Socioeconomic inequalities affecting adult obesity in rural Bangladesh: Evidence from the Bangladesh Integrated Household Survey

By

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A thesis is submitted to the Department of Economics and Social Science in partial fulfillment of the requirements for the degree of M.SC in Applied Economics.

Department of Economics and Social Science

BRAC University

Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing degree at Brac University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

4. I have acknowledged all main sources of help.

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Approval

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Abstract

The rising prevalence of obesity represents an important public health issue. The burden of obesity is increasing in the world as well as in Bangladesh. This research aims to know whether socioeconomic inequality exists in obesity in rural Bangladesh and what is the magnitude of the inequality. Study has used Bangladesh Integrated Household Survey (BIHS) 2015 data to measure the true association between socio economic status and obesity. Potential variables like age, gender, job of residence etc. are controlled at the time of analysis. To moderate the effect of confounders, stratum specific odds ratios are calculated. After determining the potential confounders, a logistic model is fitted including those confounders to assess the actual effect of socio economic status on obesity. From stratum specific logistic regression, it is seen that among the rich rural women odds of being obese is 74% higher compared to poor rural women, whereas among the rich rural men odds of being obese is 45% higher compared to poor rural men. Also Prevalence of obesity is apparently higher in coastal divisions, whereas lower in north divisions. A division wise gender-sensitive policy should be developed to address the inequality in obesity.

Dedication

My family.

Acknowledgement

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Chapter 1

Introduction

1.1 General Idea

Obesity is a major public health concern of the twenty first century because of its alarming upward trend in both developed and developing countries (Bhurosy and Jeewon (2014)). Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. A crude measure of obesity is the body mass index (BMI). BMI is calculated as a ratio of a person's weight to the square of that person's height. BMI greater or equal 30 is considered as obese. BMI greater or equal to 25 is considered as overweight.

Overweight and obesity are potential risk factors for a number of chronic diseases, including diabetes, cardiovascular diseases and cancer. Overweight and obesity are now increasing in low and middle-income countries, mostly in urban settings (WHO (2016)).

1.2 Background and Motivation

Obesity is already among the top 10 risks to human health worldwide(WHO (2002)). According to the WHO report 2016, more than 1.9 billion adults aged 18 years and older were overweight. Of these over 650 million adults were obese. 39% of adults aged 18 years and over (39% of men and 40% of women) were overweight (WHO (2016)). Epidemiological surveys used BMI as a measure of general obesity and central/abdominal obesity is measured by the ratio of waist circumference (WC) to waist hip ratio (WHR).

For both developed and developing countries overweight and obesity are an increasing public health problem (Bhurosy and Jeewon (2014)). The prevalence of overweight and obesity varies between countries and tends to increase with socio economic levels. Highest prevalence is found in WHO Region of the Americas and the lowest is found in WHO Region for Southeast Asia(Bonita et al. (2013)). With increasing economic development, increasing rates of overweight and obesity have been reported in most of the Southeast Asia countries (Ng et al. (2014)).

Like other developing countries, Bangladesh is experiencing a rapid demographic and epidemiological transition which has been associated with increases in overweight and obesity Biswas et al. (2019). In 2011, cross-sectional data indicated that the prevalence of overweight and obesity in ever married women was 18% (Balarajan and Villamor (2009)). Research suggests that the rate of overweight and obesity increased from 2.7% in 1996 to 8.9% in 2006 among urban Bangladeshi women of reproductive age group (Mohsin et al. (2010)). A recent study noted that prevalence of obesity was 17.9% among urban school-going children and the highest rate of obesity (27.7%) was observed among 6-9 year olds.

Zaman et al. (2001) examined central obesity as classic risk factor of cardiovascular disease in Bangladesh. From the study of Tareque et al. (2015) it is seen that in Bangladesh, odds of having hypertension, diabetes, and their coexistence was higher for the people who were overweight and obese. Alam et al. (2016) showed that BMI is a significant determinant of diabetes and prediabetes in adult people of Bangladesh.

From the study of Siddiquee et al. (2015) it is seen that high socio economic status, physical inactivity, fat intake and protein intake are the significant indicators of obesity in Bangladesh. Shafique et al. (2007) found that age, years of schooling, area of residence and percentage of monthly household expenditure were the indicators of female obesity for both urban and rural women of Bangladesh.

