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Prevalence of Undernutrition and its Socio-Demographic Determinants among Rural Bengalee Muslim Preschool Children of Bankura District, West Bengal, India

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Abstract: Despite recent global economic growth, the high prevalence of child undernutrition is an urgent public health issue in low and middle-income countries, including India. Moreover, one-third of infant mortality is associated with undernutrition. The present cross-sectional study aims to report the burden of undernutrition and to explore its association with socio-demographic variables among the Bengalee Muslim preschool children of Bankura district, West Bengal, India. This present study was conducted among 800 preschool children (400 males and 400 females) aged 12 to 59 months. The children were selected using a systematic random sampling method, and the sample size was estimated using standard formula. Descriptive, parametric, non-parametric, and inferential statistical analyses were performed accordingly. Males were taller and heavier than females. Significant age variations in mean height and weight were found among the study participants. The overall prevalence of stunting, wasting, and underweight was 23.0%, 30.5%, and 36.0%, respectively. The results of the chi-square test showed that all the socio-demographic variables were significantly associated with the nutritional status of these children. A multivariate logistic regression revealed that non-exclusive breastfeeding, higher birth order, and the lower mothers' age at childbirth were the significant predictors of stunting. Low family income, large family size, and low maternal educational status were the significant predictors of wasting. Moreover, low family income, non-exclusive breastfeeding, and mothers' age at childbirth were significant predictors of underweight. The findings of the present study revealed that there were numerous determinants of undernutrition among the Bengalee Muslim preschool children. Therefore, the appropriate government and non-government agencies should adopt the policy for an income-generating scheme to enhance household income, awareness of exclusive breastfeeding, family planning, adult education programmes, and surveillance against child marriage.

Key words: Undernutrition, Socio-demographic factors, Muslim, Preschool, Children

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Introduction

Childhood undernutrition is a complex public health problem in low and middle-income countries despite recent global economic growth (Ali et al. 2017; Kang and Kim 2019; Chowdhury et al. 2018; Brown et al. 2020; Hossain et al. 2023). It is determined by several socio-economic and demographic factors including maternal age at marriage, maternal age at childbirth, child birthweight, breastfeeding practice, parental education and occupation, household income, drinking water, and latrine facility (Abuya et al. 2012; Asfaw et al. 2015; Kang and Kim 2019; Murarkar et al. 2020; Ghosh 2023; Hossain et al. 2023; Toma et al. 2023; Singh et al. 2024).

Poor health hampers several factors in a nation's progress such as social well-being, national saving, demographic change, and higher labor productivity, which are obstacles to the development of a country (Devine et al. 2014; Duminy et al. 2023). Good health enhances a nation's well-being, higher labour productivity, improved human capital, higher rates of national saving, and demographic change (WHO 2003). Child undernutrition is one of the major causes of childhood morbidity and mortality (Chowdhury et al. 2018; Hossain et al. 2023)and it contributes to over half of child deaths each year, predominantly in developing countries (Benson and Shekar 2006). Undernourished children often face chronic illness and physical disabilities, which contribute to less productivity outcomes compared to normal children (Groce et al. 2014; Asfaw et al. 2015). The United Nations fixed the Sustainable Development Goals (SDGs) to reduce all forms of malnutrition along with child mortality among children by addressing their proper nutritional needs. However, the Food and Agriculture Organization (2023) reported that 725.1 million people are undernourished whereas 195.1 million and 458.7 million people are in lower-income and lower-middle-income countries respectively (FAO 2023). Poverty reduction is one of the important factors in reducing or achieving the above SDGs, including those related to health and well-being.

Undernutrition is one of the forms of malnutrition and it encompasses three broadly recognized indicators such as stunting (low height for age), wasting (low weight for height), and underweight (low weight for age) (WHO 2022). In this context, undernutrition among children is a silent threat of developing countries including India. Several schemes, including the National Health Mission (NHM-2005) and Integrated Child Development Service Scheme (ICDS 2008–2009), have been launched to reduce child undernutrition. Still, it remains significantly high in India, including West Bengal. The National Family Health Survey-V (2019–20) reported that the prevalence of stunting, wasting, and underweight in India are 35.5%, 19.3%, and 32.1%, respectively (IIPS 2020). It is a highly alarming report that stunting, wasting, and underweight affect 61 million, 25 million, and 47 million under-five children in India, respectively (Singh et al. 2019), including West Bengal (IIPS 2020).

Noteworthy, the Sachar Committee (2006) and Ranganath Mishra Commission (2007) reported that Muslim communities in India are socially and educationally regressive, economically poor, politically powerless, and medically disadvantaged community. The poverty level (both rural and urban) among Muslims in West Bengal is higher than the national average of poverty. Most of the Muslim population (78%) resides in rural areas and their economy predominantly depends on agricul-

ture. It has also been reported that Muslim children suffer from higher rates of undernutrition compared to other communities (Prime Minister High Level Committee 2006). The above reviews highlight that socio-economic and demographic factors play a significant influence on every aspect of a child's health and nutritional status, and it has also been revealed that there is a dearth of information on the interaction between socio-demographic factors and nutritional status among the rural Bengalee Muslim preschool children. By identifying highly significant socio-demographic predictors and advocating for multi-sectoral interventions, it provides new insights for targeted public health policies in low-resource settings.

Therefore, the present study aims to report the prevalence of the different forms of undernutrition as well as to explore the relationship between undernutrition status and socio-demographic factors among the Bengalee Muslim preschool children of Kotulpur block, Bankura district of West Bengal, India.

Materials and Methods

Study Setting

The study was conducted at the different villages of Kotulpur Community Development (CD) block of Bankura district, West Bengal, India. The block is the most Muslim populated CD block of Bankura district, consisting of 32,922 population, representing 17.44% of the total population in this CD block (Census of India 2011). It consists of eight (8) gram panchayats with a total population of 1,88,775, of which 1,80,292 reside in rural areas and 8,483 in urban areas. The block covers an area of 250.38 km^2 and 65 km away from the district head quarter of the Bankura district.

