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RESEARCH ARTICLE

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Assessing the double burden of malnutrition among Bangladeshi reproductive-aged women: A comparison between unconditional and conditional quantile regression

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Abstract

Background and Aims: The coexistence of undernutrition and overnutrition creates a double burden of malnutrition (DBM) among women in Bangladesh. This study aimed to assess heterogeneous effects of sociodemographic factors on women's nutritional status using quantile regression (QR) models and to investigate the differences between the results of unconditional QR (UQR) and conditional QR (CQR) models.

Methods: A sample of 17 285 nonpregnant women aged 15 to 49 years was extracted from the latest Bangladesh Demographic and Health Survey, 2017-2018. Women's nutritional status was determined using body mass index (BMI). The UQR and CQR were used to estimate the heterogeneous effects of sociodemographic factors on women's BMI.

Results: Results show that the estimated effects of sociodemographic factors varied across the BMI distribution. For the same quantile, the effects differed between UQR and CQR. For instance, education was significantly positively associated with BMI. In UQR, secondary educated women achieved an increase of 0.996 and 1.720 in BMI at 10th and 90th quantiles, respectively, compared to noneducated women, whereas conditional effects were 1.336 and 1.492 at 10th and 90th quantiles, respectively, in CQR. These results also indicate secondary education appeared to have a lesser (or higher) impact in the lower (or upper) tail of BMI distribution, and unconditional and conditional effects for the same quantile varied notably. Other factors such as women's age, occupation, household wealth, number of children ever born and household size, religion, and place of residence were significantly associated with BMI and showed heterogeneous effects.

Conclusion: Overall, there is a need to focus on heterogeneous effects of factors on women's nutritional status. Patterns of unconditional heterogeneous effects would be more informative than conditional heterogeneous effects while studying factors' effects. These findings may aid in developing strategies targeting high-risk groups to combat the double burden of malnutrition.

KEYWORDS
Bangladesh, double burden, malnutrition, quantile regression, reproductive age

1 | INTRODUCTION

The double burden of malnutrition (DBM) or coexistence of undernutrition and overnutrition is a serious public health concern in many developing countries[1] that triggers a shift in disease profile from infectious diseases to a chronic degenerative pattern.[2] This DBM could be owing to their growing economy, rapid urbanization, demographic, and nutritional transition.[3-5] According to the World Health Organization (WHO) estimates, in 2014, globally, about 462 million adults were underweight, while 1.9 billion adults were overweight/obese.[6] Assessing DBM among reproductive-aged women is important due to their negative effects on women and child health. Undernutrition among women can increase the risk of unfavorable pregnancy outcomes such as low birth weight, preterm birth, and neonatal death.[7-9] Besides, overnutrition can increase the risks of maternal morbidity, fetal death, stillbirth, and infant mortality.[9,10] Moreover, overnutrition is a major risk factor for noncommunicable diseases such as heart disease and stroke, diabetes, musculoskeletal disorders, and cancers (eg, endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon).[11] Maternal overnutrition also has intergenerational effects; for example, the children of overnourished women are at an increased risk of being overnourished.[12] Understanding the distribution of DBM among women and their determinants in developing countries is necessary to develop preventive strategies.

Bangladesh, a developing country of South Asia, is going through a nutritional transition; therefore, the prevalence of overweight/obesity is rapidly increasing (eg, from 3% in 1996-1997 to 32% in 2017-2018 among ever-married women aged 15-49 years), while the prevalence of underweight is decreasing (eg, from 52% in 1996-1997 to 12% in 2017-2018).[13] With the rapid rise in overnutrition alongside improving, still significant undernutrition indicates a double burden of malnutrition among women in Bangladesh, which is more likely to pose serious health system challenges. In Bangladesh, however, undernutrition has been prioritized in nutrition policies so far, compared to overnutrition. Therefore, it is necessary to revisit the policies and to focus on the DBM. It is also essential to comprehend the determinants of DBM to formulate appropriate policies.

