Preventive Medicine Reports 38 (2024) 102614

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Socio-economic status and autism spectrum disorder: A case-control study in Bangladesh

Md. Shahid Khan [a,*], Mohammad Alamgir Kabir [b], Shafi Mohammad Tareq [a]

[a] Department of Environmental Sciences, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh
[b] Department of Statistics, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh

ARTICLE INFO

Keywords:
Autism spectrum disorder
Bangladesh
Case-control study
Public health
Socio-demographic factor
Socio-economic status

ABSTRACT

There are unexpectedly a few statistics about the socio-economic status (SES) and related socio-demographic factors (SDFs) of parents having child with ASD in Bangladesh. The prevalence of ASD might correlate with SES and related SDFs. A case-control study was conducted in 24 locations across 21 districts, encompassing all divisions, to assess the association between SES and the risk of developing ASD in Bangladesh. The structured questionnaire was administered through face-to-face interviews with 620 parents of the subject (310 ASD and 310 healthy controls) from January 2020 to June 2021. For univariate, bivariate and multivariate analyses, IBM SPSS version 23 was employed. The significance level was set at $P \leq 0.05$, and the Odds Ratio (OR) within a 95 % CI was used to determine whether the variable poses a higher odd or not. After adjusting all significant covariates of binary logistic regression (including some dummy variables) in forward logistic regression model analysis, the higher level of SES, advanced level of father's education (≥master), 22–35 years old age group of the father, and nuclear family were strongly associated with decreased odds of ASD compared to healthy controls. Only the male gender was strongly associated with an increased odds of ASD compared to the control. The results will aid policymakers in developing plans considering the SES and related SDFs that influence the risk of developing ASD in Bangladesh. Further research using population-based cohorts or nested case-control designs with matched control is necessary to observe and generalize the association.

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disability in early childhood (Shimomura et al., 2022), characterized by atypical socialization, restricted and repetitive behaviors, and interests (von Ehrenstein et al., 2019). Additionally, ASD is also characterized by persistent deficits in social communication and social interaction across multiple contexts, accompanied by restricted, repetitive patterns of behavior, interests, or activities (Arlington, 2013). The global prevalence of ASD has risen significantly in recent years (Fombonne, 2003; Jung et al., 2017; Rudra et al., 2017; Maenner et al., 2021; Zeidan et al., 2022), affecting approximately 1 % of children worldwide (Zeidan et al., 2022). In Bangladesh, this prevalence varies from 0.15 to 0.8 % (Hossain et al., 2017), with 40/10,000 children having ASD in rural areas (Ali et al., 2022). However, studies on ASD are not adequately prioritized in developing countries, such as Bangladesh (Hossain et al., 2017; Khan et al., 2022).

The first Bangladeshi systematic review revealed that only a few socio-demographic factors (SDFs) and environmental factors are associated with ASD, emphasizing the lack of large-scale studies in Bangladesh (Khan et al., 2022). While ASD is primarily considered a genetic disorder, growing concerns surround various prenatal and postnatal environmental risk factors including pollution (Parvin et al., 2022) contributing to its etiology (Bhandari et al., 2020). The role of non-genetic elements, such as demographic exposures, as potential risk factors for ASD has emerged from extensive literature reviews (Mathew et al., 2021). A comprehensive literature review revealed that unplanned urbanization in Dhaka City has precipitated a spectrum of public health risks, with socioeconomic determinants—such as poverty, income inequality, and limited healthcare access—exacerbating health vulnerabilities across the urban population (Rahaman et al., 2023). This trend extends throughout Bangladesh. Interestingly, adjusted odds of socioeconomic status didn't influence the correlation between perinatal factors and autism in Denmark, where universally accessible healthcare, free of charge, ensures equal healthcare access for all (Larsson et al., 2005). In contrast, the healthcare coverage system in Bangladesh is not

* Corresponding author.
E-mail addresses: khanpt9@gmail.com (Md. Shahid Khan), alamgir@juniv.edu (M. Alamgir Kabir), smtareq@juniv.edu (S. Mohammad Tareq).

https://doi.org/10.1016/j.pmedr.2024.102614
Received 6 May 2023; Received in revised form 1 January 2024; Accepted 13 January 2024
Available online 14 January 2024

universally adequate (Khan et al., 2017). Consequently, ADS is an escalating public health challenge, imposing significant burdens on families, communities, and nations worldwide. Effectively managing ASD within the confines of public health budgets necessitates a thorough understanding of the target group's dynamics (Begum et al., 2020). Despite published statistics regarding children with ASD in Bangladesh, surprisingly limited data exists concerning the socio-economic conditions of their parents (Begum et al., 2020). Therefore, this study aimed to assess the relationship between autism and socio-economic status (SES) and related SDFs. This exploration seeks to illuminate the true landscape in Bangladesh, shedding light on crucial factors to mitigate the risk of ASD development.

2. Methods

2.1. Study design

This study was an observational case-control survey.

2.2. Study areas

The cases were drawn from individuals registered with ASD at the 'Protibandhi Sheba O Shahajjo Kendro (PSOSK, under the Ministry of Social Welfare)' across all divisions of Bangladesh. Healthy controls (HCs) were selected from relatives and friends within the same areas (Song & Chung, 2010; Setia, 2016).