As emerging economies continue to industrialize, a subsequent increase in income has led to high caloric intake. Increasing obesity is not only a health risk but also carries significant costs to the economy. Obesity is one of the top three social burdens generated by humans. The economic impact of obesity amounts to $2 trillion annually and roughly 2.8% of the global GDP. At its current pace, by 2030 obesity is estimated to affect about half of the world's adult population.

With a growing economy, quality of living is now also changing in rural areas of Bangladesh. People in rural areas are now engaging in skilled professional jobs which reduce their physical activity. How ever, there is not much study that focusing on overweight and obesity in rural general population of Bangladesh. To make an adequate health policy for rural Bangladeshi it is essential to study how things are going on in rural areas with their upgrading socio economic status.

1.3 Literature Review

Khan et al. (2009) used adjusted multinomial logistic regression analysis and found that women with higher socioeconomic status were significantly negatively associated with being underweight but positively associated with being overweight and obese, as compared to the women with lower socioeconomic status. On the other hand, women who migrated from rural to urban areas showed a significantly positive association with being underweight but negative associations with being overweight and obese, when compared with women who did not migrate.

Bhuiyan et al. (2013) conducted a case control study among 198 children of age 10 15 years in seven schools in Dhaka in 2007. Results of the study showed that obesity of children was significantly associated with parents overweight status. Obesity was founded to be more likely among children who have at least one overweight parent.

Das et al. (2013) performed a multinomial logistic regression to identify the factors associated with obesity in three age group (age < 5, 5–19, > 19). This study showed that among the individuals aged more than 19, odds of being obese was comparatively higher for literate and wealthy people. Obesity was more common in

people who drunk boiled water and used sanitary toilets.

Lebel et al. (2014) focused on how BMI varied across the economic status, gender and regions of the USA and CANADA. Their study showed that mean BMI decreased with the improvement of socio economic status and education among women, whereas variation of BMI increases.

Das et al. (2014) found that mean weight for age z-score, height for age z-score, weight for height z-score, BMI for age z-score had significant difference between children whose mothers did and did not watch television regularly. Under-5 children whose mothers watched television regularly had higher odds of being overweight and obese. Researchers also demonstrated that television watching of mothers was significantly associated with childhood overweight and obesity.

Paul et al. (2015) conducted a study on the students of Jahangirnagar University, where prevalence of overweight was found to be higher in male students compared to female students.

Biswas et al. (2016) showed that hypertension, diabetes and obesity was concentrated among the richest group of Bangladeshi people. Highest inequality was observed for obesity. Compared to the richest rural household, poorest rural households had more comorbidity. An opposite situation was seen for urban people. Richest group had more comorbidities compared to the poorest Bangladeshi people.

Biswas et al. (2017) showed that among Bangladeshi women of reproductive age, prevalence of overweight and obese both have an increasing trend through 2004 to 2014. This increasing trend was seen in all three groups considered (15-24, 25-34,

35-49). Rate of increase in prevalence over the year was highest among the women of age 35 to 49.

Pujilestari et al. (2017) performed a decomposition analysis to assess the socioeconomic inequality in obesity among older people in Purworejo District,Indonesia. The study found that for both males and females abdominal obesity was significantly more prevalent if a job involved no physical labor (20% among men and 44% among women, respectively). The prevalence of abdominal obesity increased from the poorest to the richest group. Positive concentration index of abdominal obesity across wealth index was observed for both men and women (0.49 among men and .26 among women).

Biswas et al. (2019) showed that age, education, residence, economic status, and contraceptive use have an increasing influence on BMI. Before 2007 a healthy BMI was better maintained among wealthy respondents compared to the poorest but from year 2007, wealthy respondents failed to maintain a healthy BMI. Growing urbanization with wealth inequality compromised the weight control capacities of Bangladeshi women.

On the light of the previous literatures, we get to know the potential confounders associated with adult obesity. From one study, we get to know that obesity is more concentrated in urban poor compared to urban rich Tanwi et al. (2019)

Obesity related comorbidities impose a significant amount of economic hardship not only to the person suffering from the diseases but also to the family and to society. The recent Demographic and Health Survey of Bangladesh has provided evidence for this notion Mohsena et al. (2016). However, it is not known whether

the diseases are more prevalent to the people who have higher socioeconomic status (SES) in society comparing to the people who have low SES. That is whether the prevalence of obesity is equally distributed in society.