Previous evidence shows that different factors are associated with body mass index (BMI) and underweight or overweight/obesity among women in Bangladesh.[14-18] Earlier research has categorized the BMI and used categorical data models to measure associations with different factors.[14] However, categorizing a continuous variable is linked to information loss and analytical complexities,[19] and hence it is more meaningful to measure BMI on a continuous scale. An earlier study used a mean-based model to assess the association between different factors and BMI,[18] which may mask the complete picture of the relationship and differential effects of factors on BMI. For example, women's working status was significantly inversely associated with BMI across all quantiles (except the lowest), and the magnitude of effects also varied across quantiles, but mean-based model did not capture these heterogeneous effects.[20] This means that working status may have different effects on undernutrition and overnutrition. There is a paucity of research in Bangladesh using the quantile-based model to estimate the heterogeneous effects of factors on women's nutritional status.[20,21]

Earlier studies have used conditional quantile regression (CQR) to estimate the heterogeneous effects of covariates on the conditional distribution of BMI.[20,21] However, CQR assessed a covariate's effect on a quantile of the BMI conditional on other covariates' specific values. Based on this CQR result, policymakers might select women with a particular BMI threshold for policy design; however, this threshold can fall into various quantiles depending on women's observed characteristics. Under this circumstance, the effect of a unit change of a covariate on the BMI distribution (keeping all other covariates constant) leads to more meaningful interpretation, which can be acquired using unconditional quantile regression (UQR).[22] The UQR enables us to assess the relationship between covariates and BMI across the unconditional (marginal) BMI distribution.[23] Moreover, the results of CQR and UQR are not necessarily equivalent and may differ substantially.

So far as we know, there is no research in Bangladesh to assess the heterogeneous effects of sociodemographic factors on women's unconditional BMI distribution and compare them with heterogeneous effects of factors on women's conditional BMI distribution. Since sociodemographic factors and policy measures can have different effects on women's nutrition at different points along the nutritional spectrum, assessing unconditional effects over conditional effects can inform policies about specific risk groups, which can assist policymakers in combating this health burden. This study aimed to (a) assess sociodemographic factors' heterogeneous effects on the unconditional and conditional BMI distribution using QR models, and (b) compare the results of UQR with the results of CQR.

2 | MATERIALS AND METHODS

2.1 | Study design

Study data were compiled from the latest Bangladesh Demographic and Health Survey (BDHS) 2017-2018 that was conducted by the collaboration between NIPORT, Mitra & Associates, and ICF International. This nationally representative cross-sectional survey aimed to provide quality data on different indicators (eg, sociodemographic, health, and nutrition) to assist in evidence-based policymaking.[13] This survey used a stratified two-stage cluster sampling to draw a representative sample, and the survey report describes the survey design and data collection process.[13] Ethical clearance to conduct the BDHS 2017-2018 was obtained from the National Research Ethics Committee of the Bangladesh Medical Research Council (Dhaka, Bangladesh) and ICF Macro Institutional Review Board (USA). All individuals provided consents before each survey interview and anthropometric measurements. Confidentiality and anonymity were ensured at all stages in accordance with international ethical standards. This present study used publicly available secondary datasets of BDHS 2017-2018, which are available on request at the DHS program website (http://dhsprogram.com/data/available-datasets.cfm).

2.2 | Analytic sample preparation

The women's records file of BDHS 2017-2018 contained data of 20 127 women aged 15 to 49 years. The final analytic sample of the present study included 17 285 women, excluding any women who were not a usual resident of the household (n = 1636), who were pregnant (n = 927), and who had missing values in BMI (n = 272) and occupational status (n = 7).

2.3 | Outcome of interest

Women's BMI, an indicator of nutritional status, was the outcome variable of interest. BMI is defined as weight in kilogram divided by height in meters squared (or kg/m^2).[13] Women's anthropometric data were measured by trained personnel using standardized techniques during the survey interview.[13]

