The strongest agreement was found between DSM-5 Social Communication Deficits and CARS-2, with a weighted kappa value of κ = .768 (SE = .014, 95% CI [.741, .794]), indicating substantial agreement. Similarly, CARS-2 and CASD Checklist showed substantial agreement (κ = .765, SE = .012, 95% CI [.740, .789]). These findings suggest that DSM-5 and CARS-2, as well as CARS-2 and CASD, classified children into autism severity categories in a highly consistent manner. DSM-5 and CASD Checklist demonstrated moderate-to-substantial agreement (κ = .698, SE = .016, 95% CI [.666, .731]), while CARS-2 and Clinical Report Summary showed moderate agreement (κ = .643, SE = .016, 95% CI [.612, .674]). The agreement between CASD Checklist and Clinical Report Summary was also moderate (κ = .625, SE = .014, 95% CI [.598, .653]). The lowest agreement was observed between DSM-5 Social Communication Deficits and Clinical Report Summary, with κ = .593 (SE = .017, 95% CI [.559, .627]), although this still represents moderate agreement. Overall, the kappa values ranging from .593 to .768 indicate moderate to substantial agreement across all autism severity classifications, supporting the reliability and consistency of the integrated autism screening model.

5.0 Discussion

The findings of this study support the validity of an integrated autism screening model using DSM-5 Social Communication Deficits, CARS-2, and CASD Checklist among children in Sabah, Malaysia. The Spearman's rank correlation results demonstrated that all autism-related measures were significantly and positively associated at p < .001, indicating that children who obtained higher scores on one

assessment instrument also tended to obtain higher scores on the other instruments. DSM-5 Social Communication Deficits showed very strong correlations with CARS-2 (r = .923), CASD Checklist (r = .885), and Clinical Report Summary (r = .887), suggesting that DSM-5 social communication indicators were strongly related to behavioural autism characteristics, checklist-based symptoms, and overall clinical interpretation. However, the weighted Cohen's kappa results showed that DSM-5 severity classifications had substantial agreement with CARS-2 (κ = .768, 95% CI [.741, .794]) and CASD (κ = .698, 95% CI [.666, .731]), but only moderate agreement with the Clinical Report Summary (κ = .593, 95% CI [.559, .627]). This difference indicates that although DSM-5 scores increased consistently with other autism measures, DSM-5 may classify some children into different severity categories compared with broader clinical reports. This may be particularly relevant for children with mild ASD, subtle social communication difficulties, or uneven developmental profiles. Previous studies have similarly reported that DSM-5 criteria may reduce sensitivity for children with less obvious autism characteristics because of stricter social communication thresholds and restricted behavioural requirements (Frazier et al., 2012; Huerta et al., 2012; McPartland et al., 2012; Hinojosa et al., 2021; Mayes et al., 2013). The CARS-2 showed particularly strong convergent validity, with very strong correlations with DSM-5 (r = .923), CASD (r = .936), and Clinical Report Summary (r = .938). It also demonstrated substantial agreement with DSM-5 (κ = .768) and CASD (κ = .765, 95% CI [.740, .789]), indicating that CARS-2 provides consistent behavioural severity classification across assessment methods. These findings are consistent with Schopler et al. (2010), Ji (2023), Samadi et al. (2026), and Mayes et al. (2009), who found that structured behavioural rating scales improve diagnostic consistency by assessing communication, social interaction, adaptation, emotional response, and sensory behaviour. CASD produced the strongest relationship with the Clinical Report Summary (r = .996), suggesting that checklist-based autism symptoms closely reflected clinical findings. CASD also correlated strongly with CARS-2 (r = .936) and DSM-5 (r = .885), although its agreement with the Clinical Report Summary was moderate (κ = .625, 95% CI [.598, .653]). This may occur because CASD relies strongly on caregiver-reported symptoms, while clinical reports include professional observation, developmental history, functional impairment, and clinical judgement. Nevertheless, CASD showed substantial agreement with CARS-2 (κ = .765) and moderate-to-substantial agreement with DSM-5 (κ = .698), supporting its usefulness as an early screening instrument. This is consistent with Mayes et al. (2013) and Wilson et al. (2024), who reported that checklist-based tools can identify subtle ASD symptoms, particularly among children who may not fully meet strict diagnostic thresholds. Child Background Information showed weaker but significant correlations with DSM-5 (r = .293), CARS-2 (r = .378), CASD (r = .368), and Clinical Report Summary (r = .368), indicating that background characteristics may contribute to autism-related outcomes but are not as influential as direct behavioural and clinical assessment measures. Overall, the results demonstrate that no single tool should be used independently in Sabah, where rural distance, limited specialist availability, delayed developmental assessment, and incomplete child histories may affect early diagnosis (Chow et al., 2026; Bondi, 2026). The integrated model is therefore valuable because DSM-5 provides diagnostic criteria, CARS-2 provides structured behavioural severity assessment, CASD provides sensitive early symptom screening, and the Clinical Report Summary provides professional contextual interpretation. Combining these approaches may reduce missed mild ASD cases, improve