Furthermore, the research on rural Bangladesh is also limited. Thus the contribution of this study is to find, does socioeconomic inequality exists in obesity in rural Bangladesh? If inequality is present, what the magnitude of the inequality. The other studies have mostly used logistics regression analysis to estimate the effects of covariates on obesity but this study will show the extent of inequality with concentration index, which is a widely used measure of inequality in health economics. The conditional inference tree for prediction will also provide another dimension to show the chances of being obese determined mostly by Educational level of an individual.

1.4 Objective of the Study

The main objective of this study is to evaluate the effect of socio economic status on obesity in the rural bangladeshi population. Some specific objectives are

- To find the existence of the socio economic inequality in obesity in rural Bangladesh.
- To find the division wise magnitude of the inequality if it is present.
- To find the gender wise magnitude of the inequality if it is present.
- To find the job residence wise magnitude of the inequality if it is present.

Chapter 2

Methodology

Information about the data source, a concise description of the variables and the statistical methods that are used for analyzing the data are described in this chapter.

2.1 Data Source

This study has used Bangladesh Integrated Household Survey (BIHS), 2015 data to nd the socioeconomic inequality existence in obesity among rural adults. Since October 2010, the Policy Research and Strategy Support Program (PRSSP) for Food Security and Agricultural Development, funded by the United States Agency for International Development (USAID) and implemented by the International Food Policy Research Institute (IFPRI), has been providing evidence-based policy research support in Bangladesh. Building on IFPRIs previous work in the country alongside the Government of Bangladesh (GOB), USAID and other development partners, the program lls the need for demand-driven food and agricultural policy research. BIHS is the central Bangladeshi national representative survey which collects comprehensive on (1) plot-level agricultural production and performs (2) Dietary consumption of every individual household members (3) anthropometric

measurements (height and weight) of all household individuals, as well as (4) data to measure womens authorization in agriculture index (WEAI). A communal survey supplements the BIHS data to deliver information on area-specic contextual aspects. The BIHS sample is statistically illustrative at the following levels: (1) nationwide representative of rural Bangladesh; (2) representative of rural areas of every single of the seven directorial divisions of the country: Dhaka, Chittagong, Barishal, Khulna, Rajshahi, Sylhet and Rangpur (3) representative of the FTF Zone of Inuence (ZOI) in south-western Bangladesh. USAID offered IFPRI the list of FTF locations (districts and upazilas or sub-districts). 1Using this list, a consultant statistician sampled the FTF ZOI separately for its statistical representativeness. 2A sound and appropriate statistical method was used to calculate the total BIHS sample size of 6,500 households in 325 primary sampling units (PSUs) or villages. The BIHS sample design followed a stratified sampling in two steps selection of PSUs and selection of households within each PSU using the sampling frame established from the community series of the population census of Bangladesh in 2001. Afterwards, sampling weights were adjusted on the basis of 2011 of population census by latest. The domains of the national surveys were the rural areas of the entire country, and the domains of the FTF ZOI were all the upazilas belonging to the ZOI. In the beginning stage of sampling, the total BIHS sample of 325 PSUs were allocated amongst the eight strata (the FTF ZOI and seven divisions) with probability proportional to size (size being the number of households in each level), which caused in the following distribution: 87 in Dhaka, 48 in Chittagong, 21 PSUs in Barisal, 27 in Khulna, 29 in Rajshahi, 27 in Rangpur, 36 in Sylhet, and 50 in the FTFZOI. In the second stage, 20householdswere randomly selected from each PSU. IFPRI has widespread experience in the design and application of similar surveys in Bangladesh and other countries. The IFPRI-PRSSP researchers also consulted the 2010Household Income and Expenditure Survey (HIES) questionnaires of the

Bangladesh Bureau of Statistics (BBS) in order to collect data on a comparable set of variables. The BIHS questionnaires include modules that together provide useful data in an integrated format to answer the varied research questions posed in dierent PRSSP studies. The surveys collect gender-disaggregated information, as appropriate. This study take the explanatory variable and other confounders by merging data from dierent modules and it exclude pregnant and lactating women from the study, as they have potential reason of being obese.

2.2 Ethical Consideration

Ethical approval for BIHS Round 1 and Round 2 is received from the institutional review board of the international food policy research institute, Washington, DC, USA. As the data set used in the study is secondary, it does not require ethical approval.