2.4 | Explanatory variables

The present study included a set of sociodemographic and community variables; women's age (years), religious status (ie, Muslim, non-Muslim), number of children ever born (CEB), education status of women (ie, no education, primary, secondary, higher), women's occupation (ie, not working, white-collar job, and blue-collar job), women's TV watching frequency (ie, no or less than once week, at least once a week), household size (ie, number of household members), household wealth index (ie, poor, middle, rich), and place of residence (ie, urban/rural). During the survey interview, each woman was asked if she works or has worked in the past 12 months, and this information was used to define occupation status. In this study, women's occupational status was classified into the following classes: not working, white-collar job (ie, professional, technical, managerial, clerical, sales and services), and blue-collar job (ie, agriculture (employee), agriculture (self-employed), household and domestic, skilled and unskilled manual laborers).[24] The household wealth index was constructed in this survey using household asset data through principal component analysis, and the resulting score was classified into five classes (ie, poorest, poorer, middle, rich, and richest) based on quintiles.[13] The poorest and poorer classes were merged into the poor class in this study, while the richest and richer classes were merged into the rich class.

2.5 | Analytical strategy

Descriptive analyses were performed to summarize the analytic sample. To estimate the heterogeneous effects of factors on BMI distribution, we used QRs at the 10th, 25th, 50th, 75th, and 90th quantiles. In the QR framework, the CQR is the commonly used model for evaluating the heterogeneous effects of a covariate on the dependent variable's conditional distribution (eg, BMI). That means CQR assesses a covariate effect on a quantile of dependent variable conditional on specific values of other covariates considered in the model.[23] The interpretation of the effects is limited when the effects are different for different conditional quantiles. Consequently, the estimates may result in a loss of generalizability or interpretability in the context of policy or population.[23] A sophisticated approach to overcome these limitations is UQR, where estimated effects do not depend on the set of covariates in the model.[22] The UQR comprises running a regression of the re-entered influence function (RIF), a robust estimation technique that regresses the influence function of the unconditional quantile of the dependent variable on the covariates.[25] In UQR, RIF is defined as follows[25]:

$$\mathrm{RIF}(Y;q_\tau,F_Y) = q_\tau + \frac{\tau - I[Y \le q_\tau]}{f_Y(q_\tau)},$$

where τ is a given quantile, q_τ is the value of the dependent variable Y (eg, BMI) at the τth quantile.[25] $f_Y(q_\tau)$ is the density function of Y at q_τ, and F_Y is the cumulative distribution function of Y.[25] I is an indicator variable, which takes the value 1 when the value of Y is less than the corresponding τ.[25] To obtain UQR estimates using ordinary least squares, RIF is regressed on the explanatory variables X.[25] Standard errors of coefficients are calculated using bootstrap with 1000 replications. All statistical analyses were performed using the statistical software R version 4.0.3.[26]

3 | RESULTS AND DISCUSSION

3.1 | Descriptive statistics

Table 1 presents descriptive statistics of the analytic sample. Women's average BMI was 23.3 kg/m^2, which was higher than Asian women's normal BMI range of 18.5-23.0 kg/m^2[27]). Among them, about 38.2% women were in normal-weight group, where 49.6% and 12.2% were overweight/obese (23.0-27.5/≥27.5 kg/m^2) and underweight (<18.5 kg/m^2), respectively. The average age was 32.6 years (SD 9 years). The median number of CEB and household members was 2 and 5, respectively. Nearly half of the women had no formal education or only primary education, and most (46.9%) had no working status. More than half of the women watched TV at least once a week. The majority of the women were Muslim, reflecting the country's overall religious affiliation. In the sample, most women were from affluent households and resided in rural areas.

3.2 | Comparison between unconditional and conditional quantile regression models

Table 2 reports and compares the estimates of UQR and CQR for five selected quantiles (10th, 25th, 50th, 75th, and 90th). Figures S1 and S2 depict the graphical representation of the findings of UQR and CQR, respectively, demonstrating how sociodemographic factors' effects on women's BMI varied across quantiles. Our results show that different sociodemographic factors considered in this analysis were significantly related to BMI, but the relationships were heterogeneous across BMI quantiles. Though both models provide information about the heterogeneous effects of factors, CQR shows conditional effects, whereas UQR shows unconditional effects. It is worth noting that, unlike the conditional effect, the unconditional effect can be viewed in terms of the population for which the estimates are made.