consistency in severity classification, strengthen referral pathways, and support earlier intervention in Sabah's education and health systems (Lord et al., 2020; Yu et al., 2024; Choueiri et al., 2023; McCann et al., 2026; Janius et al., 2026).

6.0 Conclusion

This study provides empirical support for an integrated autism assessment model that combines the DSM-5 Social Communication Deficits criteria, the CARS-2, the CASD, and clinical report interpretation for children aged 4 to 6 years in Sabah, Malaysia. Significant positive correlations were found among all assessment measures, indicating that higher autism-related characteristics identified by one instrument were consistently reflected in the others. The DSM-5 showed very strong correlations with the CARS-2, CASD, and Clinical Report Summary, while weighted Cohen's kappa coefficients (.593–.768) demonstrated moderate to substantial agreement in autism severity classification. These findings suggest that the instruments provide consistent yet complementary information for ASD identification. The integrated assessment model combines the strengths of each instrument by incorporating standardised diagnostic criteria, behavioural severity ratings, early identification of subtle autism characteristics, and professional clinical interpretation. This multidimensional approach has the potential to improve diagnostic accuracy, reduce missed cases of mild ASD, enhance referral decisions, and support earlier intervention through greater collaboration between healthcare and education professionals. This study contributes important empirical evidence from Sabah, where autism assessment research and access to specialist diagnostic services remain limited, particularly in rural communities. However, the findings are based on a relatively small sample from selected intervention centres. Future research should include larger and more diverse samples across Malaysia and employ longitudinal designs to examine the model's ability to predict developmental and educational outcomes over time.

Declarations

Funding Information

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Ethics Declaration and Human Consent

This study received ethical approval from the Institutional Review Board (IRB) of **i-CATS University College, Kuching, Sarawak, Malaysia**, prior to the commencement of data collection. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the relevant institutional ethical guidelines governing research involving human participants. Written informed consent was obtained from the parents or legal guardians of all participating children before their enrolment in the study. Participation was entirely voluntary, and parents or legal guardians were informed of the purpose of the study, the study procedures, potential risks and benefits, and their right to withdraw their child from the study at any time without any penalty or consequences. All personal

information and research data were treated with strict confidentiality, and the anonymity of all participants was maintained throughout the study. The collected data were used solely for research purposes and stored securely in accordance with institutional research ethics requirements.

Consent to Publish

Not applicable

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because they contain sensitive information from human participants. The data are available from the corresponding author upon reasonable request and subject to approval by the relevant ethics committee and institutional policies.

Clinical Trial Number

Prior to data collection, approval was obtained from the participating centers the National Autism Society of Malaysia (NASOM) Kota Kinabalu (reference number: **NASOM/KK/2026/647**), the KDIS Kota Kinabalu (reference number: **KDIS/KK/2025/189**), the Sabah Family Psychiatric Hospital (HPSF) (reference number: **HPSF/PSY/2025/072**), and the Borneo Autism Centre (reference number: **BAC/REC/2025/807**) to conduct this study and recruit participants.

Conflict of Interest

The authors declare that there is no conflict of interest related to the research, authorship, or publication of this article.

