Society of Medical Education & Research

Comparative Analysis of Dietary Diversity and Nutritional Status in Children with and without Autism Spectrum Disorder in Bangladesh

Thabo M. Nkosi[1], Lerato P. Maseko[1]*, Nomsa Dlamini[1]

[1]Department of Social and Behavioral Health Sciences, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

*E-mail ✉ lerato.maseko@gmail.com

Abstract

This study aimed to examine differences in dietary diversity and nutritional status between children diagnosed with autism spectrum disorder (ASD) and those without ASD. A total of 344 children participated in this cross-sectional investigation, comprising 172 children without ASD recruited from three public schools and 172 children with ASD from six specialized schools in Dhaka, Bangladesh. Multinomial logistic regression was employed to evaluate the relationship between ASD and both nutritional status and dietary diversity in the participants.

The average age of participants was 7.9 years, with 29.7% being female. Children with ASD showed a greater likelihood of overweight and obesity relative to the non-ASD group (RRR: 2.85, 95% CI 1.28–6.34, p-value 0.011). Dietary diversity was substantially lower among children with ASD compared to those without (RRR: 18.57, 95% CI 4.49–76.77, p-value < 0.001). Daily consumption frequency of foods from starchy roots, sugars, preserves and syrups, meat, fish and eggs, as well as milk and milk products, was significantly reduced in the ASD group compared to the non-ASD group (p-value < 0.05). In contrast, intake of cereals, vegetables and fruits, fats and oils, and beverages was comparable between the two groups. Children with ASD faced elevated risks of overweight and obesity alongside reduced dietary diversity. We suggest conducting comprehensive longitudinal research to investigate the effectiveness of customized interventions for modifying eating behaviors and managing body weight.

Keywords: Dietary diversity, Nutritional status, Children, Autism spectrum disorder, Bangladesh

Introduction

Malnutrition remains a major worldwide public health issue, especially during school-age years when nutrient reserves are built to support the upcoming adolescent growth spurt [1]. Inadequate protein and energy consumption can result in malnutrition, impairing immunity, physical growth, cognition, and academic performance [2, 3]. Children affected by malnutrition often display reduced productivity and heightened

susceptibility to long-term illnesses [4]. According to the Food and Agricultural Organization (FAO), approximately 11.3% of the Asian population experienced undernourishment in 2018 [5], and undernutrition contributed substantially to global mortality [6]. Recently, the triple burden of malnutrition—including undernutrition, micronutrient deficiencies, and overweight/obesity—has become a serious challenge for children, adolescents, economies, and countries [1].

Autism spectrum disorder (ASD) refers to a group of neurodevelopmental conditions marked by challenges in social interaction, communication, and restricted or repetitive patterns of behavior [7]. Genetic factors are considered the main etiology of ASD [8]. Worldwide, over 28 million individuals are impacted by ASD, with an adjusted prevalence of 0.37% [9]. In Bangladesh,

ASD prevalence ranges between 0.15% and 0.80% [10], with rural areas reporting a lower rate of 0.07% and the capital city of Dhaka showing a higher rate of 3% [11]. Research indicates that children with ASD have an increased risk of overweight and obesity, linked to sedentary behavior, selective eating patterns, co-occurring medical issues, and side effects of medications [12–14]. Additionally, many children globally do not achieve the adequate dietary variety necessary for proper growth and development [15, 16]. Children with ASD frequently demonstrate food selectivity and atypical eating practices, resulting in insufficient nutrient consumption [17]. Common micronutrient shortfalls in this population include protein, vitamin B12, calcium, vitamin D, potassium, pantothenic acid, and choline [18, 19]. Since early childhood is a vital window for development, nutrient shortfalls during this phase can negatively influence growth and long-term well-being [20].

Evidence regarding eating patterns and nutritional health in children with ASD remains scarce. Available studies suggest that rates of overweight and obesity exceed national averages in this group [21, 22]. Addressing this knowledge gap, the present cross-sectional investigation sought to assess differences in dietary diversity and nutritional status between children with and without ASD in Bangladesh. We proposed that children with ASD might display restricted dietary variety, which could adversely affect their nutritional profile.