Sample and sample size calculation

The present cross-sectional study was conducted among 12 to 59 months old Muslim preschool children. The study was approved by the Institutional Ethical Committee of the Institution of the Sidho-Kanho-Birsha University (Ref. No. R/IEC/406/SKBU/2023 dated 24.03.2023, with effect from July 2022). The information provided by participants was kept confidential by excluding personal identifiers from the schedule. Parents of the children's convenience was a priority in this study during data collection, and we respected their rights as participants. We also confirm that all methods and procedures were carried out in accordance with the relevant guidelines and regulations (Helsinki Declaration). The study participants were an unknown population due to the unavailability of the religious specific data on preschool children. The Integrated Child Development Scheme (ICDS) authority focuses on gathering only the social categorical data (General, SC, and ST). Therefore, Cochran's (1977) unknown sample formula was adopted to calculate the minimum sample size as follows:

$$n_0 = \frac{Z^2pq}{e^2},\ n_0 = \frac{(2.58)^2 \times 0.5 \times 0.5}{0.05^2} =$$

$$= \frac{6.6564 \times 0.25}{0.0025} = 666 + 10\% = 733$$

Where n_0= sample size; Z= level of confidence; p=degree of variability; q=1-p; e= level of precision (Cochran 1963).

According to NFHS-V (2019–21), the maximum prevalence of the Composite Index of Anthropometric Failure is 48.78% in Bankura district (computed by the author). Therefore, the maximum variability assumed is equal to 50% (p=0.5) and takes a 99% confidence level with ±10 %. The above calculation

shows that the minimum sample size is 733. Therefore, a total of 800 Muslim preschool children (400 males and 400 females) were investigated.

Sampling Technique

The study participants were selected from forty Integrated Child Development Service scheme centers from twenty-eight Muslim dominated villages of Kotulpur Block. The study participants were selected using a systematic random sampling method, whereas age and sex-specific serial numbers of the children in the ICDS register book were used to choose the participants (children). Every consecutive third age and sex-specific children were selected from each center proportionally, out of the total estimated age and sex-specific sample (100 children), which comprised (100×2×4) of total 800 preschool children.

Anthropometric Measurements

Anthropometric measurement is a crucial tool for evaluating nutritional assessment and associated health risks (WHO 1995). Anthropometry is a quick, easy, and inexpensive method. Therefore, it is one of the most commonly used and globally accepted methods (Bhattacharya et al. 2019; WHO 1995). Anthropometric measurements (height and weight) were taken by a trained investigator (first authors) using an internationally accepted standard protocol (Lohman et al. 1988). Crown-heel length and height was measured using an infantometer and standard stadiometer respectively and recorded to the nearest 0.1 cm. Weight was measured using a spring balance weighing machine (Krups) and recorded to the nearest 0.5 kg.

Assessment of Nutritional Status

Three commonly recognized nutritional indicators, namely stunting, wasting, and underweight were assessed based on age, height, and weight as recommended by WHO in 2006. The Anthro-plus software (Version 3.2) was used to calculate the Z-score values of height for age (HAZ), weight for height (WHZ), and weight for age (WAZ), following the guidelines of the World Health Organization (WHO, 2006). These Z-score values were used to assess stunting (HAZ), wasting (WHZ), and underweight (WAZ). The cut-off points for stunting, wasting, and underweight were defined as <-2SD z-scores (age and sex specific).

The formula is given below.

$$\text{Z score} = \frac{\text{X} - \text{Median values of WHO, 2006}}{\text{Standard deviation of WHO, 2006}}$$

Where, X=Particular score of height or weight of a child. (WHO, 2006)

The above calculation reveals three Z score values. The values are:

HAZ= Height for age Z-score. Stunting is defined as <-2SD Z-scores value.

WHZ= Weight for height Z-score. Wasting is defined as <-2SD Z-scores value.

WAZ= Weight for age Z-score. Underweight is defined as <-2SD Z-scores value.

Socio-demographic variables

Socio-demographic data were collected from the ICDS register and head of household or guardian or parents of the children. The date of birth, religion, mother's age at marriage, age of mother at childbirth, and birth weight are recorded from the ICDS register. Birth order, number of siblings, number of household members, duration of breastfeeding, household income, mother's education, father's education, father's occupation, availability of latrine facilities and separate kitchens, and type of cooking fuel were collected through a schedule survey.

Data management

Mother's age at marriage was recorded per the Indian Child Protection Act (2006) which sets the minimum legal age for marriage of women at 18 years. The National Report (NFHS) in India justified that women's average age at childbirth is slightly over 21 years. And the present data on it were categorized accordingly.

Birth order and the number of siblings were also recorded and categorized into quartiles for analytic purposes. Birth weight was obtained from the '*mother and child protection card*' and categorized as WHO standard, with weights below 2,500 grams or 2.5 KG categorized as 'low birth weight'. Breastfeeding data was documented as continuous data and categorized according to the WHO standard, with the first six months of exclusive breastfeeding defined as exclusively breastfeeding. The number of household members was also recorded. Household income was recorded in Indian currency and categorized using quartile. Father's occupation was categorized into three categories Casual (engaged in irregular workers), Self (those meaning their businesses or properties), and Regular workers (employed in stable or long-term properties). The highest levels of parental education were recorded based on the various educational institutions they were schooled. Latrine facilities, cooking fuel, and separate kitchens were also recorded as socio-economic indicators.

Table 1. List of dependent and independent variables examined in the present study

Variables	Description
Stunting	'0' Not Stunted & '1' Stunted
Wasting	'0' Not Wasting & '1' Wasting
Underweight	'0' Not Underweight & '1' Underweight
Mother's Age at Marriage	Child Marriage (below 18 years) and Adult Marriage (18 years and above).
Age of Mother at Childbirth	20 years & below, and 21 years & above
Birth Order	1st birth order and 2nd and subsequent birth order
Sibling	No sibling and having sibling
Birth Weight	Normal birth weight (≥ 2.5 kg) and low birth weight (< 2.5 kg)
Exclusive Breastfeeding	Yes (exclusive breastfeeding or first six months of breastfeeding) and No (below six months of breastfeeding)
Number of Household Members	4 & below and 5 & above
Monthly Household Income	Rs <6500, Rs 6501 to Rs 9000 and Rs >9001
Father's Occupation	Casual (refer to irregular workers), Self (refer to work in own properties), and Regular workers
Father's Education	Primary (class IV and below) and Upper primary & above
Mother's Education	Upper primary & lower (class VIII and below) and High School & above
Latrine Facility	Yes and No
Separate Kitchen	Yes (separate kitchen room for cooking) and No (no separate kitchen for cooking)
Cooking Fuel	Gas and Fairwood or leave