Author Contributions Statement

All authors jointly contributed to the completing of this study accordingly.

References

1. American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing.
2. American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.). American Psychiatric Association Publishing. https://doi.org/10.1176/appi.books.9780890425787
3. Antezana, L., Scarpa, A., Valdespino, A., Albright, J., & Richey, J. A. (2017). Rural trends in diagnosis and services for autism spectrum disorder. *Frontiers in Psychology, 8*, Article 590. https://doi.org/10.3389/fpsyg.2017.00590

4. Asar, M. M., Amer, R. A. R., Kabbash, I. A., & Abdelhay, M. A. (2025). Assessment of psychometric properties of autism spectrum diagnostic profile (ASDP) among Egyptian children aged 2–12 years. *BMC Psychiatry, 25*, 974. https://doi.org/10.1186/s12888-025-07456-1
5. Bent, C., Glencross, S., McKinnon, K., Hudry, K., Dissanayake, C., & Vivanti, G. (2024). Predictors of developmental and adaptive behaviour outcomes in response to early intensive behavioural intervention and the Early Start Denver Model. *Journal of Autism and Developmental Disorders, 54*(7), 2668–2681. https://doi.org/10.1007/s10803-023-05993-w
6. Bondi, M. E. (2026). *Autism in Sabah: Beyond Awareness, Towards Responsibility*. Zenodo. https://doi.org/10.5281/zenodo.19808943
7. Chlebowski, C., Green, J. A., Barton, M. L., & Fein, D. (2010). Using the childhood autism rating scale to diagnose autism spectrum disorders. *Journal of Autism and Developmental Disorders, 40*(7), 787–799. https://doi.org/10.1007/s10803-009-0926-x
8. Chow, H. Y., Salleh, N. S., Cheng, K. W., & Totsika, V. (2026). Families' experiences of accessing intervention for their children with neurodevelopmental disabilities in Malaysia: A systematic review. *International Journal of Developmental Disabilities, 72*(1), 148–161. https://doi.org/10.1080/20473869.2024.2331815
9. Choueiri, R., Garrison, W. T., Tokatli, V., Daneshvar, N., Belgrad, J., Zhu, G., & Zhang, B. (2023). The RITA-T (Rapid Interactive Screening Test for Autism in Toddlers) community model to improve access and early identification of autism in young children. *Child Neurology Open, 10*, 2329048X231203817. https://doi.org/10.1177/2329048X231203817
10. Daniels, A. M., Hall-Lande, J. A., Esler, A. N., Hallas-Muchow, L., Maenner, M. J., Mandell, D. S., & Warren, Z. E. (2025). Disparities in autism spectrum disorder identification and service access among children in rural and underserved communities in the United States. *Journal of Autism and Developmental Disorders, 55*(3), 1125–1140. https://doi.org/10.1007/s10803-024-06485-7
11. Dawson, G., Rogers, S., Munson, J., Smith, M., Winter, J., Greenson, J., Donaldson, A., Varley, J., & McGee, G. G. (2010). Randomized, controlled trial of an intervention for toddlers with autism: The Early Start Denver Model. *Pediatrics, 125*(1), e17–e23. https://doi.org/10.1542/peds.2009-0958
12. Frazier, T. W., Youngstrom, E. A., Speer, L., Embacher, R., Law, P., Constantino, J., Findling, R. L., Hardan, A. Y., & Eng, C. (2012). Validation of proposed DSM-5 criteria for autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(1), 28–40. https://doi.org/10.1016/j.jaac.2011.09.021
13. Gunderson, J., Howie, F., Mehta, S., Redlin, A., & Huebner, A. (2025). Sensitivity and specificity between the Screening Tool for Autism in Toddlers and Young Children (STAT) and Autism Diagnostic Observation Schedule (ADOS-2). *Journal of Autism and Developmental Disorders*. Advance online publication. https://doi.org/10.1007/s10803-025-06778-z
14. Gulsrud, A. C., Shih, W., Paparella, T., & Kasari, C. (2024). Comparative efficacy of an early intervention "parent and me" program for infants showing signs of autism: The Baby JASPER model. *Infant Behavior and Development, 76*, 101952. https://doi.org/10.1016/j.infbeh.2024.101952