Materials and Methods

Design, population, and settings

This comparative cross-sectional study was carried out in Dhaka City, Bangladesh, from January 2020 to March 2020. Participants were children aged 4–14 years, either with or without ASD. Data for the ASD group were gathered from six dedicated special schools within the Dhaka North City Corporation (DNCC), while age- and sex-matched data for the non-ASD group were obtained from three large public schools (each with more than 2000 students) in the same region. Children in the ASD group had a physician-confirmed diagnosis and were enrolled in special education settings, whereas those in the non-ASD group attended regular public schools and exhibited no indications of autism. We excluded children with ASD who were overly hyperactive and declined anthropometric assessment. Children with coexisting serious conditions—such as terminal diseases or severe

disorders that could directly influence dietary diversity or nutritional status—were also excluded after review to minimize confounding. Written informed consent was obtained from parents or guardians. Interviews were performed by trained personnel with non-ASD children directly and with parents of ASD children. The calculated minimum sample size was 89 per group, but we enrolled 178 per group for greater accuracy. After removing six incomplete pairs (ASD and matched non-ASD), the final sample consisted of 172 children with ASD and 172 without ASD.

Anthropometric measurements

Participant weight was recorded with a calibrated digital scale, while height was determined using a standard stadiometer and measuring board. All measurements were performed with children barefoot and wearing minimal clothing. Nutritional status was evaluated through the WHO AnthroPlus software, generating BMI-for-age Z-scores (BAZ) and height-for-age Z-scores (HAZ) [23]. BMI-for-age Z-scores were classified according to WHO standards as underweight (< -2 SD), normal weight (-2 SD to $+1$ SD), overweight ($> +1$ SD to $+2$ SD), and obese ($> +2$ SD) [24, 25]. Stunting was identified when HAZ fell below -2 SD relative to the WHO reference median [26].

Dietary assessment

Dietary data for both ASD and non-ASD children were obtained via a Food Frequency Questionnaire (FFQ) that covered sixteen food groups: cereals, white roots and tubers, vitamin A-rich vegetables and tubers, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, other fruits, organ meat, flesh meat, eggs, fish and seafood, legumes, nuts and seeds, milk and milk products, oils and fats, sweets, spices, condiments, and beverages [27]. The FFQ incorporated regionally common foods in each category. A complete list of local items included per group is presented in Additional file 2. A 24-hour dietary recall was applied to document consumption of foods and drinks from the FFQ items over the preceding day. Subsequently, the sixteen groups were consolidated into nine groups to calculate Individual Dietary Diversity Scores (IDDS): cereals, starchy roots, legumes, vegetables and fruits, sugars, preserves and syrups, meat, fish and eggs, milk and milk products, fats and oils, and beverages, in line with FAO recommendations and prior studies [22, 27, 28]. IDDS was computed per the FAO Guideline 2011, assigning

"1" if at least one item from a group was consumed and "0" otherwise, yielding scores from 0 to 9. Scores were grouped into low diversity (0–3), medium diversity (4–5), and high diversity (6–9). Elevated IDDS indicates greater dietary variety. This approach is commonly employed in nutrition research to gauge diet quality and detect groups vulnerable to nutrient deficiencies.

Statistical analysis
Continuous variables were summarized as means with standard deviations (SD), whereas categorical variables were presented as frequencies and percentages. Differences in means between ASD and non-ASD groups were tested using independent t-tests, and categorical differences were examined with Chi-square tests. Adjusted multinomial logistic regression was applied to assess differences in nutritional status and dietary diversity between the groups. Covariates showing significant bivariate differences (p-value < 0.05) were included for confounding adjustment. Age and sex were also incorporated due to their biological relevance. The final adjusted models treated ASD as the primary exposure and controlled for age, sex, maternal education, paternal education, monthly household income, and family type. Relative risk ratios (RRR) with 95% confidence intervals were reported for associations with

nutritional status and dietary diversity in ASD versus non-ASD children. In the models, "normal weight" served as the reference for nutritional status (compared against "underweight" and "overweight/obese"), while "medium" diversity was the reference for dietary diversity (compared against "low" and "high"). All analyses were performed using STATA-16.