Statistical Analysis

All statistical analyses were carried out using IBM SPSS (Version 25). Basic descriptive statistics were compiled. Student's t-test was performed to assess sex differences (age-specific) in mean height and weight. One-way ANOVA (Scheffe's procedure) was performed to test for age variations in mean height and weight for each sex. The chi-square test was also performed to assess the variation in the prevalence of undernutrition in the different categories of each independent variable. Binary logistic regression analyses were performed to find out the individual predictor(s) of stunting, wasting, and underweight. Furthermore, multiple logistic regressions (Forward: Likelihood Ratio) analyses were performed to explore the most important determinants of undernutrition after removing or controlling the effect of the other independent variables. In this analysis, undernutrition was presented as the dependent (outcome) variable, categorized into "0" (normal) and "1" (stunted, wasted, and underweight), while socio-demographic variables were the independent variable. All the Statistical tests were set at $p<0.05$.

Simple logistic regression

$$\text{Logit (P)} = \text{In}\,(p/1-p)=\beta_0+\beta_1X_1$$

Multivariate binary logistic regression

$$\text{logit(P)} = \text{In}(p/1-p)=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\beta_nX_n$$

Where,

P= the probability of the event occurring,

1-p=the probability of the event not occurring.

β_o=Intercept

β_1, β_2……βn = the coefficients for the independent variables X_1, X_2…..X_n.

Results

Socio-demographic characteristics

The results of socio-demographic characteristics revealed that more than half of mothers married before reaching adulthood (54.88%). Furthermore, it was observed that more than half of the present mothers gave birth at the age of below 21 years of age. About 45.15% of children were born in the first birth order and 40.75% of children did not have siblings. About one-fourth of the studied children (24.38%) were born with low birth weight. A total of 15% of children did not get exclusive breastfeeding during their first six months of life. More than half of the families are small in nature (4 and below family members). One-fourth of the household's monthly income was less than Rs 6500. About half of fathers were engaged in casual work and only 16.88% were involved in regular work. 43.00% of fathers completed at least the primary level. More than half of mothers completed at least the upper primary level. 20.50% of households did not have latrine facilities and 91.38% had separate kitchens. Only 24.75% of households were using LPG for cooking.

Anthropometric characteristics

Anthropometric characteristics among the studied Muslim preschool children are depicted in Table 3. There were increasing trends in height and weight with increasing age. Apparently, males were taller and heavier than females. Age-specific significant sex differences in mean height (t=3.09; p=<0.01) and weight (t=3.16; p=<0.01) were noticed at the age of 24–35 months. Overall, the males were significantly heavier (t=2.26, p=<0.05) than femlaes. Significant age variations in mean height (Males-F=134.32,

p<0.001; Females-F=148.03, p<0.001) and weight (Males-F=440.89, p<0.001; Females-F=552.26, p<0.001) were also found among the study participants.

Table 2. Socio-demographic characteristics of the study population

Background Characteristics		Frequency	Percent (%)
Mother's Age at Marriage	Child Marriage	439	54.88
	Adult Marriage	361	45.13
Mother's age at Childbirth	20 years and below	486	60.75
	21 years and above	314	39.25
Birth Order	1st	361	45.13
	2nd and Subsequent	439	54.88
Sibling	No Sibling	326	40.75
	Having Sibling	474	59.25
Birth Weight	2.5 kg and above	605	75.63
	Less than 2.5 kg	195	24.38
Exclusive Breastfeeding	Yes	680	85.00
	No	120	15.00
Number of Family Members	4 & below	415	51.88
	5 & above	385	48.13
Monthly Household Income	Rs below 6500	204	25.50
	Rs 6501 to 9000	290	36.25
	Rs more than 9001	306	38.25
Father's Occupation	Casual	399	49.88
	Self	266	33.25
	Regular	135	16.88
Father's Education	Primary	344	43.00
	Upper primary & above	456	57.00
Mother's Education	Upper primary & lower	410	51.25
	High school & above	390	48.75
Latrine facility	Yes	636	79.50
	No	164	20.50
Separate Kitchen	Yes	731	91.38
	No	69	8.63
Cooking Fuel	Gas	198	24.75
	Fairwood or leaves	602	75.25

Table 3. Anthropometric characteristics of the study participants

Age (Months)	Sex	No	Weight Mean (SD)	t-test	Height Mean (SD)	t-test
12–23	Males	100	9.29(1.54)	1.54	77.53(5.30)	1.7
	Females	100	8.96(1.42)		76.33(4.73)	
24–35	Males	100	11.16(1.71)	3.09**	87.84(5.02)	3.16**
	Females	100	10.43(1.62)		85.75(4.31)	
36–47	Males	100	12.58(1.82)	1.04	95.20(4.36)	1.43
	Females	100	12.33(1.66)		94.28(4.72)	
48–59	Males	100	13.99(1.85)	0.99	100.91(4.47)	-1.5
	Females	100	13.71(2.09)		101.91(4.98)	

Age (Months)	Sex	No	Weight Mean (SD)	t-test	Height Mean (SD)	t-test
Age Combined	Males	400	11.75(2.45)	2.26*	90.37(9.98)	1.1
	Females	400	11.36(2.49)		89.57(10.64)	
	Males		F=134.32***		F=440.89***	
	Females		F=148.03***		F=552.26***	

Level of significance: *p<0.05, **p<0.001, ***p<0.00

Prevalence of undernutrition

The overall prevalence of stunting among the studied preschool children was 23.0% and there was no sex difference in the prevalence of stunting (Table 4). According to WHO (1995), the severity of stunting among the studied preschool children was medium. The overall prevalence of wasting was 30.5% and males (32.8%) were more wasted compared to females (28.8%) (table 4). The prevalence shows that the rate of wasting is a critical situation (29) and males and females show similar rates of wasting. The overall prevalence of underweight was 36.0% and the sex-specific prevalence of underweight was high among males (37.3%) compared to females (34.8%). The prevalence of underweight also indicates that the severity of undernutrition was very high (WHO 1995) among the studied Muslim preschool children.