2.3. Inclusion and exclusion criteria

Individuals with autism and HCs aged between two and 24 years were included. Respondents were limited to parents of ASD cases and HCs, considering that parents generally possess more comprehensive knowledge about the subjects compared to relatives, caregivers, or step/foster parents (Rudi et al., 2018). Exclusions comprised two respondents classified as foster/step parents, 36 parents unwilling to provide consent, and respondents affected by psychiatric illnesses (two) or deafness (three).

2.4. Selection of participants (case-control)

A total of 24 out of 103 PSOSK centers were included using a simple random sampling method throughout Bangladesh, ensuring the covering of each division to collect case data (Table 1). The sample size of 306 ASD cases was determined based on the "table for determining sample size for a given population" by Krejcie and Morgan (1970) from a population of 1498 individuals with ASD. Subsequently, 310 individuals with ASD were selected as cases, and a similar number of HCs were randomly (simple random sampling) chosen from relatives and friends within the same areas as the cases, within the same age ranges (two to 24 years) (Song & Chung, 2010; Setia, 2016).

Table 1
Sampling method for population of ASD, recruited from Bangladesh, 2020–2021 (n = 620).

Division wise number of selected PSOSK	Division wise PSOSK	Selected PSOSK by simple random sampling	Registered number of ASD at selected PSOSK	Approximate % to be included from total population of ASD
Two: ≤9 PSOSK	Mymensingh, 7	2	84	5
	Barisal, 9	2	55	5
	Sylhet, 8	2	134	10
Three: 10–14 PSOSK	Rajshah, 10	3	332	20
	Rangpur, 14	3	136	10
	Khulna, 13	3	145	10
Four: 15–19 PSOSK	Chattogram, 18	4	304	20
Five: ≥20 PSOSK	Dhaka, 24	5	308	20
Total	103	24	1498	100

PSOSK: Protibandhi Sheba O Shahajjo Kendro.

2.5. Data collection tool and procedures

For the questionnaire, SES and related SDFs were logically chosen as independent variables (IVs). The structured questionnaire was constructed after an extensive review of existing literatures (Pham et al., 2022; Khan et al.,2022; Berger et al., 2021; Al-Mamari et al., 2021; Afrin et al., 2021; Acharya & Sharma, 2021; Hegazy et al., 2021; Alali et al., 2021; Carlsson et al., 2021; Luo et al., 2020; Roy et al., 2020; Volk et al., 2020; Begum et al., 2020; Xie et al., 2020; von Ehrenstein et al., 2019; Fatema et al., 2019; Hamra et al., 2019; Maia et al., 2019; Soke et al., 2019; Bhuiyan et al., 2017) and focused on Bangladeshi SES and related SDFs (Table 3) that might be associated with the odds of ASD in Bangladesh. The questionnaire was validated by experts from academics (supervisor, biostatistician), practitioners (paediatrician, physician, disability specialists) and a researcher specializing in autism, guided by the existing literature (Elangovan & Sundaravel, 2021). The questionnaire was pretested on 30 parents having a child with ASD in the Dhaka and Chattogram divisions. Data collection spanned January 2020 to June 2021, conducted through random face-to-face interviews with respondents. Scientific protocols were strictly adhered to during data collection, involving comprehensive training for data collectors and clear explanations provided to respondents.

2.6. Measures of SES and related SDFs

Measurement of SES was based on monthly total household income (MTHI) during pregnancy, categorized as follows: ≤10000 (reference group = RG), 10001–20000, 20001–30000, and ≥ 30001 Bangladeshi Taka (BDT). Correspondingly, related SDFs were assessed across various categories: 1). Level of education during pregnancy for both father and mother, segmented into six categories: illiterate (RG), primary, SSC/equivalent, HSC/equivalent, degree/honors/equivalent, and ≥ master. 2). Father's occupation during pregnancy, categorized as job (RG), business, day labor, and others. 3). Mother's occupation during pregnancy, classified as job (RG), homemaker, and others. 4). For job-holder mothers, the babysitter was divided into three categories: relatives (RG), caregivers, and not applicable (N/A). 5). Family type during pregnancy categorized as joint family (RG) or nuclear family. 6). Age groups of fathers during childbirth: lowest through 21 years (RG), 22–35 years, and 36 years through highest. 7). Age groups of mothers during childbirth: lowest through 18 years (RG), 19–30 years, and 31 years through highest. 8). Subject's gender was categorized as female (RG) and male. 9). Mother's residence from pregnancy to three years of early childhood: rural (RG) and urban. 10). Factors such as consanguinity of parents, twin baby, autistic sibling, and other NDD sibling categorized into no (RG) and yes. Additionally, dummy variables were created for father's [dummy 1: others (RG), 22–35 years. dummy 2: others (RG), 36 years through highest] and mother's [dummy 1: others (RG), 19–30 years. dummy 2: others (RG), 31 years through highest] age groups and father's education level [<master and others (RG), and ≥ master] specifically for multivariate and forward logistic regression analyses.