Results and Discussion

Characteristics of the participants
The average age across participants was 7.9 years, with most children (41.9%) falling in the 7–9-year range. Females constituted 29.7% of the total 344 children. Parents of ASD children generally had substantially higher educational attainment than those of non-ASD children. For mothers, 67.4% in the ASD group held a bachelor's degree or above, compared to only 6.4% in the non-ASD group (p-value < 0.001). A comparable trend was observed for fathers, with 83.7% in the ASD group versus 12.2% in the non-ASD group possessing a bachelor's degree or higher (p < 0.001). Households of ASD children also reported significantly higher monthly income (> 70,000 BDT [BDT, Bangladeshi taka, national currency of Bangladesh]) in 52.9% of cases (p-value < 0.001) **(Table 1)**.

Table 1. Characteristics of the participants with ASD and non-ASD

Characteristic	Non-ASD, n (%)	ASD, n (%)	Total, n (%)
Age range (years)	4–14	4–14	4–14
Mean age (years)	7.8	8.0	7.9
Age group (years)			
4–6 years	65 (37.8)	50 (29.1)	115 (33.4)
7–9 years	67 (39.0)	77 (44.8)	144 (41.9)
10–14 years	40 (23.3)	45 (26.2)	85 (24.7)
Sex			
Male	121 (70.4)	121 (70.4)	242 (70.4)
Female	51 (29.7)	51 (29.7)	102 (29.7)
Mother's education			
Below secondary	114 (66.3)	10 (5.8)	124 (36.1)
Secondary/higher secondary	47 (27.3)	46 (26.7)	93 (27.0)
Bachelor and above	11 (6.4)	116 (67.4)	127 (36.9)
Father's education			
Below secondary	108 (62.8)	8 (4.7)	116 (33.7)
Secondary/higher secondary	43 (25.0)	20 (11.6)	63 (18.3)
Bachelor and above	21 (12.2)	144 (83.7)	165 (48.0)
Mother's occupation			

Services	10 (5.8)	9 (5.2)	19 (5.5)
Housewife	147 (85.5)	143 (83.1)	290 (84.3)
Others	15 (8.7)	20 (11.6)	35 (10.2)
Father's occupation			
Services	65 (37.8)	80 (46.5)	145 (42.2)
Business	66 (38.4)	48 (27.9)	114 (33.1)
Others	41 (23.8)	44 (25.6)	85 (24.7)
Type of family			
Nuclear	151 (87.8)	128 (74.4)	279 (81.1)
Joint	21 (12.2)	44 (25.6)	65 (18.9)
Monthly family income (BDT)			
< 40,000	102 (59.3)	15 (8.7)	117 (34.0)
40,000–70,000	53 (30.8)	66 (38.4)	119 (34.6)
> 70,000	17 (9.9)	91 (52.9)	108 (31.4)

ASD autism spectrum disorders, BDT Bangladeshi Taka (national currency of Bangladesh)

p-value from Chi-square test; values in bold indicate statistical significance

Nutritional status and individual dietary diversity

Children diagnosed with ASD exhibited a significantly higher average BMI than their non-ASD peers (18.3 ± 3.3 compared to 16.1 ± 3.0, p-value < 0.001). The prevalence of overweight and obesity was notably elevated in the ASD group, with 26.2% classified as overweight and 26.2% as obese, whereas the non-ASD group showed 9.9% in each category (p-value < 0.001). Conversely, mean individual dietary diversity scores were lower among ASD children (4.9 ± 1.6) than non-ASD children (5.6 ± 1.3, p-value < 0.001). In terms of dietary diversity categories, 19.8% of ASD children were in the low range, 42.4% in the medium range, and 37.8% in the high range. Among non-ASD children, these percentages were 5.2%, 39.5%, and 55.2%, respectively. Differences between the two groups were statistically significant (p-value < 0.001) **(Table 2)**.