Table 4. Prevalence of undernutrition (stunting, Wasting and underweight) among the Bengalee Muslim preschool children

Category of undernutrition	Sex	Prevalence	χ^2
Stunting	Males	23.00% (92)	0.001
	Females	23.00% (92)	
	Overall	23.00% (184)	
Wasting	Males	32.75% (131)	1.91
	Females	28.75% (113)	
	Overall	30.50% (244)	
Underweight	Males	37.25% (149)	0.54
	Females	34.75% (139)	
	Overall	36.00% (288)	

Association between undernutrition and socio-demographic factors

The results of chi-square test are represented in Table 5. There were fourteen socio-demographic variables under consideration. The results revealed that mother's age at marriage (χ^2=5.61; p<0.01), mother's age at childbirth (χ^2=9.83; p<0.001), birth order (χ^2=5.61; p<0.01), siblings (χ^2=4.93; p<0.05), birth weight (χ^2=4.76; p<0.05), breastfeeding (χ^2=73.35; p<0.001), monthly household income (χ^2=6.44; p<0.01), father's occupation (χ^2=8.19; p<0.01), father's education (χ^2=4.78; p<0.05) and cooking fuel (χ^2=4.21; p<0.05) were significantly associated with stunting status of the studied preschool children. Furthermore, wasting is also significantly associated with twelve socio-demographic variables. Mother's age at marriage (χ^2=8.69; p<0.01), mother's age at childbirth (χ^2=9.67; p<0.001), birth order (χ^2=6.18; p<0.05), siblings (χ^2=7.42; p<0.01), birth weight (χ^2=10.98; p<0.001), breastfeeding (χ^2=12.44; p<0.001), number of household members (χ^2=40.89; p<0.001) monthly household income (χ^2=57.93; p<0.001), father's education (χ^2=4.77; p<0.05), mother's education (χ^2=37.67; p<0.001), separate kitchens (χ^2=6.00; p<0.05) and cooking fuel (χ^2=4.86; p<0.05) were significantly associated with wasting status of the children. Moreover, underweight was also significantly associated with the mother's age at marriage (χ^2=9.63; p<0.01), mother's age at childbirth (χ^2=14.27; p<0.001), birth order

(χ^2=15.93; p<0.001), siblings (χ^2=14.45; p<0.001), birth weight (χ^2=6.45; p<0.05), breastfeeding (χ^2=24.10; p<0.001), number of household members (χ^2=40.89; p<0.001), monthly household income (χ^2=34.12; p<0.001), father's occupation (χ^2=6.55; p<0.05), father's education (χ^2=3.83; p<0.05), mother's education (χ^2=22.80; p<0.001), latrine facilities (χ^2=5.91; p<0.05), separate kitchens (χ^2=7.11; p<0.05) and cooking fuel (χ^2=11.98; p<0.01).

Table 5. Relationship between socio-demographic variables and undernutrition among the preschool children

`		Stunting	χ2	Wasting	χ2	Underweight	χ2
Mother's Age at Marriage	Child Marriage	26.20%	**5.61****	34.85%	**8.69****	40.77%	**9.63****
	Adult Marriage	19.11%		25.21%		30.19%	
Mother's age at Childbirth	20 years & below	26.75%	**9.83*****	34.57%	**9.67****	41.15%	**14.27*****
	21 years & above	17.20%		24.20%		28.03%	
Birth Order	1st	19.11%	**5.61****	26.04%	**6.18***	28.53%	**15.93*****
	2nd and more	26.20%		34.17%		42.14%	
Sibling	No Sibling	19.02%	**4.93***	25.15%	**7.42****	28.22%	**14.45*****
	Having Sibling	25.74%		34.18%		41.35%	
Birth Weight	2.5 kg and above	21.16%	**4.76***	27.44%	**10.98*****	33.55%	**6.45***
	Less than 2.5 kg	28.72%		40.00%		43.59%	
Breastfeeding	Yes	17.65%	**73.35*****	28.09%	**12.44*****	32.50%	**24.10*****
	No	53.33%		44.17%		55.83%	
Number of Household Members	4 & below	22.89%	0.06	20.48%	**40.89*****	33.25%	2.82
	5 & above	23.12%		41.30%		38.96%	
Monthly Household Income	Rs below 6500	28.92%	**6.44****	50.98%	**57.93*****	51.47%	**34.12*****
	Rs 6501 to 9000	22.76%		27.24%		35.52%	
	Rs more than 9001	19.93%		19.93%		26.14%	
Father's Occupation	Casual	26.07%	**8.19****	32.33%	1.41	39.85%	**6.55***
	Self	22.93%		29.32%		34.21%	
	Regular	14.07%		27.41%		28.15%	
Father's Education	Primary	26.74%	**4.78***	34.59%	**4.77***	39.83%	**3.83***
	Upper primary & above	20.18%		27.41%		33.11%	
Mother's Education	Upper primary & lower	23.66%	0.206	40.24%	**37.67*****	43.90%	**22.80*****
	High school & above	22.31%		20.26%		27.69%	
Latrine facility	Yes	21.70%	2.97	29.56%	1.29	33.96%	**5.91***
	No	28.05%		34.15%		43.90%	
Separate Kitchen	Yes	22.71%	0.41	29.27%	**6.00***	34.61%	**7.11****
	No	26.09%		43.48%		50.72%	
Cooking Fuel	Gas	17.68%	**4.21***	24.24%	**4.86***	25.76%	**11.98*****
	Fairwood or leaves	24.75%		32.56%		39.37%	