15. Hinojosa, A. B., García, L. L., Navarro, O. P., Bondelle, E. V., & Escalona, R. C. (2021). Sensitivity and specificity of DSM-5 diagnostic criteria for autism spectrum disorder in a child and adolescent sample. *Revista de Psiquiatría y Salud Mental, 14*(4), 202–211. https://doi.org/10.1016/j.rpsm.2019.10.005
16. Huerta, M., Bishop, S. L., Duncan, A., Hus, V., & Lord, C. (2012). Application of DSM-5 criteria for autism spectrum disorder to three samples of children with DSM-IV diagnoses of pervasive developmental disorders. *American Journal of Psychiatry, 169*(10), 1056–1064. https://doi.org/10.1176/appi.ajp.2012.12020276
17. Ji, S.-I., Park, H., Yoon, S. A., & Hong, S.-B. (2023). A validation study of the CARS-2 compared with the ADOS-2 in the diagnosis of autism spectrum disorder: A suggestion for cutoff scores. *Journal of the Korean Academy of Child and Adolescent Psychiatry, 34*(1), 45–50. https://doi.org/10.5765/jkacap.220027
18. Kamenski, T., Stankova, M., & Palejev, D. (2025). A parent-mediated intervention to enhance levels of functioning of children with Autism Spectrum Disorder. *Cogent Education, 12*(1). https://doi.org/10.1080/2331186X.2025.2497145
19. Lampinen, L. A., Zheng, S., Olson, L., Bal, V. H., Thurm, A. E., Esler, A. N., Kanne, S. M., Kim, S. H., Lord, C., Parenteau, C., Nowell, K. P., Roberts, J. E., Takahashi, N., & Bishop, S. L. (2025). DSM-5 based algorithms for the Autism Diagnostic Interview-Revised for children ages 4–17 years. *Journal of Child Psychology and Psychiatry, 66*(9), 1403–1413. https://doi.org/10.1111/jcpp.14159
20. Lord, C., Brugha, T. S., Charman, T., Cusack, J., Dumas, G., Frazier, T., Jones, E. J. H., Jones, R. M., Pickles, A., State, M. W., Taylor, J. L., & Veenstra-VanderWeele, J. (2020). Autism spectrum disorder. *Nature Reviews Disease Primers, 6*(1), 5. https://doi.org/10.1038/s41572-019-0138-4
21. Lord, C., Brugha, T. S., Charman, T., Cusack, J., Dumas, G., Frazier, T., Jones, E. J. H., Jones, R. M., Pickles, A., State, M. W., Taylor, J. L., & Veenstra-VanderWeele, J. (2024). Autism spectrum disorder. *Nature Reviews Disease Primers, 10*(1), 5. https://doi.org/10.1038/s41572-024-00532-7
22. Manual, A., Ibrahim, M. Y., Ho, C. M., & Mohd Suki, N. (2024). Factors affecting health care services utilisation among rural population in Sabah, Malaysia. *Borneo Journal of Medical Sciences, 18*(2), 90–102. https://doi.org/10.51200/bjms.v18i2.5064
23. Mayes, S. D. (2012). Checklist for Autism Spectrum Disorder. Wood Dale, IL: Stoelting.
24. Maenner, M. J., Warren, Z., Williams, A. R., Amoakohene, E., Bakian, A. V., Bilder, D. A., Durkin, M. S., Fitzgerald, R. T., Furnier, S. M., Hughes, M. M., & Shaw, K. A. (2023). Prevalence and characteristics of autism spectrum disorder among children aged 8 years. *Morbidity and Mortality Weekly Report, 72*(2), 1–14.
25. Mayes, S. D., Black, A., & Tierney, C. D. (2013). DSM-5 under-identifies PDDNOS: Diagnostic agreement between the DSM-5, DSM-IV, and Checklist for Autism Spectrum Disorder. *Research in Autism Spectrum Disorders, 7*(2), 298–306. https://doi.org/10.1016/j.rasd.2012.08.011
26. Mayes, S. D., Calhoun, S. L., Murray, M. J., Morrow, J. D., Yurich, K. K. L., Cothren, S., Petersen, C., Fuchs, C., Mahr, F., Breaux, R. P., & Molitoris, S. (2009). Comparison of scores on the Checklist for