2.3 Variables used in the study

The following section describes the dependent and explanatory variables with their confounders.

Table 2.1: Variables with their categories

Variable	Variable name	Categories	Codings
Dependent	Obesity	Non-obese (BMI<23)	0
		Obese (BMI>=23)	1
Explanatory	SES	Poor	0
		Middle	1
		Rich	2

Table 2.1 continued from previous page

Variable	Variable name	Categories	Codings
Confounders	Division	Dhaka	0
		Chittagong	1
		Barisal	2
		Khulna	3
		Rajshahi	4
		Rangpur	5
		Sylhet	6
	Religion	Muslim	0
		Others	1
	Gender	Female	0
		Male	1
	Age group	18-29	0
		30-49	1
		50+	2
	Literacy	Illiterate	0
		Literate	1
	Educational status	No education	0
		Primary	1
		Secondary or higher	2
	Marital status	Married	0
		Others	1
	Occupation type	Physical labor	0
		Mild labor	1
		Professional	2

Table 2.1 continued from previous page

Variable	Variable name	Categories	Codings
	Job residence	Rural	0
		Urban	1
	Asset quintile	Poor	0
		Middle	1
		Rich	2
	Food secure	Food insecure	0
		Food secure	1

Household food security: Bangladesh Integrated Household Survey (BIHS) collected frequencies of 17 food groups consumed by the respondents household for the last 7 days at the time of interview. Following the Food Consumption Score (FCS) guideline by World Food Program (WFP), the 17 food groups were transferred into 7 food groups and the condiment items were excluded. The consumption frequencies were summed and recoded the value as 7 if any values were above 7 for each food group. Multiplying each food groups with its weighted value created a new weighted food group score. Total food consumption score for each household was calculated by summing all the weighted food groups score which ranges from 0 to 112. Based on the total food consumption score, WFP categorized households into four groups: poor consumption ($£28$), borderline consumption ($> £28$ and $£42$), acceptable low (43-52) and acceptable high ($> £52$). For this study, poor and borderline households were counted as food insecure households whereas acceptable (low and high) households were considered as food secure.

2.4 Statistical Analysis

Statistical tools, used to conduct the analysis are described under this section.

2.4.1 Bivariate Analysis

Bivariate analysis provides a preliminary idea of how response variables are associated with the covariates. Chi-square is the primary statistic that is used to test whether the two or more variables are independent or not. An observed set of frequencies are compared with a corresponding set of frequencies that are expected under the null hypothesis. The hypothesis of the chi-square test is :
H_0 : There exists no association between two attributes.
H_1 : They are associated.

The test statistic is defined as

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where $O_{ij}(i = 1, \ldots, r \text{ and } j = 1, \ldots, k)$ denotes the observed frequencies and E_{ij} $(i = 1, \ldots, r \text{ and } j = 1, \ldots, k)$ denotes the expected frequencies. The test statistic follows chi-square distribution with $(r-1)(k-1)$ degrees of freedom under the null hypothesis.

2.4.2 Logistic regression model

All the terms and definitions of logistic regression model described here is mainly based on the text "Generalized linear model" by Dobson and Barnett (2008). Bivariate analysis does not provide an indication of causal relationship between response and covariates. Therefore, regression analysis is required to assess the form of their relationship. To model the binary data one may use linear probability model, logistic regression model or probit model. Among these three, logistic regression is the most popular method for fitting binary data. Let,

$$E(Y|x) = \pi(x)$$

be the conditional mean π of dependent variable,Y given explanatory variable X. Then the logistic regression model p(x) is

$$\pi(x) = p(Y = 1|X) = \frac{\exp(\beta_0 + \beta_1 X)}{1 + \exp(\beta_0 + \beta_1 X)}$$

and

$$1 - \pi(x) = p(Y = 0|X) = \frac{1}{1 + \exp(\beta_0 + \beta_1 X)},$$

where β_0 and β_1 are the model parameters.

The logistic function $\alpha(x)$ ranges between 0 to 1 which makes the model popular. Transformation defined as

$$g(x) = \log \frac{\pi(x)}{1 - \pi(x)} = \beta_0 + \beta_1 X.$$

The importance of this transformation is that g(x) achieves many properties of linear regression. It is linear in parameter and ranges from $(-\infty, +\infty)$. The quantity

$\frac{\pi(x)}{1-\pi(x)}$ is called the odds and that is why logit is called log odds.