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

The relationship between undernutrition and socio-demographic factors

The results of the binary logistics regression analyses are depicted in Table 6. The findings show the individual risk factors as socio-demographic determinants of undernutrition status of preschool children. The mother's age at marriage less than 18 years were 1.50, 1.59, and 1.59 times higher risk of stunting (O.R=1.50; C.I=1.07–2.11; p<0.05), wasting (O.R=1.59; C.I=1.17–2.16; p<0.01) and underweight (O.R=1.59; C.I=1.19–2.14; p<0.01) compared to the children of the mothers who got marriage at adulthood age. The mother's age at childbirth less than 21 years were 1.76, 1.65 and 1.80 times more at risk of stunting (O.R=1.76; C.I=1.23–2.51; p<0.01), wasting (O.R=1.65; C.I=1.20–2.28; p<0.01) and underweight (O.R=1.80; C.I=1.32–2.44; p<0.01) compared to the mother's age at childbirth 21 years and above years. Second and subsequent children are 1.50, 1.47, and 1.82 times higher prevalence of stunting (O.R=1.50; C.I=1.07–2.11; p<0.05), wasting (O.R=1.47; C.I=1.08–2.00; p<0.05) and underweight (O.R=1.82; C.I=1.36–2.45; p<0.001) rather than the first child. Children with siblings are at 1.48, 1.55 and 1.79 times higher risk of stunting (O.R=1.48; C.I=1.05–2.08; p<0.05), wasting (O.R=1.55; C.I=1.13–2.12; p<0.01) and underweight (O.R=1.79; C.I=1.32–2.43; p<0.001) compared to children with no sibling. Low birthweight children (less than 2.5 kg) are 1.50, 1.76 and 1.53 times more stunting (O.R=1.50; C.I=1.04–2.17; p<0.05), wasting (O.R=1.76; C.I=1.26–2.47; p<0.001) and underweight (O.R=1.53; C.I=1.10–2.13; p<0.01) rather than optimum birthweight children. The children who did not get exclusive breastfeed were 5.33, 2.03, and 2.63 times higher risk of stunting (O.R=5.33; C.I=3.54–8.03; p<0.001), wasting (O.R=2.03; C.I=1.36–3.01; p<0.001) and underweight (O.R=2.63; C.I=1.77–3.90; p<0.001) compared to those children who got exclusive breastfeeding. Large family size was 2.73 times more risk of wasting (O.R=2.73; C.I=2.00–3.74; p<0.001) than those who had a small family. Children in lower-monthly household income were at 1.70, 4.18, and 3.00 times higher risk of stunting (O.R=1.70; C.I=1.12–2.58; p<0.05), wasting (O.R=4.18; C.I=2.82–6.18; p<0.001) and underweight (O.R=3.00; C.I=2.06–4.36; p<0.001) compared to children in higher- monthly household income. Children in middle-income group families also face a higher risk of wasting (O.R=1.50; C.I=1.03–2.20; p<0.05) and underweight (O.R=1.56; C.I=1.10–2.21; p<0.05) compared to children in the higher-income group. Children whose fathers engaged in casual work were 2.15 and 1.69 times more likely to be at risk of stunting (O.R=2.15; C.I=1.26–3.67; p<0.001) and underweight (O.R=1.69; C.I=1.11–2.59; p<0.05) compared to those whose fathers engaged in regular work. Children with a lower level of father's education were 1.44, 1.40, and 1.34 times higher risk of stunting (O.R=1.44; C.I=1.04–2.01; p<0.05), wasting (O.R=1.40; C.I=1.03–1.90; p<0.05) and underweight (O.R=1.34; C.I=1.00–1.79; p<0.05) compared to higher level-educated father. The lower level of mother education was also a higher risk of wasting (O.R=2.65; C.I=1.93–3.64; p<0.001) and underweight (O.R=2.04; C.I=1.52–2.75; p<0.001) for children. The prevalence of underweight was 1.52 times higher risk among children in households without latrine facilities compared to

those in households with latrine facilities (O.R=1.52; C.I.=1.07–2.16; p=<0.05).

Children in households without separate kitchens were 1.86 and 1.94 times more likely to be at risk of wasting (O.R=1.86; C.I=1.12–3.07; p<0.05) and underweight (O.R=2.04; C.I.=1.18–3.19, p=<0.01) compared to those with separate kitchens. Use of firewood or leaves for cooking were 1.53, 1.51, and 1.87 times higher risk of stunting (O.R=1.53; C.I=1.02–2.31; p<0.05), wasting (O.R=1.51; C.I=1.05–2.18; p<0.05) and underweight (O.R=1.87; C.I=1.31–2.68; p<0.05) compared to those that cook with LPG.

Furthermore, multivariate logistic regression analyses were run to assess the simultaneous impact of different socio-demographic variables on undernutrition (Tables 7, 8 and 9). Regarding stunting, ten significant predictors of earlier statistics had lost their impact due to the influence of the remaining four dominant variables in the multivariate model. Among these four variables, non-exclusive breastfeeding was the most dominant predictor (wald-64.55; Exp (B)-5.69; p<0.001) followed by the second and higher birth order (wald-13.18; Exp (B)-2.01; p<0.001), mother's age at childbirth below 21 years (wald-11.39; Exp (B)-1.96; p<0.001) and low birth weight (wald-5.18; Exp (B)-5.69; p<0.05). The final model (4) also revealed that the percent variation in stunting explained by all these independent variables combined was 16.00 %, and the final model was entirely satisfactory.

Concerning wasting, among twelve significant variables, four socio-demographic variables lost significance due to the influence of the remaining seven variables in the multivariate model. Among these seven variables, lower-income households (Rs below 6500) (wald-46.98; Exp (B)-5.02; p<0.001) are the most dominant predictor followed by fewer household members (4 and below) (Wald-43.39; Exp (B)-3.28; p<0.001), lower level of mother education (below upper primary) (Wald-22.23; Exp (B)-2.33; p<0.001), no separate kitchens (Wald-8.90; Exp (B)-2.43; p<0.01), mother's age at childbirth below 21 years (wald-13.07; Exp (B)-1.97; p<0.001), non-exclusive breastfeeding (Wald-8.06; Exp (B)-1.93; p<0.01), and low birth weight (Wald-9.38; Exp (B)-1.82; p<0.01). The results of the final model show that the percent variation in wasting explained by all these independent variables combined was 22.20 %, and the variation explained in the final model was statistically significant.

Regarding underweight, among thirteen significant variables, five socio-demographic variables lost their significance due to the influence of the remaining eight variables in the multivariate model. Among these eight variables, lower-income households (Rs below 6500) (Wald -22.36; Exp (B)-2.61; p<0.001) was the most dominant predictor followed by non-exclusive breastfeeding (Wald -19.87; Exp (B)-2.63; p<0.001), mother's age at childbirth below 21 years (Wald -16.69; Exp (B)-2.04; p<0.001), second and higher birth order (Wald -16.27; Exp (B)-2.04; p<0.001), no separate kitchens (Wald -7.69; Exp (B)-2.13; p<0.01), lower level of mother education (below upper primary) (Wald -8.81; Exp (B)-1.64; p<0.01), and low birth weight (Wald -4.81; Exp (B)-1.49; p<0.05). Furthermore, the results of the final model also revealed that the percent variation in underweight explained by all these independent variables combined was 17.90%, and the variation explained in the final model was statistically significant.