In this study, age is an important driver of BMI among women in Bangladesh. Results show that age had a significant positive association with BMI, but effects varied across the unconditional and conditional BMI distribution. These heterogeneous effects are in line with an earlier study.[20] Quantile models find that the coefficients were larger in magnitude as we move from the 10th to the 90th quantiles. The effect of women's age at 90th quantile was almost 2.5 times the estimate at 10th quantile in the UQR, which was almost 2.1 times in the CQR. Though unconditional effects represented the marginal effects of age on BMI, conditional quantile effects represented age's effects on BMI dependent on the other covariates' values. The results also show that the unconditional and conditional effects for the same

TABLE 1 Characteristics of the analytic sample, categorical, and continuous variables

	Descriptive statistics					
	Mean	Median	SD	Min	Max	IQR
Women's BMI (kg/m^2)	23.3	23.0	4.3	12.2	59.5	5.8
Women's age (years)	32.6	32.0	9.0	15	49	15
Number of CEB	2.5	2.0	1.6	0	13	2
Household size	5.1	5.0	2.4	1	30	2
			n			%
Women's BMI (kg/m^2) group[a]						
<18.5			2101			12.2
18.5-23.0			6612			38.2
23.0-27.5			5815			33.6
≥27.5			2757			16.0
Women's education						
No education			3010			17.4
Primary			5648			32.7
Secondary			6467			37.4
Higher			2160			12.5
Women's occupation						
Blue collar			7789			45.1
Not working			8107			46.9
White collar			1389			8.0
Watching TV						
No/less than once a week			7990			46.2
At least once a week			9295			53.8
Religious status						
Muslim			15 530			89.8
Non-Muslim			1755			10.2
Household wealth status						
Poor			6622			38.3
Middle			3360			19.4
Rich			7303			42.3
Place of residence						
Urban			6324			36.6
Rural			10 961			63.4

Abbreviations: BMI, body mass index; CEB, children ever born; IQR, interquartile range; SD, standard deviation.
[a]According to the Asian populations cut-points.

TABLE 2 Multivariable unconditional and conditional quantile regression analysis of the association between factors and women body mass index (kg/m^2)