Table 2. BMI-for-age, height-for-age Z-scores, and individual dietary diversity scores among children with and without ASD

Variable	Non-ASD (mean ± SD)	ASD (mean ± SD)	Total (mean ± SD)	p-value*
Weight (kg)	24.6 ± 8.5	30.6 ± 11.9	27.6 ± 10.8	< 0.001
Height (cm)	122.1 ± 14.1	127.2 ± 14.6	124.6 ± 14.5	< 0.001
BMI (kg/m²)	16.1 ± 3.0	18.3 ± 3.8	17.2 ± 3.6	< 0.001
Individual dietary diversity score	5.6 ± 1.3	4.9 ± 1.6	5.3 ± 1.5	< 0.001
	n (%)	n (%)	n (%)	
BMI-for-age Z-score				< 0.001
Underweight	22 (12.8)	9 (5.2)	31 (9.0)	
Healthy	116 (67.5)	73 (42.5)	189 (55.0)	
Overweight	17 (9.9)	45 (26.2)	62 (18.0)	
Obese	17 (9.9)	45 (26.2)	62 (18.0)	
Height-for-age Z-score				0.50
Stunting	18 (10.5)	22 (12.8)	40 (11.6)	
Healthy	154 (89.5)	150 (87.2)	304 (88.4)	
Individual dietary diversity				< 0.001
Low	9 (5.2)	34 (19.8)	43 (12.5)	

Medium	68 (39.5)	73 (42.4)	141 (41.0)
Higher	95 (55.2)	65 (37.8)	160 (46.5)

ASD autism spectrum disorders, SD standard deviation

*p-value from two-sample t-tests (continuous) and Chi-square tests (categorical); bold values indicate significance

Daily food intake among participants

Analysis of daily intake patterns revealed that children with ASD consumed legumes more frequently than non-ASD children (44.2% vs. 33.1%, p-value 0.03). However, their consumption of starchy roots (33.1% vs. 52.3%, p-value 0.001), sugars, preserves, and syrups (23.8% vs. 40.7%, p-value < 0.001), meat, fish, and eggs (70.9% vs. 95.9%, p-value 0.001), and milk and milk products (33.7% vs. 52.3%, p-value < 0.001) was considerably lower than that of children without ASD. Intake frequencies for cereals, vegetables and fruits, fats and oils, and beverages did not differ significantly between groups **(Table 3)**.

Table 3. Daily food consumption by food group among children with and without ASD

Food groups	Non-ASD, n (%)	ASD, n (%)	Total, n (%)	p-value*
Cereals	172 (100.0)	170 (98.8)	342 (99.4)	0.49
Starchy roots	90 (52.3)	57 (33.1)	147 (42.7)	< 0.001
Legumes	57 (33.1)	76 (44.2)	133 (38.7)	0.03
Vegetables and fruits	119 (69.2)	115 (66.9)	234 (68.0)	0.64
Sugars, preserves, and syrups	70 (40.7)	41 (23.8)	111 (32.3)	0.001
Meat, fish, and eggs	165 (95.9)	122 (70.9)	287 (83.4)	< 0.001
Milk and milk products	90 (52.3)	58 (33.7)	148 (43.0)	< 0.001
Fats and oils	172 (100.0)	172 (100.0)	344 (100.0)	–
Beverages	33 (19.2)	37 (21.5)	70 (20.4)	0.59

ASD autism spectrum disorders

*p-value from Chi-square tests; bold values indicate statistical significance

Relationship between ASD and nutritional status and dietary diversity

Adjusted multinomial logistic regression models indicated that children with ASD were 2.85 times more likely to fall into the overweight or obese categories compared to children without ASD (RRR: 2.85, 95% CI 1.28–6.34, p-value 0.011). Additionally, the likelihood of having low dietary diversity was 18.57 times higher in ASD children compared with their non-ASD counterparts (RRR: 18.57, 95% CI 4.49–76.77, p-value < 0.001) **(Table 4)**.