Table 6. Risk of undernutrition among Muslim children in the study area

Background Characteristics		Stunting O.R (95% of C.I)	Wasting O.R (95% of C.I)	Underweight O.R (95% of C.I)
Mother's Age at Marriage	Child Marriage	1.50 (1.07–2.11)*	1.59 (1.17–2.16)**	1.59 (1.19–2.14)**
	Adult Marriage		Reference	
Mother's age at Childbirth	20 years & below	1.76 (1.23–2.51)**	1.65 (1.20–2.28)**	1.80(1.32–2.44)***
	21 years & above		Reference	
Birth Order	1st		Reference	
	2nd & more	1.50 (1.07–2.11)*	1.47 (1.08–2.00)*	1.82 (1.36–2.45)***
Sibling	No Sibling		Reference	
	Having Sibling	1.48 (1.05–2.08)*	1.55 (1.13–2.12)**	1.79 (1.32–2.43)***
Birth Weight	2.5 kg and above		Reference	
	Less than 2.5 kg	1.50 (1.04–2.17)*	1.76 (1.26–2.47)***	1.53 (1.10–2.13)**
Exclusive Breastfeeding	Yes		Reference	
	No	5.33 (3.54–8.03)***	2.03 (1.36–3.01)***	2.63 (1.77–3.90)***
Number of Family Members	4 & below		Reference	
	5 & above	1.01 (0.73–1.41)	2.73 (2.00–3.74)***	1.28 (0.96–1.71)
Household Income	Rs below 6500	1.70 (1.12–2.58)*	4.18 (2.82–6.18)***	3.00 (2.06–4.36)***
	Rs 6501 to 9000	1.23 (0.83–1.83)	1.50 (1.03–2.20)*	1.56 (1.10–2.21)*
	Rs more than 9001		Reference	
Father's Occupation	Casual	2.15 (1.26–3.67)**	1.27 (0.82–1.95)	1.69 (1.11–2.59)*
	Self	1.82 (1.03–3.19)*	1.10 (0.69–1.74)	1.33 (0.84–2.09)
	Regular		Reference	
Father's Education	Primary	1.44 (1.04–2.01)*	1.40 (1.03–1.90)*	1.34 (1.00–1.79)*
	Upper primary & above		Reference	
Mother's Education	Upper primary & lower	1.08 (0.78–1.50)	2.65 (1.93–3.64)***	2.04 (1.52–2.75)***
	High school & above		Reference	
Latrine facility	Yes		Reference	
	No	1.41 (0.95–2.08)	1.24 (0.86–1.78)	1.52 (1.07–2.16)*
Separate Kitchen	Yes		Reference	
	No	1.20 (0.68–2.11)	1.86 (1.12–3.07)*	1.94 (1.18–3.19)**
Cooking Fuel	Gas		Reference	
	Fairwood or leaves	1.53 (1.02–2.31)*	1.51 (1.05–2.18)*	1.87 (1.31–2.68)***

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Table 7. Multivariate logistic regression analyses between stunting (dependent outcome variables) and socio-demographic variables among the studied preschool children

Background Characteristics		Model-1		Model-2		Model-3		Model-4	
		Wald	Exp(B) (95% of C.I.)	Wald	Exp(B) (95% of C.I.)	Wald	Exp(B) (95% of C.I.)	Wald	Exp(B) (95% of C.I.)
Exclusive Breastfeeding	Yes				Reference				
	No	64.27	5.33 (3.54–8.03) ***	66.63	5.67 (3.74–8.59) ***	63.29	5.52 (3.62–8.40) ***	64.55	5.69 (3.72–8.69) ***
Birth Order	1				Reference				
	2 and above			8.43	1.70 (1.19–2.44) **	13.80	2.04 (1.40–2.97) ***	13.18	2.01 (1.38–2.93) ***
Age of Mother at Childbirth	21 years and above				Reference				
	20 years and below					12.03	1.99 (1.35–2.93)***	11.39	1.96 (1.33–2.90) ***
Birth Weight	2.5 kg and above				Reference				
	less than 2.5 kg							5.18	1.58 (1.07–2.33) *
R^2			0.115		0.130		0.152		0.160

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Table 8. Multivariate logistic regression analyses between wasting (dependent outcome variables) and socio-demographic variables among the studied preschool children

Background Characteristics		Model-1		Model-2		Model-3		Model-4	
		Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)
Household Income	More Rs than 9001				Reference				
	Rs below 6500	50.98	4.18 (2.82–6.18)***	53.35	4.55 (3.03–6.84)***	45.23	4.13 (2.73–6.24)***	44.38	4.14 (2.72–6.28)***
	Rs 6501 to 9000	4.39	1.50 (1.03–2.20)*	8.12	1.78 (1.20–2.64)**	6.29	1.67 (1.12–2.49)*	6.48	1.69 (1.13–2.54)*
Number of Family Members	4 & below				Reference				
	5 & above			40.58	2.91 (2.10–4.05)***	36.18	2.78 (1.99–3.89)***	42.39	3.14 (2.22–4.43)***
Mother's Education	High school & above				Reference				
	Upper primary& above					24.09	2.31 (1.65–3.22)***	24.16	2.34 (1.67–3.28)***
Age of Mother at Childbirth	21 years and above				Reference				
	20 years and below							15.09	2.02 (1.42–2.89)***
Separate Kitchen	Yes								
	No								
Birth Weight	2.5 kg and above								
	less than 2.5 kg								
Exclusive Breastfeeding	Yes								
	No								
Father's Occupation	Regular								
	Casual								
	Self								
R^2			0.095		0.164		0.202		0.225

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Table 8. (cont.)