Performance of a fitted logistic regression model can be assessed by the area under the receiving operating curve (ROC), a graph of sensitivity vs (1-specificity). Sensitivity is the proportion of true positive responses that are classified as positives. Specificity is the proportion of true negative responses that are classified as negatives.

2.4.3 Prediction Using Conditional Inference Tree

Conditional inference tree is a non-parametric class of regression tree. Classification tree predicts that an observation belongs to the most commonly occurring class of training observations (a random subset of whole data) in the region to which it belongs Gareth (2010). Conditional inference tree uses recursive partitioning by conditional inference to grow a tree. It is a two step procedure.

- **Step:1** A test of conditional independence is performed under

$$H_0^j : D\left(\mathbf{Y}|X_j\right) = D(\mathbf{Y}),$$

  where $j = 1, 2, ..., m$ for total m covariates. Association between Y and x_j is measured by p-values at a prespecified level of α. Choose the j^{th} variable for splitting if P_j, the P-value for j^{th} variable is minimum.

- **Step:2** After selecting the X_j variable in first step, split within it can be done by using the splitting criterion developed by Breiman et al. (1984).

Continue this procedure until the global association test is failed to be rejected.

2.4.4 Concentration index

The concentration index is a measure of quantifying the degree of income-related inequality in a specific health variable Wagstaff et al. (1991). For example, in our study we can measure whether the adult obesity in rural Bangladesh is more concentrated to rich people compared to the poor people. That is, it gives us the extent to which inequalities is more pronounced in rural rich than rural poor. In order to understand the contributions of individual's income or assets to obesity the CI was computed. CI is the mean-adjusted covariance of obesity and income/assets rank. The CI of adult obesity can take a value from -1 to +1. If CI is zero, it indicates perfect equality among obesity, If CI is negative = inequality is concentrated among the relatively poor; If CI is positive = inequality is concentrated among the relatively rich; If CI is Zero = no inequality in obesity.

Chapter 3

Analysis and Results

First, bivariate analysis is performed to identify the associated risk factors of obesity. True association between socio economic status and obesity may be confounded by other risk factors called confounders. To moderate the effect of confounders stratum specific odds ratios are calculated. After determining the potential confounders, a logistic model is fitted including those confounders to assess the actual effect of socio economic status on obesity. Here machine learning approach is also used to predict the percentage of obesity among different subgroups of population. Further, concentration index of obesity across income group is calculated to see whether obesity is equally distributed across income or not.

3.1 Exploratory Analysis

3.1.1 Graphical Analysis

Graphical analysis is performed to identify the prevalence of obesity across divisions and to discover the rationale behind it. Figure 3.1 shows that prevalence of obesity is highest in khulna division and lowest in Rangpur. Prevalence is found to be high in coastal divisions.