Table 4. Multinomial logistic regression examining associations of ASD with nutritional status and dietary diversity relative to non-ASD

Variable		Overweight & Obese		Underweight	
		RRR [95% CI]	p-value	RRR [95% CI]	p-value
Nutritional status	Non-ASD children	1.00 (Ref)		1.00 (Ref)	
	ASD children	2.85 [1.28–6.34]	0.011	1.90 [0.56–6.45]	0.303
		High		Low	
		RRR [95% CI]	p-value	RRR [95% CI]	p-value
Individual dietary diversity	Non-ASD children	1.00 (Ref)		1.00 (Ref)	
	ASD children	0.40 [0.17–0.91]	0.030	18.57 [4.49–76.77]	< 0.001

ASD autism spectrum disorders, CI confidence interval, RRR relative risk ratio

Models adjusted for age, sex, maternal education, paternal education, monthly family income, and family type

In these models, "normal weight" was set as the reference for nutritional status, with "underweight" and "overweight/obese" as comparison categories. For dietary diversity, "medium" served as the reference, with "low" and "high" compared

Bold p-values indicate statistical significance

This study examined and contrasted the nutritional status and dietary diversity between children with ASD and those without. Children in the ASD group had a mean BMI of 18.3 kg/m², while non-ASD children averaged 16.1 kg/m², yielding an overall mean BMI of 17.2 kg/m² for the combined sample. These results are consistent with prior research reporting a BMI of 18.3 kg/m² among ASD children; however, that study documented a slightly higher mean BMI of 19.3 kg/m² for non-ASD children [29], reflecting some cohort-based variability. In the present study, ASD children were nearly three times more likely to be overweight or obese than their non-ASD counterparts. Specifically, 26.2% of children with ASD were classified as overweight or obese, compared to 9.9% in the non-ASD group. A cross-sectional investigation involving 193 ASD children in Dhaka reported similar trends, with 19.7% overweight and 23.3% obese [22]. Meta-analytic evidence indicates that obesity prevalence among ASD children is approximately 22.2% [28]. Comparable figures were reported for U.S. youth aged 10–17 years from the 2016 National Survey of Children's Health (weighted n = 875,963), showing 19.4% overweight and 23.05% obese [29–31]. Studies in Turkey and the U.S. also reported obesity rates of 28.3% [32] and 18–33.6% for overweight and obesity [33], respectively. Contributing factors to increased overweight and obesity among children with ASD include limited physical activity, selective eating patterns, lifestyle factors, underlying biological conditions, comorbidities, and the effects of medications [34–36].

Regarding underweight status, 12.8% of non-ASD children were classified as underweight, whereas only 5.2% of ASD children fell into this category. Previous work in Bangladesh reported 11.9% of ASD children as underweight [22]. Both figures are lower than the 16% underweight prevalence reported in a survey of 2,690 schoolchildren across 14 schools in Dhaka City [37].

As expected, dietary diversity was lower among ASD children than among age- and sex-matched non-ASD peers. Non-ASD children displayed a broader variety of food choices, supporting prior evidence that ASD children often exhibit selective eating behaviors and limited dietary variety, which can lead to nutrient deficiencies [38]. U.S.-based studies similarly showed that ASD children consume fewer food items than non-ASD children [18]. In our analysis, ASD children were 18.57 times more likely to have low dietary diversity than non-ASD children. Supporting evidence from Sharp *et al.* indicated that ASD children experienced five times more feeding difficulties compared with their non-ASD counterparts [39]. These feeding challenges, coupled with preferences for energy-dense, low-fiber foods, may contribute to heightened risk of overweight, obesity, and micronutrient deficiencies later in life [35].