2.7. Data analyses

For data analyses, IBM SPSS version 23 was used. Univariate analysis described data as a number (percentage), mean ± standard deviation (SD) or median as an appropriate. Using bivariate analysis, the independent sample *t*-test and nonparametric tests were conducted to compare the mean and median respectively. The Chi-square (X^2) test and cross-tabulation were performed to determine a difference between

the group of participants and the level of SES and related SDFs. Subsequently, a series of bivariate/binary logistic regression (BLR) was estimated using case status (ASD = 1 and control = 0) as the DV and the level of SES and related SDFs that could be acting as covariates (IVs). Bivariate associations were estimated between cases and controls in terms of level of SES and associated factors with unadjusted/crude odds ratios (cOR) and 95 % confidence intervals (CIs) (Table 3). Only those IVs that had a significant association ($P < 0.05$) with the group of subject were retained for later inclusion in a multivariate/multiple logistic regression (MLR) model analysis to examine the relationship between variables and odds of ASD. Before running the MLR adjusted model, two dummy variables for the father's and mother's age groups respectively and one dummy variable for father's education level {as 22–35 years of father's age group (RG: ≤21 years), 19–30 years of mother's age group (RG: ≤18 years) and ≥ master level of education (RG: illiterate) were significantly associated with decreased the odds of ASD in BLR} were created (Supplementary table). The subject's age was excluded from regression analyses as it was not a variable of interest. Finally, a forward logistic regression (FLR) was conducted to control the confounding effects by adjusting the possible covariate effects (presented as adjusted odd ratio-aOR) and model fitness (final FLR model was adequately fitted the data, and attached with supplementary file).

2.8. Ethical consideration

No patients directly participated in formulating research questions, selecting outcome measures, or devising study plans. Only parents voluntarily engaged in interviews after providing written informed consent, and they were kept informed about the study's progress. Confidentiality of individuals and data was strictly maintained.

3. Results

Descriptive statistics and inferential analyses of socio-demographic characteristics related to ASD are shown in Tables 2, 3, 4 and supplementary table and Figs. 1, 2 and Supplementary figure. The MTHI during pregnancy ranged from 1075 to 600,000 Taka and the median were 20,000 and 15,000 Taka for the control and case group respectively during pregnancy. Fathers' ages at the subject's birth ranged from 15 to

Table 2
The distribution of age, MTHI, and division, recruited from Bangladesh, 2020–2021 (n = 620).

Factors	Healthy control (310)	ASD (310)	All (620)	*P* value
Subjects' age in year (Mean ± SD)	9.8 ± 6.06	10.3 ± 4.65	10.05 ± 5.41	0.25
Fathers' age[a] (Mean ± SD)	32. 83 ± 6.66	32.69 ± 7.27	32.76 ± 6.97	0.81
Mothers' age[a] (Mean ± SD)	24.97 ± 5.79	23.88 ± 5.86	24.43 ± 5.85	**0.02**
MTHI[b] during pregnancy (Median) in BDT[c]	20,000	15,000	18,000	**<0.001**
Division of the respondent, n (%)				
Chattagram	57 (18.4)	74 (23.9)	131 (21.1)	**0.002**
Barisal	21 (6.8)	21 (6.8)	42 (6.8)	
Rajshahi	30 (9.7)	52 (16.8)	82 (13.2)	
Khulna	23 (7.4)	20 (6.5)	43 (6.9)	
Mymensingh	33 (10.6)	9 (2.9)	42 (6.8)	
Sylhet	29 (9.4)	26 (8.4)	55 (8.9)	
Rangpur	59 (19.0)	49 (15.8)	108 (17.4)	
Dhaka	58 (18.7)	59 (19.0)	117 (18.9)	

[a]During childbirth in year.
[b]MTHI = Monthly total household income.
[c]BDT = Bangladeshi Taka.

Table 3
The frequency distribution (Cross tabulation with X^2-test), and binary logistic regression (BLR) analysis between autism and socio-economic status* and related socio-demographic factor in the cases and controls, recruited from Bangladesh, 2020–2021 (n = 620).