Background Characteristics		Model-5		Model-6		Model-7		Model-8	
		Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)
Household Income	More than Rs 9001				Reference				
	below Rs 6500	45.39	4.26 (2.79–6.49)***	46.10	4.36 (2.85–6.66)***	42.77	4.16 (2.72–6.38)***	46.98	5.02 (3.17–7.96)***
	Rs 6501 to 9000	7.05	1.74 (1.16–2.61)**	7.53	1.77 (1.18–2.67)**	6.92	1.74 (1.15–2.62)**	8.97	1.94 (1.26–3.01)**
Number of Family Members	4 & below				Reference				
	5 & above	43.02	3.19 (2.26–4.52)***	42.98	3.21 (2.27–4.55)***	41.93	3.18 (2.24–4.52)***	43.39	3.28 (2.30–4.67)***
Mother's Education	High school & above				Reference				
	Upper primary& above	25.24	2.40 (1.71–3.38)***	23.25	2.33 (1.65–3.28)***	24.34	2.39 (1.69–3.38)***	22.23	2.33 (1.64–3.31)***
Age of Mother at Childbirth	21 years and above				Reference				
	20 years and below	14.11	1.99 (1.39–2.84)***	13.48	1.96 (1.37–2.82)***	11.85	1.89 (1.32–2.72)***	13.07	1.97 (1.36–2.84)***
Separate Kitchen	Yes				Reference				
	No	8.18	2.28 (1.30–4.01)**	8.02	2.27 (1.29–4.02)**	7.69	2.25 (1.27–3.98)**	8.90	2.43 (1.36–4.36)**
Birth Weight	2.5 kg and above				Reference				
	less than 2.5 kg			7.96	1.72 (1.18–2.51)**	8.51	1.76 (1.20–2.57)**	9.38	1.82 (1.24–2.67)**
Exclusive Breastfeeding	Yes				Reference				
	No					7.47	1.87 (1.19–2.94)**	8.06	1.93 (1.23–3.03)**
Father's Occupation	Regular				Reference				
	Casual							3.88	0.59 (0.35–0.0998)*
	Self							6.04	0.50 (0.29–0.87)*
R^2			0.237		0.249		0.259		0.268

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Table 9. Multivariate logistic regression analyses between underweight (dependent outcome variables) and socio-demographic variables among the studied preschool children

Background Characteristics		Model-1		Model-2		Model-3		Model-4	
		Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)
Household Income	More than Rs 9001				Reference				
	Below Rs 6500	32.95	3.00 (2.06–4.36)***	28.81	2.83 (1.94–4.14)***	23.31	2.59 (1.76–3.80)***	22.94	2.58 (1.75–3.80)***
	Rs 6501 to 9000	6.11	1.56 (1.10–2.21)*	5.36	1.52 (1.07–2.17)*	4.41	1.47 (1.03–2.10)*	4.30	1.47 (1.02–2.10)*
Exclusive Breastfeeding	Yes				Reference				
	No			18.67	2.43 (1.62–3.64)***	20.57	2.58 (1.71–3.89)***	18.45	2.48 (1.64–3.75)***
Mother's Education	High school & above				Reference				
	Upper primary& above					18.86	1.98 (1.45–2.69)***	18.53	1.97 (1.45–2.69)***
Age of Mother at Childbirth	21 years and above				Reference				
	20 years and below							18.45	2.48 (1.64–3.75)***
Birth Order	1st								
	2nd and subsequent								
Separate Kitchen	Yes								
	No								
Birth Weight	2.5 kg and above								
	Less than 2.5 kg								
R^2			0.057		0.087		0.118		0.135

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Table 9. (cont.)

Background Characteristics		Model-5		Model-6		Model-7	
		Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)	Wald	Exp(B) (95% of C.I)
Household Income	More than Rs 9001			Reference			
	Below Rs 6500	21.23	2.51 (1.70–3.72)***	22.02	2.58 (1.74–3.83)***	22.36	2.61 (1.75–3.88)***
	Rs 6501 to 9000	2.92	1.38 (0.95–1.99)	3.43	1.42 (0.98–2.05)	3.84	1.45 (1.00–2.10)*
Exclusive Breastfeeding	Yes			Reference			
	No	19.57	2.59 (1.70–3.94)***	19.24	2.58 (1.69–3.94)***	19.87	2.63 (1.72–4.03)***
Mother's Education	High school & above			Reference			
	Upper primary& above	9.12	1.64 (1.19–2.27)**	9.56	1.67 (1.21–2.31)**	8.81	1.64 (1.18–2.27)**
Age of Mother at Childbirth	21 years and above			Reference			
	20 years and below	18.33	2.10 (1.49–2.95)***	17.39	2.07 (1.47–2.91)***	16.69	2.04 (1.45–2.88)***
Birth Order	1st			Reference			
	2nd and above	16.42	2.03 (1.44–2.86)***	16.54	2.05 (1.45–2.89)***	16.27	2.04 (1.44–2.88)***
Separate Kitchen	Yes			Reference			
	No			7.85	2.15 (1.26–3.66)**	7.69	2.13 (1.25–3.65)**
Birth Weight	2.5 kg and above			Reference			
	less than 2.5kg					4.81	1.49 (1.04–2.12)*
R^2			0.160		0.172		0.179

Level of significance- *=p<0.05, **=<0.01 and ***=<0.001

Discussion

Better health status brings good human resources which adhere to the nation's well-being, whereas under five children are the base of the developing nation's demography, and well-nourished preschool children are the mirror of the nation's development. Although, the major causes of under-five morbidity and mortality is undernutrition (Hossain et al. 2023) in developing countries, including India (Benson and Shekar 2006). They may have chronic illness and physical disabilities compared to normal children (Asfaw et al. 2015). This study aims to observe the impacts of socio-demographic variables on undernutrition based on stunting, wasting, and underweight among rural Muslim preschool children. The prevalence of undernutrition was high in the studied children. Wasting refers to a critical life-threatening indicator, and it significantly elevates the risk of mortality if not effectively managed with proper treatment (Black et al. 2013). Underweight seems to be a significant contributing factor in child mortality globally, with an exceptionally high impact in developing countries (Chowdhury et al. 2018; Hossain et al. 2023).