Previous studies consistently report lower intake of fruits and vegetables among ASD children [17, 40], potentially driven by heightened sensitivity to taste, texture, and visual appearance of foods. Such sensory preferences can lead to avoidance of many fruits and vegetables [17]. In our sample, fewer ASD children consumed fruits and vegetables than non-ASD peers, although this difference was not statistically significant. Protein-rich food intake, including meat, fish, eggs, and dairy, was significantly lower in the ASD group, while consumption of cereals, fats, and oils did not differ between groups. Systematic reviews support these findings, showing comparable carbohydrate and fat intake but reduced protein intake among ASD children [39, 41].

This study provides insights into the dietary behaviors and nutritional patterns of ASD and non-ASD children, which may inform the development of nutritional guidelines tailored to each group. The inclusion of age- and sex-matched participants strengthens the reliability of comparisons. However, as a cross-sectional study, it offers a snapshot of dietary and nutritional status rather than causal relationships.

Limitations include potential recall bias, as children or their parents might inaccurately report dietary intake, leading to under- or overestimation of consumption. Social desirability bias is also a concern, as participants may overstate healthy food intake or underreport less healthy foods. Furthermore, confounding factors such as physical activity, socioeconomic status, and ASD-associated comorbidities were not fully accounted for. Future research employing longitudinal designs, objective dietary assessment tools, and consideration of relevant confounders is needed to more comprehensively understand the relationship between ASD and nutrition.

Conclusion

Significant differences were observed in BMI-for-age z-scores and dietary intake patterns between ASD and non-ASD children. The higher prevalence of overweight and obesity among ASD children underscores the potential for increased risk of long-term health complications. Interventions targeting dietary behaviors and lifestyle modifications are essential to prevent future comorbidities. Longitudinal studies are recommended to evaluate the effectiveness of personalized interventions for improving dietary habits and managing weight over time. Such research can identify critical factors that influence long-term dietary behavior change, offering guidance for evidence-based strategies to enhance nutritional outcomes and overall health in children with ASD.

References

1. Keeley B, Little C, Zuehlke E. The state of the world's children 2019: children, food and nutrition—growing well in a changing world. UNICEF; 2019.
2. Gowri RA, Sargunam JH. Assessment of mental and motor abilities of school going children with anaemia. Indian J Nutr Diet. 2005;42:99–105.
3. Rahman F, Tuli SN, Mondal P, Sultana S, Hossain A, Kundu S, et al. Home environment factors associated with early childhood development in rural areas of Bangladesh: evidence from a national survey. Front Public Health. 2023;11:1209068. https://doi.org/10.3389/fpubh.2023.1209068.
4. Malnutrition. UNICEF Can Every Child n.d. https://www.unicef.ca/en/malnutrition. Accessed July 21, 2022.
5. FAO, editor. Safeguarding against economic slowdowns and downturns. Rome: FAO; 2019.
6. Gakidou E, Afshin A, Abajobir AA, Abate KH, Abbafati C, Abbas KM, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390:1345–422. https://doi.org/10.1016/S0140-6736(17)32366-8.
7. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th Edn. American Psychiatric Association; 2013. https://doi.org/10.1176/appi.books.9780890425596.
8. Betancur C. Etiological heterogeneity in autism spectrum disorders: more than 100 genetic and genomic disorders and still counting. Brain Res. 2011;1380:42–77. https://doi.org/10.1016/j.brainres.2010.11.078.
9. Solmi M, Song M, Yon DK, Lee SW, Fombonne E, Kim MS, et al. Incidence, prevalence, and global burden of autism spectrum disorder from 1990 to 2019 across 204 countries. Mol Psychiatry. 2022;2022:1–9. https://doi.org/10.1038/s41380-022-01630-7.
10. Akhter S, Hussain AHME, Shefa J, Kundu GK, Rahman F, Biswas A. Prevalence of autism spectrum disorder (ASD) among the children aged 18–36 months in a rural community of Bangladesh: a cross sectional study. F1000 Research. 2018;7:424. https://doi.org/10.12688/f1000research.13563.1.
11. Hossain MD, Ahmed HU, Jalal Uddin MM, Chowdhury WA, Iqbal MS, Kabir RI, et al. Autism Spectrum disorders (ASD) in South Asia: a systematic review. BMC Psychiatry. 2017;17:281. https://doi.org/10.1186/s12888-017-1440-x.
12. Curtin C, Anderson SE, Must A, Bandini L. The prevalence of obesity in children with autism: a secondary data analysis using nationally representative data from the National Survey of Children's Health. BMC Pediatr. 2010;10:11. https://doi.org/10.1186/1471-2431-10-11.
13. Memari AH, Kordi R, Ziaee V, Mirfazeli FS, Setoodeh MS. Weight status in Iranian children with autism spectrum disorders: Investigation of underweight, overweight and obesity. Res Autism Spectr Disord. 2012;6:234–9. https://doi.org/10.1016/j.rasd.2011.05.004.
14. Xia W, Zhou Y, Sun C, Wang J, Wu L. A preliminary study on nutritional status and intake in Chinese children with autism. Eur J Pediatr. 2010;169:1201–6. https://doi.org/10.1007/s00431-010-1203-x.