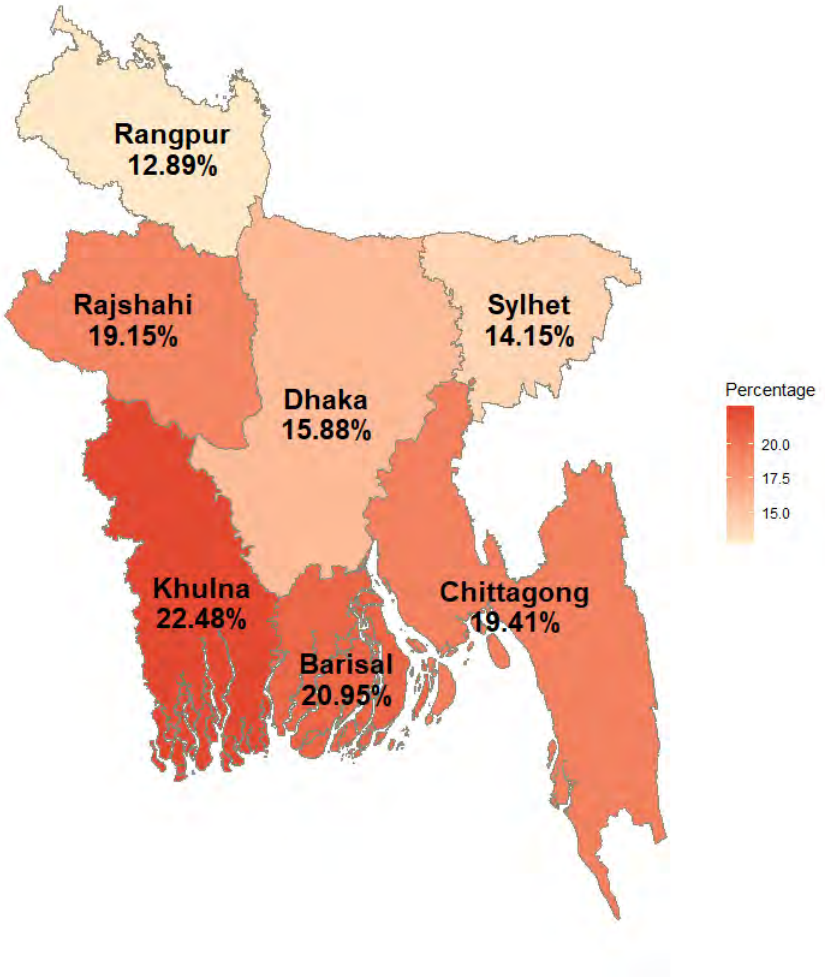

Figure 3.1: Prevalence of obesity across the divisions in Bangladesh.

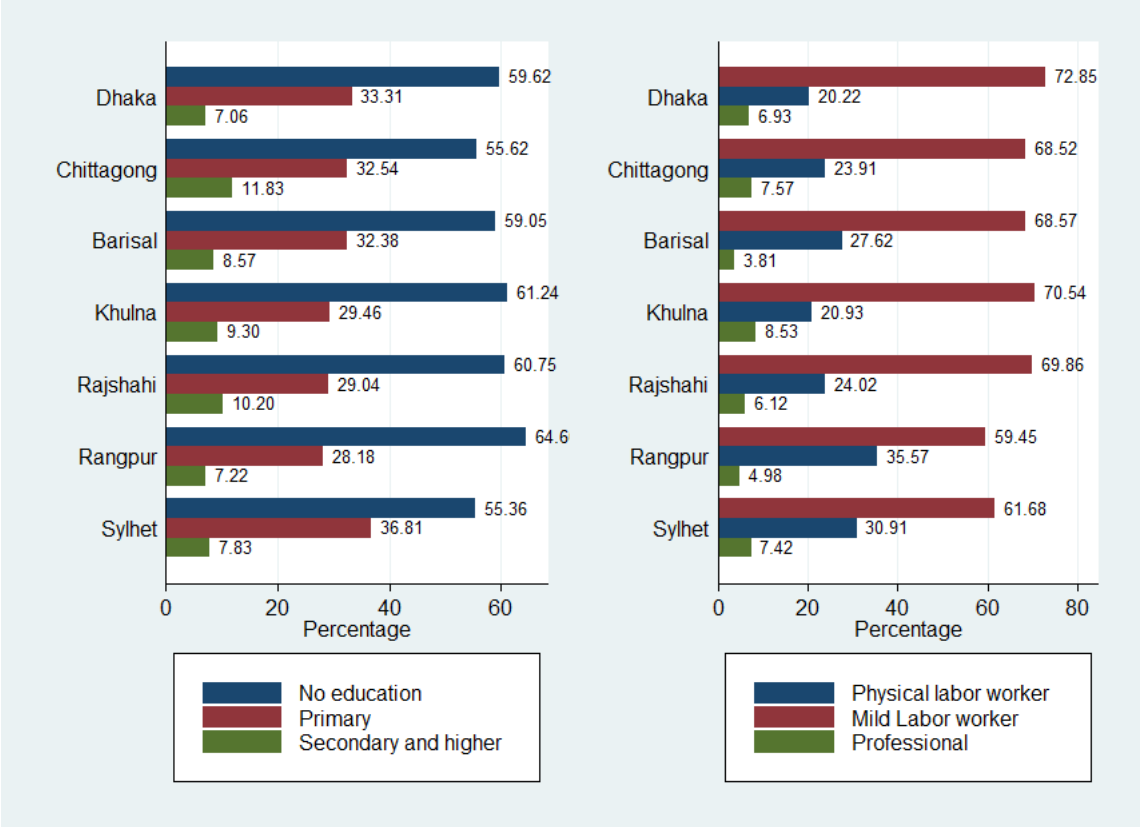

Figure 3.2: Percentage distribution of education and occupation across the divisions in Bangladesh.