Factors	Cross tabulation with X^2-test			BLR	
	Healthy control (310)	ASD (310)	*P*-value	cOR (95 %CI)	*P*-value
Level of education (father)[a]:					
Illiterate	46 (14.8)	48 (15.5)	**<0.001**	Reference	
Primary	67 (21.6)	82 (26.5)		1.17 (0.70, 1.97)	0.55
SSC/equivalent	21 (6.8)	32 (10.3)	**<0.001**	1.46 (0.74, 2.89)	0.28
HSC/equivalent	26 (8.4)	39 (12.6)		1.44 (0.76, 2.73)	0.27
Degree/Honors/ equivalent	47 (15.2)	56 (18.1)	**<0.001**	1.14 (0.65, 2.00)	0.64
Master and above	103 (33.2)	53 (17.1)		0.49 (0.29, 0.83)	**0.01**
Level of education (mother)[a]:					
Illiterate	38 (12.3)	34 (11.0)	**0.009**	Reference	
Primary	84 (27.1)	109 (35.2)		1.45 (0.84, 2.50)	0.18
SSC/equivalent	39 (12.6)	52 (16.8)		1.49 (0.80, 2.78)	0.21
HSC/equivalent	39 (12.6)	46 (14.8)	**0.009**	1.32 (0.70, 2.47)	0.39
Degree/Honors/ equivalent	53 (17.1)	35 (11.3)		0.74 (0.39, 1.39)	0.34
Master and above	57 (18.4)	34 (11.0)		0.67 (0.36, 1.25)	0.21
Occupation of father[a]:					
Job	145 (46.8)	130 (41.9)	0.63	Reference	
Business	73 (23.5)	84 (27.1)		1.28 (0.87, 1.90)	0.21
Day labor	46 (14.8)	50 (16.1)	0.63	1.21 (0.76, 1.93)	0.42
Other	46 (14.8)	46 (14.8)		1.12 (0.70, 1.79)	0.65
Occupation of mother[a]:					
Job	45 (14.5)	32 (10.3)	0.12	Reference	
Homemaker	261 (84.2)	269 (86.8)		1.45 (0.89, 2.35)	0.13
Other	4 (1.3)	9 (2.9)	0.12	3.16 (0.90, 11.18)	0.07
Level of MTHI in BDT[a:]					
≤10000	71 (22.9)	128 (41.3)	**<0.001**	Reference	
10001–20000	96 (31.0)	83 (26.8)		0.48 (0.32, 0.73)	**<0.001**
20001–30000	44 (14.2)	39 (12.6)		0.49 (0.29, 0.83)	**0.007**
≥30001	99 (31.9)	60 (19.4)		0.34 (0.23, 0.52)	**<0.001**
Babysitter for job-holder mother:					
Relatives	37 (11.9)	33 (10.6)		Reference	
Caregivers	9 (2.9)	7 (2.3)	0.76	0.87 (0.29, 2.60)	0.81
N/A	264 (85.2)	270 (87.1)		1.15 (0.70, 1.89)	0.59

(continued on next page)

Table 3 (*continued*)

Factors	Cross tabulation with X^2-test			BLR	
	Healthy control (310)	ASD (310)	*P*-value	cOR (95 %CI)	*P*-value
Type of family[a]: Joint family	137 (44.2)	163 (52.6)	**0.04**	Reference	
Nuclear family	173 (55.8)	147 (47.4)		0.71 (0.52, 0.98)	**0.04**
Age group of father[b]: Lowest thru 21 years	3 (1.0)	10 (3.2)		Reference	
22–35 years	228 (73.5)	203 (65.5)	**0.03**	0.27 (0.07, 0.98)	**0.05**
36 years thru highest	79 (25.5)	97 (31.3)		0.37 (0.10, 1.38)	0.14
Age group of mother[b]: Lowest thru 18 years	42 (13.5)	61 (19.7)		Reference	
19–30 years	224 (72.3)	205 (66.1)	0.11	0.63 (0.41, 0.98)	**0.04**
31 years thru highest	44 (14.2)	44 (14.2)		0.69 (0.39, 1.22)	0.20
Subject's gender: Female	147 (47.4)	91 (29.4)	**<0.001**	Reference	
Male	163 (52.6)	219 (70.6)		2.17 (1.56, 3.02)	**<0.001**
Mother's residence[c]: Rural	120 (38.7)	150 (48.4)	**0.015**	Reference	
Urban	190 (61.3)	160 (51.6)		1.48 (1.08, 2.04)	**0.015**
Consanguinity No	296 (51.7)	276 (48.3)	**0.003**	Reference	
Yes	14 (29.2 %)	34 (70.8)		0.93 (0.79, 1.10)	0.40
Twin baby No	308 (50.1)	307 (49.9)	0.65	Reference	
Yes	2 (40.0)	3 (60.0)		1.0 (0.85, 1.17)	0.97
Autistic sibling No	310 (51.7)	290 (58.3)	**<0.001**	Reference	
Yes	0 (0.0)	20 (100.0)		1,615,474,843 (0.00)	1.0
Other NDD sibling No	305 (50.7)	297 (49.3)	0.06	Reference	
Yes	5 (27.8)	13 (72.2)		0.97 (0.83, 1.14)	0.74

[a]during pregnancy.
[b]during childbirth.
[c]during pregnancy to three years of early childhood.
socio-economic status measured by the level of MTHI.

63 years, while mothers' ages ranged from 12 to 48 years, with subjects' ages varying between 2 and 24 years. The levels of MTHI, education of the father and mother and type of family during pregnancy; subject's gender; mother's residence during pregnancy to three years of early childhood; consanguinity; autistic sibling; and other NDD siblings were statistically significant and associated with ASD in X^2-test (Table 3).

In BLR (Table 3), all the levels of MTHI (RG: ≤10000 BDT), master and above-level of father's education (RG: illiterate), nuclear family (RG: joint family), 22–35 years of father's age group (RG: ≤21 years) and 19–30 years of mother's age group (RG: ≤18 years) were all significantly associated with decreased odds of ASD compared to HC. The male gender (RG:

female), and the mother's residence in urban areas (RG: rural) were significantly associated with an increased odds of ASD compared to HC. However, all the levels of mother's education (RG: illiterate), occupation groups of father and mother (RG: job), babysitter (RG: relatives), and presence of consanguinity/twin baby/autistic sibling/other NDD siblings (RG: no) were insignificantly associated with odds of ASD compared to HC.