15. Hossain A, Niroula B, Duwal S, Ahmed S, Kibria MdG. Maternal profiles and social determinants of severe acute malnutrition among children under-five years of age: a case–control study in Nepal. Heliyon. 2020;6: e03849. https://doi.org/10.1016/j.heliyon.2020.e03849.

16. UNICEF, editor. Children, food and nutrition. New York, NY: UNICEF; 2019.

17. Bandini LG, Anderson SE, Curtin C, Cermak S, Evans EW, Scampini R, et al. Food selectivity in children with autism spectrum disorders and typically developing children. J Pediatr. 2010;157:259–64. https://doi.org/10.1016/j.jpeds.2010.02.013.

18. Zimmer MH, Hart LC, Manning-Courtney P, Murray DS, Bing NM, Summer S. Food variety as a predictor of nutritional status among children with autism. J Autism Dev Disord. 2012;42:549–56. https://doi.org/10.1007/s10803-011-1268-z.

19. Stewart PA, Hyman SL, Schmidt BL, Macklin EA, Reynolds A, Johnson CR, et al. Dietary supplementation in children with autism spectrum disorders: common, insufficient, and excessive. J Acad Nutr Diet. 2015;115:1237–48. https://doi.org/10.1016/j.jand.2015.03.026.

20. Walker SP, Wachs TD, Meeks Gardner J, Lozoff B, Wasserman GA, Pollitt E, et al. Child development: risk factors for adverse outcomes in developing countries. The Lancet. 2007;369:145–57. https://doi.org/10.1016/S0140-6736(07)60076-2.

21. Akhter S, Shefa J, Hasan MM. Nutritional status of children with neurodevelopment disorders from a tertiary medical center of Bangladesh. BIRDEM Med J. 2018;8:118–25. https://doi.org/10.3329/birdem.v8i2.36641.

22. Islam MdN, Bari FS, Chayon SM, Yesmin F, Akter S, Kashem SB. A cross-sectional study on nutritional status and dietary patterns of children with autism. Malays J Nutr. 2020;26:401–10. https://doi.org/10.31246/mjn-2019-0126.

23. Growth reference 5–19 years—application tools n.d. https://www.who.int/tools/growth-reference-data-for-5to19-years/application-tools. Accessed 21 July 2022.

24. WHO Multicentre Growth Reference Study Group, Onis M. WHO Child Growth Standards based on length/height, weight and age: WHO Child Growth Standards. Acta Paediatr. 2007;95:76–85.

https://doi.org/10.1111/j.1651-2227.2006.tb02378.x.

25. de Onis M. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85:660–7. https://doi.org/10.2471/BLT.07.043497.

26. Tamrat A, Yeshaw Y, Dadi AF. Stunting and its associated factors among early adolescent school girls of Gondar Town, Northwest Ethiopia: a school-based cross-sectional study. BioMed Res Int. 2020;2020:8850074. https://doi.org/10.1155/2020/8850074.