	Unconditional quantile regression (UQR)					Conditional quantile regression (CQR)				
	$\beta_{10\%}$ (95% CI)	$\beta_{25\%}$ (95% CI)	$\beta_{50\%}$ (95% CI)	$\beta_{75\%}$ (95% CI)	$\beta_{90\%}$ (95% CI)	$\beta_{10\%}$ (95% CI)	$\beta_{25\%}$ (95% CI)	$\beta_{50\%}$ (95% CI)	$\beta_{75\%}$ (95% CI)	$\beta_{90\%}$ (95% CI)
Intercept	15.572 (15.388, 15.763)	15.876 (15.656, 16.049)	16.927 (16.703, 17.123)	19.405 (19.121, 19.645)	21.444 (20.977, 21.85)	14.797 (14.347, 15.247)	15.694 (15.209, 16.18)	17.188 (16.694, 17.682)	19.408 (18.875, 19.942)	21.388 (20.409, 22.368)
Women's age	0.059 (0.055, 0.062)	0.096 (0.092, 0.100)	0.134 (0.130, 0.139)	0.141 (0.136, 0.146)	0.147 (0.139, 0.155)	0.076 (0.066, 0.086)	0.101 (0.089, 0.113)	0.124 (0.112, 0.136)	0.140 (0.127, 0.153)	0.157 (0.135, 0.179)
Women's education (Ref. No education)										
Primary	0.587 (0.544, 0.624)	0.894 (0.853, 0.92)	1.205 (1.169, 1.255)	1.154 (1.102, 1.207)	1.034 (0.973, 1.114)	0.759 (0.561, 0.956)	0.887 (0.677, 1.097)	1.150 (0.934, 1.365)	1.175 (0.880, 1.470)	1.068 (0.688, 1.448)
Secondary	0.996 (0.918, 1.045)	1.488 (1.430, 1.556)	1.856 (1.791, 1.926)	1.697 (1.633, 1.783)	1.720 (1.606, 1.848)	1.336 (1.135, 1.537)	1.563 (1.329, 1.797)	1.694 (1.460, 1.928)	1.654 (1.356, 1.953)	1.492 (1.084, 1.900)
Higher	1.083 (1.014, 1.156)	1.821 (1.752, 1.89)	2.252 (2.191, 2.345)	1.998 (1.917, 2.09)	1.913 (1.797, 2.062)	1.766 (1.434, 2.097)	2.000 (1.697, 2.303)	2.037 (1.740, 2.333)	1.940 (1.524, 2.357)	1.341 (0.831, 1.850)
Women's occupation (Ref. blue collar)										
Not working	−0.114 (−0.140, −0.098)	0.068 (0.049, 0.085)	0.376 (0.357, 0.390)	0.534 (0.502, 0.557)	0.738 (0.702, 0.793)	0.024 (−0.135, 0.182)	0.214 (0.055, 0.373)	0.363 (0.210, 0.515)	0.386 (0.198, 0.575)	0.573 (0.283, 0.863)
White collar	−0.102 (−0.117, −0.084)	−0.156 (−0.192, −0.100)	−0.243 (−0.257, −0.230)	−0.168 (−0.211, −0.143)	0.061 (0.049, 0.078)	−0.193 (−0.480, 0.095)	−0.142 (−0.416, 0.133)	−0.181 (−0.473, 0.111)	−0.156 (−0.567, 0.256)	0.068 (−0.393, 0.529)
Watching TV (Ref. No or less than once a week)										
At least once a week	0.479 (0.454, 0.525)	0.735 (0.714, 0.766)	0.853 (0.815, 0.875)	0.717 (0.686, 0.743)	0.997 (0.932, 1.053)	0.604 (0.463, 0.744)	0.709 (0.550, 0.869)	0.768 (0.597, 0.939)	0.780 (0.580, 0.979)	1.022 (0.714, 1.330)
Number of CEB	−0.004 (−0.013, −0.001)	0.026 (0.021, 0.032)	−0.073 (−0.076, −0.058)	−0.106 (−0.110, −0.101)	−0.070 (−0.082, −0.059)	−0.008 (−0.063, 0.048)	−0.021 (−0.085, 0.042)	−0.027 (−0.096, 0.041)	−0.068 (−0.153, 0.017)	−0.107 (−0.220, 0.007)
Religious status (Ref. Muslim)										
Non-Muslim	−0.216 (−0.246, −0.174)	−0.283 (−0.305, −0.264)	−0.506 (−0.55, −0.471)	−0.499 (−0.534, −0.478)	−0.515 (−0.586, −0.467)	−0.220 (−0.450, 0.011)	−0.395 (−0.605, −0.185)	−0.434 (−0.654, −0.214)	−0.392 (−0.687, −0.098)	−0.515 (−0.930, −0.101)
Household size	−0.020 (−0.021, −0.015)	−0.055 (−0.059, −0.051)	−0.063 (−0.07, −0.059)	−0.044 (−0.046, −0.042)	−0.033 (−0.038, −0.029)	−0.033 (−0.067, 0.000)	−0.029 (−0.064, 0.006)	−0.051 (−0.083, −0.02)	−0.044 (−0.091, 0.003)	−0.043 (−0.109, 0.023)

(Continues)

TABLE 2 (Continued)