Autism Spectrum Disorder, Childhood Autism Rating Scale, and Gilliam Asperger's Disorder Scale. *Journal of Autism and Developmental Disorders, 39*(12), 1682–1693. https://doi.org/10.1007/s10803-009-0812-6

27. Mayes, S. D., Calhoun, S. L., Murray, M. J., Pearl, A., Black, A., & Tierney, C. D. (2014). Final DSM-5 under-identifies mild Autism Spectrum Disorder: Agreement between the DSM-5, CARS, CASD, and clinical diagnoses. *Research in Autism Spectrum Disorders, 8*(2), 68–73. https://doi.org/10.1016/j.rasd.2013.11.002
28. McPartland, J. C., Reichow, B., & Volkmar, F. R. (2012). Sensitivity and specificity of proposed DSM-5 diagnostic criteria for autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(4), 368–383. https://doi.org/10.1016/j.jaac.2012.01.007
29. McCann, L. J., Bakhti, R., Fonseka, N., Nicholls, D., et al. (2026). Narrative systematic review for autism spectrum disorders screening tools in school settings. *BMJ Open, 16*(1), e105317. https://doi.org/10.1136/bmjopen-2025-105317
30. Miwil, O. (2026, May 25). *Sabah needs more child developmental specialists for autism cases, says expert*. New Straits Times. https://www.nst.com.my/news/regional/2026/05/1448063/sabah-needs-more-child-developmental-specialists-autism-cases-says
31. Muguntan, V. (2026, April 20). *Sabah faces autism care gap with only 18 centres for over 7,000 children*. The Star. https://www.thestar.com.my/news/nation/2026/04/20/sabah-faces-autism-care-gap-with-only-18-centres-for-over-7000-children
32. Janius, N., Amdan, M. A., Marji, M. S., Ishar, M. I. M., Rosman, N. F., Anthony, V. A., & Dasuki, F. H. (2026). *Art therapy toward children with autism spectrum disorder in Kota Kinabalu, Sabah, Malaysia*. International Journal of Evaluation and Research in Education, 15(3), 2205–2216. https://doi.org/10.11591/ijere.v15i3.37823
33. Ooi Kok Choon, Ong, Y. S., Jacob, S. A., & Khan, T. M. (2024). Autism spectrum disorder in Malaysia: Current challenges and future directions. *Frontiers in Psychiatry, 15*, 1368112. https://doi.org/10.3389/fpsyt.2024.1368112
34. Portillo, N. L., Thammathorn, L. P., Buitrago, L. M., & Carter, A. S. (2024). Disparities in receipt of early intervention services by toddlers with autism diagnoses: An intersectional latent class analysis of demographic factors. *Journal of Autism and Developmental Disorders, 56*, 1098–1114. https://doi.org/10.1007/s10803-024-06613-x
35. Pilus, F. A. M. (2025, May 1). *Autism in Malaysia: Nearly 60,000 children diagnosed, registered as of 2024*. New Straits Times. https://www.nst.com.my/news/nation/2025/05/1209944/autism-malaysia-nearly-60000-children-diagnosed-registered-2024
36. Ridout, S., & Eldevik, S. (2024). Measures used to assess treatment outcomes in children with autism receiving early and intensive behavioral interventions: A review. *Review Journal of Autism and Developmental Disorders, 11*, 607–619. https://doi.org/10.1007/s40489-023-00355-9
37. Samadi, S. A., et al. (2025). The Childhood Autism Rating Scale Second Edition (CARS2) and its applicability in an Iranian sample. *Autism Research*. https://doi.org/10.1002/aur.70022