27. Kennedy G, Ballard T, Dop M-C. Guidelines for measuring household and individual dietary diversity. Rome: FAO; 2011.

28. Ghosh GK, Islam MN, Juthi KN, Yesmin A, Rahman T, Rabeya R. Nutritional status, dietary diversity, and food security of adolescent girls in rural Bangladesh. Ethiop J Health Dev 2021;35.

29. Sohel MI, Ashrafuzzaman Md, Acharjee P, Epsi EZ, Ullah HMH. Assessment of nutritional status between children with autism spectrum disorder and normal children of Bangladesh. Chattagram Maa-O-Shishu Hosp Med Coll J. 2021;20:55–9. https://doi.org/10.3329/cmoshmcj.v20i2.56475.

30. Kahathuduwa CN, West BD, Blume J, Dharavath N, Moustaid-Moussa N, Mastergeorge A. The risk of overweight and obesity in children with autism spectrum disorders: a systematic review and meta-analysis. Obes Rev. 2019;20:1667–79. https://doi.org/10.1111/obr.12933.

31. Healy S, Aigner CJ, Haegele JA. Prevalence of overweight and obesity among US youth with autism spectrum disorder. Autism. 2019;23:1046–50. https://doi.org/10.1177/1362361318791817.

32. Şengüzel S, Cebeci AN, Ekici B, Gönen İ, Tatlı B. Impact of eating habits and nutritional status on children with autism spectrum disorder. J Taibah Univ Med Sci. 2021;16:413–21. https://doi.org/10.1016/j.jtumed.2020.11.010.

33. Hill AP, Zuckerman KE, Fombonne E. Obesity and autism. Pediatrics. 2015;136:1051–61. https://doi.org/10.1542/peds.2015-1437.

34. Oreskovic NM, Neumeyer AM, Duggan MP, Kuhlthau KA. Assessment of walking routes as a possible approach for promoting physical activity in children with autism spectrum disorder: brief report. Dev Neurorehabil. 2020;23:59–63. https://doi.org/10.1080/17518423.2019.1646343.

35. Raspini B, Prosperi M, Guiducci L, Santocchi E, Tancredi R, Calderoni S, et al. dietary patterns and weight status in Italian preschoolers with autism spectrum disorder and typically developing children. Nutrients. 2021;13:4039. https://doi.org/10.3390/nu13114039.

36. Dhaliwal KK, Orsso CE, Richard C, Haqq AM, Zwaigenbaum L. Risk factors for unhealthy weight gain and obesity among children with autism spectrum disorder. Int J Mol Sci. 2019;20:3285. https://doi.org/10.3390/ijms20133285.

37. Niport NI of PR and T-, Welfare M of H and F, ICF. Bangladesh demographic and health survey 2017–18; 2020.

38. Sharp WG, Berry RC, McElhanon BO, Jaquess DL. Dietary diversity in children with autism. In: Patel VB, Preedy VR, Martin CR, editors. Compr. Guide Autism, New York, NY: Springer New York; 2014, p. 2077–97. https://doi.org/10.1007/978-1-4614-4788-7_127.

39. Sharp WG, Berry RC, McCracken C, Nuhu NN, Marvel E, Saulnier CA, et al. Feeding problems and nutrient intake in children with autism spectrum disorders: a meta-analysis and comprehensive review of the literature. J Autism Dev Disord. 2013;43:2159–73. https://doi.org/10.1007/s10803-013-1771-5.

40. Evans EW, Must A, Anderson SE, Curtin C, Scampini R, Maslin M, et al. Dietary patterns and body mass index in children with autism and typically developing children. Res Autism Spectr Disord. 2012;6:399–405. https://doi.org/10.1016/j.rasd.2011.06.014.

41. Esteban-Figuerola P, Canals J, Fernández-Cao JC, Arija VV. Differences in food consumption and nutritional intake between children with autism spectrum disorders and typically developing children: a meta-analysis. Autism. 2019;23:1079–95. https://doi.org/10.1177/1362361318794179.