	Unconditional quantile regression (UQR)					Conditional quantile regression (CQR)				
	$\beta_{10\%}$ (95% CI)	$\beta_{25\%}$ (95% CI)	$\beta_{50\%}$ (95% CI)	$\beta_{75\%}$ (95% CI)	$\beta_{90\%}$ (95% CI)	$\beta_{10\%}$ (95% CI)	$\beta_{25\%}$ (95% CI)	$\beta_{50\%}$ (95% CI)	$\beta_{75\%}$ (95% CI)	$\beta_{90\%}$ (95% CI)
Household wealth status (Ref. middle)										
Poor	−0.755 (−0.843, −0.725)	−0.957 (−1.004, −0.918)	−0.940 (−0.98, −0.911)	−0.549 (−0.597, −0.506)	−0.170 (−0.194, −0.134)	−0.497 (−0.685, −0.309)	−0.653 (−0.836, −0.470)	−0.727 (−0.952, −0.502)	−0.846 (−1.086, −0.606)	−0.797 (−1.160, −0.435)
Rich	0.400 (0.379, 0.420)	0.561 (0.537, 0.585)	0.966 (0.922, 1.000)	1.542 (1.492, 1.615)	1.660 (1.552, 1.734)	0.791 (0.580, 1.001)	0.852 (0.650, 1.055)	1.067 (0.830, 1.304)	1.145 (0.886, 1.404)	1.302 (0.938, 1.665)
Place of residence (Ref. rural)										
Urban	0.127 (0.111, 0.143)	0.307 (0.268, 0.327)	0.504 (0.487, 0.524)	0.721 (0.701, 0.756)	0.973 (0.902, 1.047)	0.211 (0.043, 0.378)	0.356 (0.174, 0.538)	0.527 (0.354, 0.701)	0.661 (0.453, 0.868)	0.746 (0.445, 1.046)

Abbreviations: CEB, child ever born; CI, confidence interval; CQR, conditional quantile regression; Ref., reference category; UQR, unconditional quantile regression.

quantile could be different. According to our results, older age is a protective factor for women's undernutrition but a risk factor for overnutrition. The increased risk of overnutrition with age could be attributed to fewer opportunities or reluctance for regular physical activity due to numerous family responsibilities and daily work–related stress.

Women's education, an important socioeconomic status (SES) marker, had a significant and positive association with BMI in UQR and CQR. These results align with a related study, which assessed women's education and BMI relationship using CQR.[20] In UQR, compared to women with no formal education, women with higher education had higher BMI, with effects rising from 1.083 (10th quantile) to 2.252 (50th quantile) and then steadily decreasing to 1.913 at 90th quantile. The higher education status of women depicted a similar pattern of association with BMI in CQR. However, unconditional and conditional effects of education on women's BMI for the same quantile varied notably. For primary and secondary educated women, the patterns of relationships across the quantiles were nearly similar to what this study found for higher educated women. The positive relationship between any education and BMI (at lower tail of distribution) could be explained by better knowledge of healthy foods, awareness of the impacts of undernutrition, and greater access to resources through empowerment. In contrast, higher sedentary occupations with less physical activity, and higher consumption of caloric ready-made or processed foods, could explain the positive relationship between education and BMI (at upper tail of distribution). Education is important for women's nutritional outcomes and would be a vital component in designing and implementing interventions to combat the DBM among women in Bangladesh.

This study also investigated the relationship between women's occupation (a marker of SES) and BMI. Though women's occupation had a significant association with BMI in both models, the results were inconsistent. According to UQR and CQR, women who were not working in the last 12 months were significantly positively related to BMI at the 25th, 50th, 75th, and 90th quantiles, compared to women with blue-collar jobs. These relationships could be attributed to decreased physical activity. Conversely, women who were not working tended to have lower BMI at 10th quantile in UQR (not in CQR), which could be attributed to a lack of income and food availability. Compared to women engaged in blue-collar jobs, women with white-collar jobs had a negative association with BMI at 10th, 25th, 50th, and 75th quantiles in UQR. White-collar workers are more likely than blue-collar workers to have a higher economic condition, resulting in better nutritional status. However, negative associations between white-collar jobs and BMI at low to mid-upper tail in this study could be explained by other unmeasured factors. For instance, at the lower BMI tail, these negative associations might result from time devoted to work and intensity of work, while access to healthy food and better dietary practice could explain negative associations in the mid-upper BMI tail. In contrast, white-collar working status had a positive association with BMI at 90th quantile in UQR, which could be owing to sedentary lifestyle and consumption of calorie-dense foods. White-collar job status was not significantly related to women's BMI in CQR. These findings are perplexing, given that only 8% of the women in this sample had white-collar jobs (as per descriptive analysis), and education was found to positively affect women's nutritional status (as per regression analysis). Further research is necessary to comprehend the underlying mechanism of these results.