The major findings of the present study revealed that socio-demographic variables were significantly associated with the undernutrition status of and predicted the nutritional status of the children. After designing several models using multivariate analysis, the results indicate that breastfeeding, birth order, age of mother at childbirth, birth weight, household income, number of family members, mother's education, separate kitchen, and father's occupation were the strong predictors of undernutrition among rural Muslim preschool children in the study area. Early childbearing is a significant issue in developing countries. Globally, 11% of births are to adolescent mothers, and developing nations contribute 95% of these births (WHO 2011). Early motherhood also raises the risk of premature birth, low birth weight, undernutrition, frequent illness, infant mortality, and poor growth in children (Tarigan et al. 2023; Fall et al. 2015). The present study also shows the same result. Twenty years of age of the mother at childbirth is the third strongest predictor of stunting and underweight and the fourth strongest predictor for wasting among Muslim preschool children. Birth order plays a crucial role in child undernutrition. Several studies have thoroughly documented that children with higher birth order face a greater risk of undernutrition compared to those of lower birth order (Rahman 2016; Dharmaraj et al. 2021; Dhingra and Pingali 2021). Higher birth order was the second most significant predictor of stunting and fourth for underweight among children in the study area.

According to WHO guidelines (2023), children born weighing less than 2.5 kg are classified as having low birth weight (WHO 2023c). Low birth weight significantly increases health risks in children as well as it is associated with undernutrition, different diseases (cough, diarrhoea, pneumonia), delayed growth and development, and the risk of mortality (Ntenda 2019; Jana et al. 2023). It is a leading cause of half of all premature deaths (Jana, Dey, and Ghosh 2023). In the study area, 24.38% of Muslim children are born with low birth weight, and models indicate that low birth weight is one of the strong predictors of stunting, wasting, and underweight. Exclusive breastfeeding plays a critical role in infants' health and in sustaining optimum

nutritional status in children (WHO 2023a). Children breastfed for less than 6 months are at risk of poor nutritional status along with higher rates of mortality and morbidity (Syeda et al. 2021; Scherbaum and Srour 2016). Several studies have found that it is one of the predictors of child undernutrition (Akter 2021; Khan and Islam 2017; Kumar and Singh 2015; Pereira et al. 2021). In the study, non-exclusive breastfeeding was the strongest predictor of stunting and the second strongest predictor of underweight. Income played a significant role in maintaining good health. Without economic self-sufficiency, a household cannot sustain the necessary quality and quantity of food required for balanced nutrition (Raghunathan et al. 2021). In developing countries, the majority of children face a high prevalence of undernutrition, which significantly delays their growth (McGovern et al. 2017; Rahma and Mutalazimah 2022). High household incomes contribute to better food quality, safe drinking water, improved sanitation, and the well-being of a family, which is related to child nutrition (Singh et al., 2019).

Multivariate regression suggests that household income is the strongest predictor of wasting and underweight. Large family members also influence the child's undernutrition, but this relationship is complex and influenced by socio-economic conditions and cultural practices (Faye, Fonn, and Kimani-Murage 2019). Several previous studies reported that children in large families are more likely to experience undernutrition compared to children in small families (Ahmed et al. 2016; Ghimire et al. 2020; Mandosir et al. 2023; Toma et al. 2023). The number of household members is the second strongest predictor of wasting among Muslim preschool children. Mother education plays a significant role in influencing undernutrition and is crucial for its reduction and prevention (Makoka and Masibo 2015; Prasetyo et al. 2023). An educated mother has been found to have an understanding of the importance of hygienic food, good feeding practices, recognition and causes of diseases, means of prevention and health management for their child, as well as other activities that promote the well-being of the child's health (Khattak et al. 2017; Kavosi et al. 2014). Mother education was the third strongest predictor of wasting and the fifth of being underweight. Occupation influences income, access to health care services, and quality and quantity of food available (Babar et al. 2010; Abraham et al. 2015; WHO 2017). Low-income households often struggle to provide nutritious food and cover medical expenses for their children, resulting in undernutrition (French et al. 2019). Therefore, child undernutrition is very high in developing countries, including India (Vyas et al. 2011).

This study also suggests that the father's occupation is one of the strongest predictors of wasting and the second strongest predictor of being underweight, and fathers seem to be the main earning member of the family. World Health Organization (2023) states that air pollution within the household was responsible for an estimated 3.2 million deaths of children under the age of 5 years (WHO 2023b), and cooking in living rooms may be the primary cause of household air pollution. Although the present study did not estimate household pollution, the relationship between smoking and undernutrition has not been examined. This study treats separate kitchens as socio-economic indicators. However,

a study also reported that children from households without separate kitchens have frequently experienced undernutrition (Mondal and Paul 2020). The present study also found that a separate kitchen is one of the strongest predictors of wasting and being underweight. This determinant is considered a proxy indicator of socio-economic status. The present study revealed that there are several determinants of the different forms of undernutrition among the studied children. These determents comprise socio-economical, demographic as well as socio-behavioral. The optimal living standards are very scarce among the studied children. The economic upliftment may bring the optimal living standard which accompanies the good health and nutritional status of the younger children.

Conclusion

The present study finds that undernutrition seems to be a serious health among rural Muslim preschool children in the study area. Exclusive breastfeeding, household income, mother's age at childbirth, birth weight, maternal educational status, household income, separate kitchen, and birth order are significant predictors of childhood nutritional status. Therefore, the appropriate authorities should take effective policies of skill enhancement programs aimed at boosting household income, which can directly contribute to better nutritional outcomes. Additionally, the government should actively promote awareness programs that focus on educating communities about essential issues like the importance of exclusive breastfeeding, low birth weight, child health, eliminating child marriage, mother education, and family planning. Also, promoting the involvement of Non-government Organizations (NGOs) is a prerequisite for implementing different awareness programs and strategies to improve child health and nutritional status.

Institutional Ethical Approval

The present study was approved by the Institutional Ethical Committee of the Institution of the Sidho-Kanho-Birsha University (Ref. No. R/IEC/406/SKBU/2023 dated 24.03.2023, with effect from July 2022). The information provided by participants was kept confidential by excluding personal identifiers from the schedule. Parents of the children's convenience was a priority in this study during data collection, and we respected their rights as participants. We also confirm that all methods and procedures were carried out in accordance with the relevant guidelines and regulations (Helsinki Declaration).

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Author statement

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Authors' contributions

SAH: Originated study ideas, drafted and designed research, performed the statistical analysis and interpretation of results and primarily drafted a manuscript. MDA: Compiled and designed the study, providing direction and supervision. KB: Revised the manuscript. SB supervised the study and finalized the manuscript.

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