Table 4
Forward logistic regression (FLR) model analysis between autism and socio-economic status* and related socio-demographic factor in the cases and controls, recruited from Bangladesh, 2020–2021 (n = 620).

Factors	Sample size of case and control for each subgroup	FLR	
		aOR (95 % CI)	*P*-value
Level of education (father)[a]: < Master and others	464	Reference 0.56 (0.35, 0.87)	**0.011**
Master and above	156		
Level of MTHI in BDT[a]: ≤10000	199	Reference	
10001–20000	179	0.46 (0.30, 0.71)	**<0.001**
20001–30000	83	0.56 (0.32, 0.97)	**0.038**
≥30001	159	0.43 (0.26, 0.73)	**0.002**
Age group of father[b], **dummy 1:** Others	189	Reference	
22–35 years	431	0.61 (0.42, 0.88)	**0.008**
Subject's gender: Female	238	Reference	
Male	382	2.35 (1.66, 3.33)	**<0.001**
Type of family[a]: Joint family	300	Reference	
Nuclear family	320	0.70 (0.50, 0.99)	**0.040**

[a]During pregnancy.
[b]During childbirth.
*Socio-economic status measured by the level of MTHI.

Table 4 represents the final model of the ***forward logistic regression (FLR) analyses***. After adjusting all significant covariates (from BLR) together, all the levels of MTHI (RG: ≤10000 BDT) with aOR of 0.46 (CIs: 0.30 to 0.71, $P = < 0.001$) for 10001–20000; aOR of 0.56 (CIs: 0.32 to 0.97, $P = 0.038$) for 20001–30000 and aOR of 0.43 (CIs: 0.26 to 0.73, $P = 0.002$) for ≥ 30001 BDT groups respectively during pregnancy were significantly associated with decreased odds of ASD compared to HC. Master and above-level of father's education (RG: others) with aOR of 0.56 (CIs: 0.35 to 0.87, $P = 0.011$) and nuclear family (RG: joint family) with aOR of 0.70 (CIs: 0.50 to 0.99, $P = 0.040$) during pregnancy were also significantly associated with decreased odds of ASD compared to HC. Similarly, 22–35 years of father's age with aOR of 0.61 (CIs: 0.42 to 0.88, $P = 0.008$) during childbirth were significantly associated with decreased odds of ASD compared to HC. Only the male gender of the subject (RG: female) was significantly associated with increased odds of ASD compared to HC (aOR 2.35, CIs 1.66 to 3.33, $P < 0.001$). However, all other dummy age groups, and the mother's residence in urban area (RG: rural) were not included in the final FLR model.

4. Discussion

This case-control study stands as the first of its kind, exploring the association between autism likelihood and SES along with related SDFs, systematically covering all divisions of Bangladesh. Binary, multivariate, and forward logistic regression analyses (BLR, MLR, FLR) were conducted to evaluate how SES and related SDFs influenced respondents' likelihood of having ASD or not (Tables 3, 4, supplementary table, and Figs. 1, 2, supplementary figure). Exclusions were minimal, involving only two participants affected by psychiatric illnesses, three affected by deafness and two foster or step-parents, as these parents