Furthermore, watching TV once a week was linked to a higher BMI across all quantiles in UQR, with varying magnitudes across the BMI distribution. The effect of watching TV once a week at the 90th quantile (0.997) was almost 2.1 times the estimated effect at the 10th quantile (0.479), compared to those with no or less exposure to TV. Similar to the UQR, the CQR coefficients for women who watched TV at least once a week were positive and significant across all the quantiles; however, there was a notable difference in the effect sizes for the same quantile between UQR and CQR. The heterogeneous positive effects of watching TV on BMI align with an earlier study.[28] Exposure to TV is likely to increase women's knowledge and awareness about the consumption of healthy/nutritious foods and the negative impact of malnutrition because different media campaigns are likely to be designed to disseminate information about women's nutrition and the necessity of increasing the consumption of healthy foods while decreasing the consumption of calorie-dense foods. Besides, positive relationships between TV watching and BMI at the upper quantile (ie, overnourished women) may be explained by a lower level of physical activity and an increased calorie consumption due to advertising. This study did not look at TV viewing duration and pattern, so more research would be needed to understand these relationships fully.

Another factor, the increased number of CEB was inversely related to BMI across all quantiles (except 25th quantile) in UQR; however, number of CEB variable was not significantly related to BMI in CQR. An additional child was associated with a −0.004 and −0.070 decrease in BMI at 10th and 90th quantiles. The inverse relationship between CEB and BMI is in line with an earlier study in the literature.[14] Similarly, increased household size was found to be inversely related to women's BMI across all quantiles in UQR, although this association was not significant in CQR. Though the mechanisms underlying this relationship remain unknown, having more children and living in a larger family may influence a woman's nutritional status through a complex pathway that includes biological, SES, food security, diet quality, homemade food intake, and health-care access. These findings, however, warrant further study since these two characteristics are important for developing policies. Religion was also found to be inversely related to women's BMI. Non-Muslim women had a lesser BMI than Muslim women across all quantiles in UQR and CQR, except for the 10th quantile in CQR. Religion had the greatest impact on the upper tail of the unconditional BMI distribution (ie, overnourished women) and the least impact on the lower tail (ie, undernourished women), which could be explained by differences in dietary habits and cultural influences. Given that most Bangladeshis are Muslims, the role of religion may need to be taken into account during policy development and implementation.

A key SES marker, household wealth, was significantly related to BMI, with heterogeneous effects across BMI quantiles, in line with an earlier study.[20] Relative to women living in middle-class households, women from wealthy households tended to have higher BMI, with the least effect at 10th quantile (0.400) and the greatest effect at 90th quantile (1.660). Wealthy households, like UQR, showed positive effects across the conditional BMI distribution in CQR; however, effects for the same quantile differed significantly between UQR and CQR. In the low-BMI group, wealthy household plays protective roles against possible undernutrition, which could be due to higher food security and greater access to healthy foods. In contrast, high-BMI group women experienced a large effect of rich wealth status, which could be attributed to a higher sedentary lifestyle and processed foods consumption. Poor household wealth status showed a negative association with BMI across all quantiles in both models. However, stronger negative effects were noticed for women with lower BMI (10-50th quantiles) in UQR, which was not evident from CQR. A possible reason for the stronger effects in the low-BMI group could be the household food security and lesser access to nutritious foods. In a nutshell, the highest burden of undernutrition and overnutrition remains primarily within the poor and the wealthier households, respectively; however, these effects are expected to be changed as Bangladesh is experiencing a nutritional transition.[29]

Furthermore, significant urban–rural differences in women's nutritional status were observed in this study. Women residing in urban areas had significant and positive associations with BMI across all quantiles in both models, compared to women living in rural areas. Effects of residing in urban areas increased monotonically from the bottom to the top of the unconditional and conditional BMI distributions; however, effect sizes were substantially different between two models (eg, 0.127 in UQR vs 0.211 in CQR at 10th quantile; and 0.973 in UQR and 0.746 in CQR at 90th quantile). This study's results could be attributable to urbanization and nutrition transition, for example, rural to urban migration, the adaptation of urban lifestyle, and changing food habits. Overall, variations in DBM between rural and urban areas may be due to rising socioeconomic disparities, which are important for policy formulation and intervention design.