38. Schopler, E., Reichler, R. J., & Renner, B. R. (1986). The Childhood Autism Rating Scale (CARS). Los Angeles, CA: *Western Psychological Services*.
39. Schopler, E., Van Bourgondien, M. E., Wellman, G. J., & Love, S. R. (2010). The Childhood Autism Rating Scale, Second Edition (CARS2). Los Angeles, CA: *Western Psychological Services*.
40. Shaw, K. A., Williams, S., Patrick, M. E., Amoakohene, E., Bakian, A. V., Bilder, D. A., Durkin, M. S., Esler, A., Furnier, S. M., Hall-Lande, J., Hughes, M. M., Maenner, M. J., Poynter, J. N., Salinas, A., Shenouda, J., Vehorn, A., Warren, Z., & Cogswell, M. E. (2025). *Prevalence and early identification of autism spectrum disorder among children aged 4 and 8 years—Autism and Developmental Disabilities Monitoring Network, 16 sites, United States, 2022*. *Morbidity and Mortality Weekly Report: Surveillance Summaries, 74*(2), 1–22. https://doi.org/10.15585/mmwr.ss7402a1
41. Stahmer, A. C., Dufek, S., Brookman-Frazee, L., Rieth, S. R., & Aarons, G. A. (2024). Study protocol for a cluster randomized controlled community effectiveness trial of the Early Start Denver Model compared to community early behavioral intervention. *BMC Psychology, 12*(1), 513. https://doi.org/10.1186/s40359-024-02020-0
42. Swain, D., Han, J. E., Brown, H., Lord, C., Rogers, S., Estes, A., Kasari, C., Pickles, A., & Kim, S. H. (2025). Caregiver behavioral changes mediate the effects of naturalistic developmental behavioral interventions: Combining evidence from three randomized controlled trials. *Autism, 29*(7), 1835–1848. https://doi.org/10.1177/13623613251328463
43. The Borneo Post. (2025, August 14). *Sabah launches first autism centre*. https://www.theborneopost.com/2025/08/14/sabah-launches-first-autism-centre/
44. Vanar, M. (2026, April 20). *Sabah faces autism care gap with only 18 centres for over 7,000 children*. *The Star*. https://www.thestar.com.my/news/nation/2026/04/20/sabah-faces-autism-care-gap-with-only-18-centres-for-over-7000-children
45. Wiggins, L. D., Robins, D. L., Bakeman, R., Adamson, L. B., & Rice, C. E. (2019). DSM-5 criteria for autism spectrum disorder maximizes diagnostic sensitivity and specificity in preschool children. *Social Psychiatry and Psychiatric Epidemiology, 54*(6), 693–701. https://doi.org/10.1007/s00127-019-01674-4
46. Wilson, R. B., Vangala, S., Reetzke, R., Piergies, A., Ozonoff, S., & Miller, M. (2024). Objective measurement of movement variability using wearable sensors predicts ASD outcomes in infants at high likelihood for ASD and ADHD. *Autism Research, 17*(6), 1094–1105. https://doi.org/10.1002/aur.3150
47. World Health Organization. (2023). *Autism spectrum disorders*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders
48. Young, R. L., & Rodi, M. L. (2013). Redefining autism spectrum disorder using DSM-5: The implications of the proposed DSM-5 criteria for autism spectrum disorders. *Journal of Autism and Developmental Disorders*.
49. Yuen, M. C., & Lee, L. W. (2022). Inclusive education and special education support in Malaysia: Current trends and challenges. *International Journal of Academic Research in Progressive Education*

and Development, 11(3), 1200–1215.

50. Yunus, A. (2025, January 9). *Autism-focused preschools to be opened nationwide, says Ahmad Zahid*. The Star. https://www.thestar.com.my/news/nation/2025/01/09/autism-focused-preschools-to-be-opened-nationwide-says-ahmad-zahid
51. Yu, Y., Ozonoff, S., & Miller, M. (2024). Assessment of autism spectrum disorder. *Assessment, 31*(2), 242–265. https://doi.org/10.1177/10731911231173089
52. Zuckerman, K. E., Lindly, O. J., & Sinche, B. K. (2023). Parental concerns, provider response, and timeliness of autism spectrum disorder diagnosis. *Journal of Pediatrics, 255*, 113–120. https://doi.org/10.1016/j.jpeds.2022.12.021

Tables

Tables 1 to 7 are available in the Supplementary Files section.

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