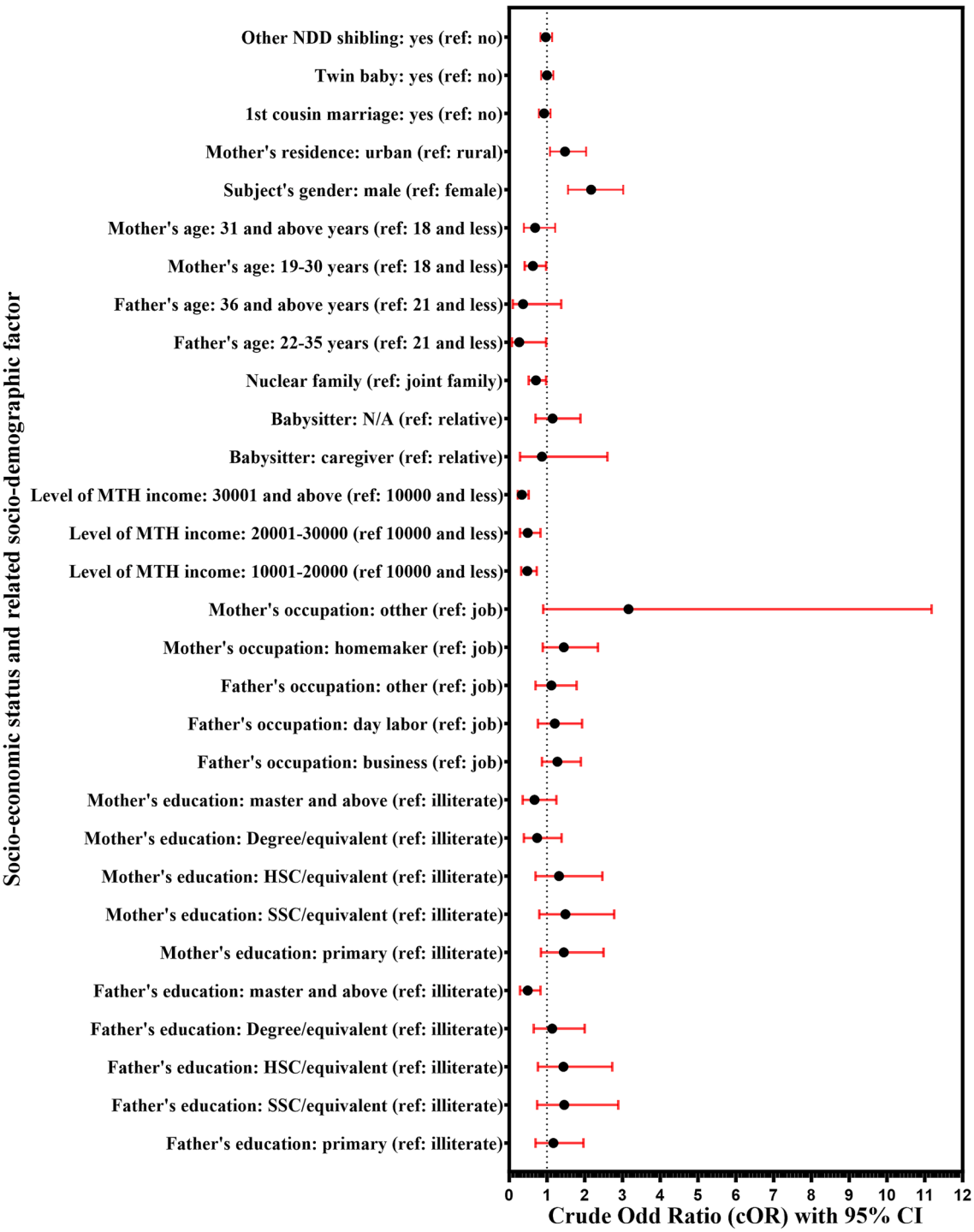

Fig. 1. Forest plot showing the crude odds ratios (cOR) with 95 % confidence intervals (CIs), and *P*-value for relationship between autism and socio-economic status and related socio-demographic factor in the cases and controls, calculated by binary logistic regression (BLR) model analysis (autistic sibling was not included in plot: cOR 1615474843, 95 % CIs of 0.00 with $P = 1$), recruited from Bangladesh, 2020–2021 (n = 620).

faced challenges in providing necessary information. Moreover, 36 parents opted not to participate.

Notably, higher levels of SES/MTHI (RG: ≤10000 BDT) exhibited a significant reduction in the odds of ASD across BLR, MLR, and FLR analyses compared to the control in this study. This aligns with the findings of Oommen et al. (2018), suggesting that higher SES might mitigate the odds of ASD. Conversely, SM Fatema et al. (2019) reported that income level was not associated with ASD odds, but lower SES demonstrated a dose–response association with ASD (Pham et al., 2022). However, studies by Khanom et al. (2015) and Hegazy et al. (2021) proposed that higher SES could elevate the odds of ASD. In this study, master and above-level father's education, in both BLR (RG: illiterate) and FLR (RG: others) analyses, significantly decreased the odds of ASD compared to the control. Conversely, the levels of the mother's education were not significant, where ≥ master and degree/honors/equivalent levels insignificantly decreased the odds of ASD in BLR. However, other education groups insignificantly increased the odds. Therefore, compared with healthy control the advanced level of parental education might