Overall, this study contributes to the literature in several ways. This study is among the few to consider the quantile models to assess varying effects of sociodemographic factors on women's nutritional status in Bangladesh. In particular, findings of unconditional model are promising because they provide health policymakers with knowledge about the heterogeneous effects of factors and enable them to target specific groups of women for interventions, such as those with a BMI of 10% or less and those with a BMI of 90% or more; however, these thresholds in conditional models may fall within different BMI quantiles. This study has other strengths aside from methodological advancement. Large-scale nationally representative data aids in the generalization of study findings among nonpregnant women in Bangladesh. The results are less prone to outliers, more robust, and practically applicable.

Based on the findings of this study, the following policy recommendations for dealing with DBM among Bangladeshi reproductive-aged women could be proposed. For example, enhancing women's overall SES (such as education, occupation, and wealth status) may enhance access to income, purchasing power, and food affordability, but this is not sufficient because the risk of overnutrition among women increases as SES improves. As a result, more systematic educational and awareness campaigns promoting behavioral change (eg, physical activity, dietary pattern) are essential. Besides, better health literacy and nutritional education are important to comprehend the necessity of improved nutritional status and change societal perception. In parallel, it is essential to address the obesogenic urban environment as Bangladesh is experiencing rapid urbanization. Furthermore, increasing access to healthier foods, reducing calorie-dense food intake, and reducing socioeconomic inequalities, especially among the urban poor, are necessary.

4 | LIMITATIONS OF THE STUDY

Despite the unique strengths, there are some limitations to this study. First of all, the study was limited to only nonpregnant women aged 15 to 49 years; thus, the results are not generalizable for women of all age groups. Second, since this study used cross-sectional data, the findings need to be interpreted with caution as it had no scope to assess the causal relationship. Third, this study did not evaluate some factors related to DBM, such as dietary habits, physical activity, sleeping nature, disease profiles, family history, and residential area environmental features (eg, density of fast-food shops, availability of parks) due to lack of data. Furthermore, statistical models did not consider spatial contextual autocorrelation, which may influence the estimated associations. Acknowledging these limitations paves the way for future research.

5 | CONCLUSION

This study investigated the complex association between sociodemographic factors and women's BMI in Bangladesh using large-scale national-level data and quantile models. There was notable heterogeneity in the effects of sociodemographic factors across the conditional and unconditional BMI distribution. Besides, unconditional and conditional effects for the same quantile also varied. Compared to conditional heterogeneous effects (CQR), unconditional heterogeneous effects of factors based on UQR may have greater public health significance. These UQR model results would aid in identifying sociodemographic risk factors and the most vulnerable women to intervene. Practical strategies such as educational and awareness initiatives targeting low- and high-BMI groups can help combat the DBM. Furthermore, assessing these selected sociodemographic features is insufficient to understand DBM; further studies are needed to evaluate the effects of some other potential risk factors (eg, dietary habits, physical activity, environmental features) and the underlying mechanism.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTIONS

Conceptualization: Jahidur Rahman Khan.
Methodology: Jahidur Rahman Khan, Jahida Gulshan.
Formal Analysis: Jahidur Rahman Khan.
Supervision: Jahida Gulshan.
Validation: Jahida Gulshan.
Visualization: Jahidur Rahman Khan.
Writing—Original Draft Preparation: Jahidur Rahman Khan, Jahida Gulshan.
Writing—Review and Editing: Jahidur Rahman Khan, Jahida Gulshan.

All authors have read and approved the final version of the manuscript.

Jahidur Rahman Khan, as the first author, confirms having full access to all of the data and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

TRANSPARENCY STATEMENT

Jahidur Rahman Khan confirms that the manuscript is an honest, accurate, and transparent account of the study being reported, and no important aspects of the study have been omitted.

DATA AVAILABILITY STATEMENT

This study used secondary 2017 to 2018 Bangladesh demographic and health survey, which is available in the DHS program website: http://dhsprogram.com/data/available-datasets.cfm.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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