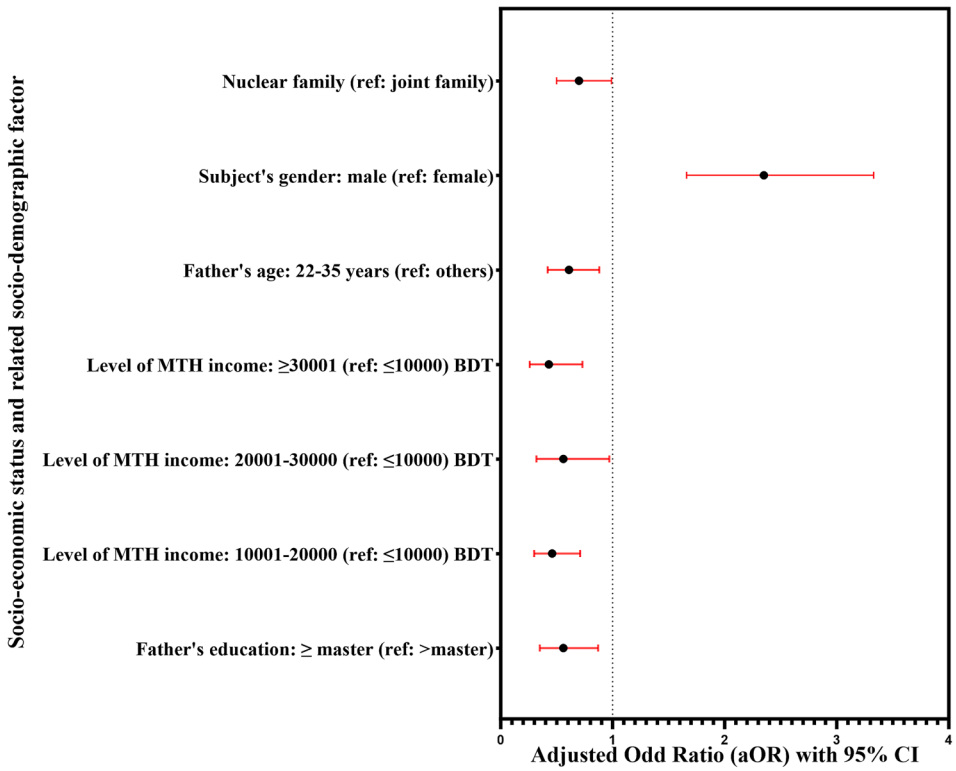

Fig. 2. Forest plot showing the adjusted odds ratios (aOR) with 95 % confidence intervals (CIs), and *P*-value for relationship between autism and socio-economic status and related socio-demographic factor in the cases and controls, calculated by forward logistic regression (FLR) model analysis, recruited from Bangladesh, 2020–2021 (n = 620).

decrease the odds of ASD in Bangladesh. However, SM Fatema et al. (2019) found opposite trends in Bangladesh. Notably, the education level for most of the Bangladeshi fathers (Afrin et al., 2021) and Omani mothers (Al-Mamari et al., 2021) having a child with autism was a bachelor degree or above. While certain studies (Hamra et al., 2019; von Ehrenstein et al., 2019; Berger et al., 2021) have supported a positive association of advanced maternal education with ASD odds, others (Soke et al., 2019; Afrin et al., 2021) have found negative trends.

Furthermore, compared with the healthy control in this study, the nuclear family (in BLR and FLR) significantly decreased the odds of ASD. Previous statistics indicated that a substantial percentage ranging from 68.2 % (Bhuiyan et al., 2017) to 87 % (Hasnain and Akter, 2014) of children with ASD came from nuclear family backgrounds, whereas the proportions in this study were 47.4 % for ASD and 55.8 % for controls.

The advanced age groups of both fathers and mothers were not found to be significant in the BLR. Moreover, all the dummy age groups of father and mother were insignificant and decreased the odds of ASD in MLR. Notably, the 22–35 years of father's age group (RG: other) during childbirth was significantly associated with a decreased odds of ASD than HC in the final FLR model. Several studies have reported a positive association between ASD odds and advanced maternal or paternal age (Oommen et al., 2018; Geetha et al., 2019; Maia et al., 2019; von Ehrenstein et al., 2019; Volk et al., 2020; Al-Mamari et al., 2021; Berger et al., 2021). As age advanced, there was a significant increase in the OR of maternal age as a likelihood of ASD (Al-Mamari et al., 2021). However, few studies found no link between advanced paternal (Volk et al., 2020) or maternal (Hamra et al., 2019; Soke et al., 2019) age and ASD.

Thus, higher parental SES, advanced paternal education, belonging to the middle-aged group (22–35 years), and residing in a nuclear family were linked to a reduced odds of ASD in this study. Notably, these results deviate from the majority of previous studies. It is noteworthy that advanced paternal education might contribute to a higher parental SES, marriage or fatherhood at an advanced age, and the adoption of a nuclear family lifestyle, potentially influencing the ASD odds.

In this study, the male gender was highly significant (BLR, MLR, FLR) and increased > twofold odds of ASD compared to HC which is in similar line with several previous studies (Krakowiak et al., 2015; Oommen et al., 2018; Maia et al., 2019; Soke et al., 2019; Gil-Hernández et al., 2020; Hegazy et al., 2021). However, some other studies opposed this relation (Hamra et al., 2019; von Ehrenstein et al., 2019; Voke et al., 2020). The frequency of male gender (70.6 %) in this study is closer to previous studies (Bhuiyan et al., 2017; Fatema et al., 2019; Al-Mamari et al., 2021).

In the BLR analysis of this study, maternal residence in urban areas was significantly associated with increased odds of ASD, supporting the findings of SM Fatema et al. (2019). However, this association decreased insignificantly in the MLR analyses and was absent in the FLR analyses. Rapid urbanization is related to pollution, which leads to a range of public health risks, and socioeconomic determinants further intensify the health risks (Rahaman et al., 2023). Thus, urbanization has been linked to increased odds of ASD, as demonstrated in several previous studies (Bhuiyan et al., 2017; Ali et al., 2018; Luo et al., 2020; Alali et al., 2021).

Parental occupation was not added to MLR and FLR analyses in the present study. However, the father's and mother's occupation groups were found to be insignificantly associated with increased odds of ASD in BLR analyses. In a previous study conducted in Bangladesh, SM Fatema et al. (2019) found that parental occupation was not a predictor of ASD, while Hasnain and Akter (2014) reported opposing trends. For children whose fathers worked in technological fields, there was a higher likelihood of having ASD, while occupations of mothers did not show the relation (Dickerson et al., 2014). Categories of babysitters for job-holder mothers were not significant in BLR and were not included in MLR, although the N/A group increased the odds of ASD in this study. Notably, this study found about 86.8 % of homemakers and 87.1 % of them had no babysitter. The biological parents (95 %), usually mothers

(89 %) were the primary caregivers of American children with ASDs (Hoefman et al., 2014). Acharya & Sharma (2021) found two out of nine mothers having child with ASD were job holders. In Dhaka city, Begum et al. (2020) found 75 % of the participants were unemployed while 90.9 % of the participants were mothers.

While higher parental socioeconomic status (SES), parental occupation, and urbanization are often interconnected factors that could potentially influence the odds of ASD, this study did not establish a definitive link between ASD and urbanization or parental occupation.

Consanguinity was found to insignificantly decrease the odds of ASD in BLR and was not included in MLR, despite being significant in the X^2-test in this study. Several previous studies have reported that consanguinity increases the odds of ASD (Mamidala et al., 2015; SM Fatema et al., 2019; Roy et al., 2020). However, the prevalence of consanguineous marriage history was 9.1 % in previous research (Bhuiyan et al., 2017), while it was 12.32 % in the present study.

Interestingly, in this study, twin babies had no relation with the development of ASD. Hallmayer et al. (2002) found about 3.0 % of autistic twins compared to 2.63 % of twin births per year. Having an autistic sibling showed a significant relation based on the X^2-test, and although it insignificantly increased the odds of ASD by 1,615,474,843 times in BLR analysis, having another neurodevelopmental disorder (NDD) sibling was not associated with the odds of ASD in the present study. The prevalence of siblings suffering from ASD in Bangladesh ranged from 3.2 % (Bhuiyan et al., 2017) to 10 % (Islam et al., 2018), whereas this study found that 6.45 % of siblings had ASD. In a Swedish cohort, about 12.97 % had ASD without intellectual disability (ASD-ID), 13.55 % had ASD with intellectual disability (ASD + ID) among males, and 7.12 % had ASD-ID and 6.16 % had ASD + ID among females from first-degree siblings (Xie et al., 2020).

This study systematically encompassed 24 areas of 21 districts from all divisions of Bangladesh, revealing a strong association between higher levels of SES and reduced odds of ASD. Moreover, it unveiled multidimensional relationships between the odds of ASD and SES, related SDFs. While some findings align with prior studies, a note of caution is warranted in interpreting the results. Many relationships lost significance after adjusting for all significant variables in MLR and FLR analyses, indicating the need to control for covariate effects comprehensively. Consequently, meticulous attention to SES and associated modifiable SDFs is imperative for mitigating the odds of ASD in Bangladesh.

4.1. Limitations

This study acknowledges several limitations. Foremost among these is the inability to secure matched controls, owing to logistical and feasibility constraints. To mitigate this limitation, confounding effects were meticulously addressed by adjusting covariates in the multivariate logistic regression (MLR and FLR) model analyses. Another limitation is recall bias. To minimize this, a random sampling technique was employed, ensuring that the phrasing of questions did not influence participants' responses. Additionally, an important limitation involves the underrepresentation of higher SES categories within the ASD group. Mere 12.6 % for the 20001–30000 BDT group and 19.4 % for the $\geq$ 30001 BDT group were represented. This discrepancy can be attributed to the underrepresentation of individuals from these categories, particularly those who do not typically engage with governmental setups, especially within the social welfare sector (PSOSK) in Bangladesh. Furthermore, there were challenges in data collection, particularly in the Mymensingh and Khulna divisions, where the percentage of collected data for the case group deviated from the expected proportion. In the Mymensingh and Rajshahi divisions, the ratio of collected controls did not align closely with the cases due to the unavailability of respondents.

Despite these limitations, the findings underscore the potential impact of considering SES/MTHI and related SDFs during pregnancy and early childhood on reducing the odds of autism. Policymakers, stakeholders, and both public and private organizations can leverage these results for informed decision-making.

5. Conclusion

This case-control study aimed to evaluate the association between the likelihood of ASD and SES along with related SDFs in Bangladesh. In FLR analysis, the higher SES/MTHI status groups were strongly associated with decreased odds of ASD compared to HC. Similarly, the advanced level of father's education, 22–35 years age group of father and nuclear family were significantly associated with decreased odds of ASD compared to HC. Only the male gender was strongly and significantly associated with increased odds of ASD compared to HC. These findings will aid policymakers in formulating plans that account for the influence of SES and related SDFs on ASD odds in Bangladesh. Subsequent research, utilizing population-based cohorts or nested case-control designs with matched controls, is imperative to observe and generalize these associations.

CRediT authorship contribution statement

Md. Shahid Khan: Conceptualization, Methodology, Resources, Project administration, Software, Visualization. **Mohammad Alamgir Kabir:** Conceptualization, Methodology, Supervision. **Shafi Mohammad Tareq:** Conceptualization, Methodology, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The respondent's families, assistant data collectors, officers and staff of PSOSK, supervisors; teachers and all members of Department of Environmental Sciences (Jahangirnagar University) are thanked.

Funding statement

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical approval

This study was in accordance with the Declaration of Helsinki (World Medical Association, 2013) and approved by the "Higher Studies Committee" (Serial number: 45; Reg. Number: 2931; date: March 6, 2018), and "Biosafety, Biosecurity and Ethical Committee" {Ref No: BBEC.JU/M 2023/01(12)} of the Jahangirnagar University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2024.102614.

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