From the above figure it seems that people from the coastal divisions like Chittagong, Barisal and Khulna are more likely to attain primary, secondary and higher levels of education. It provides the rationale of high prevalence of obesity in these divisions. Moreover, in Khulna division the percentage of professional people is highest with 2^{nd} lowest percentage of workers engaged in physical labor, causing the highest prevalence of obesity. Percentage of workers engaged physical labor is highest in Rangpur which leads to the lowest prevalence of obesity. The 2^{nd} highest percentage of physical labor workers are found in Sylhet division that produces the 2nd lowest prevalence.

Another reason of prevalence of obesity among coastal areas might be the Kalapara coastal belt, which is the source of saline water. The coastal belt is suffering the adverse impact of this saltwater intrusion more than other part of Bangladesh Alam et al. (2017). Salt has a link with overweight and obesity Grimes et al. (2016). Therefore, soil and water salinity could be reason behind more overweight and obese people in coastal region compared to northern part of Bangladesh.

3.1.2 Bivariate Analysis

Bivariate analysis shows whether the factors are associated with obesity or not. The results of this analysis along with the P-value of the associated χ^2 test are shown in Table 3.1.

Table 3.1: Bivariate analysis for obesity

Factors	Categories	Obesity		Chi-square value	P-value
		No % (count)	Yes %(count)		
Socio economic status	Poor	86.22 (1208)	13.78 (193)	27.94	0.001
	Middle	85.79 (924)	14.21 (153)		
	Rich	80.2 (1677)	19.8 (414)		
Division	Dhaka	84.12 (1298)	15.88 (245)	21.97	0.001
	Chittagong	80.59 (681)	19.41 (164)		
	Barisal	79.05 (83)	20.95 (22)		
	Khulna	77.52 (100)	22.48 (29)		
	Rajshahi	80.85 (515)	19.15 (122)		

Table 3.1 continued from previous page

Factors	Categories	Obesity		Chi-square value	P-value
		No % (count)	Yes %(count)		
	Rangpur	87.11 (507)	12.89 (75)		
	Sylhet	85.85 (625)	14.15 (103)		
Religion	Muslim	83.3 (3376)	16.7 (677)	.13	0.722
	Others	83.91 (433)	16.09 (83)		
Gender	Female	84.88 (1089)	15.12 (194)	2.95	0.086
	Male	82.78 (2720)	17.22 (566)		
Age group	18-29	82.72 (881)	17.28 (184)	3.57	0.168
	30-49	84.37 (1948)	15.63 (361)		
	50+	82.01 (980)	17.99 (215)		
Literacy	Illiterate	87.95 (730)	12.05 (100)	15.38	0.001
	Literate	82.35 (3079)	17.65 (660)		

Table 3.1 continued from previous page

Factors	Categories	Obesity		Chi-square value	P-value
		No % (count)	Yes %(count)		
Educational status	No education	86.47 (2332)	13.53 (365)	77.13	0.001
	Primary	81.39 (1203)	18.61 (275)		
	Secondary or higher	69.54 (274)	30.46 (120)		
Marital status	Married	80.58 (386)	19.42 (93)	2.99	0.084
	Others	83.69 (3423)	16.31 (667)		
Occupation type	Physical labor	89.26 (1031)	10.74 (124)	45.89	0.001
	Mild labor	81.91 (2544)	18.09 (562)		
	Professional	75.97 (234)	24.03 (74)		
Job residence	Rural	83.92 (3503)	16.08 (671)	10.85	0.001
	Urban	77.47 (306)	22.53 (89)		
Asset quintile	Poor	88.57 (1566)	11.43 (202)	62.54	0.001

Table 3.1 continued from previous page

Factors	Categories	Obesity		Chi-square value	P-value
		No % (count)	Yes %(count)		
	Middle	82.46 (804)	17.54 (171)		
	Rich	78.81 (1439)	21.19 (387)		
Food secure	Food insecure	90.20 (276)	9.80 (30)	11.03	0.001
	Food secure	82.88 (3533)	17.12 (730)		

This study includes 1283 female and 3286 male respondents. Prevalence of obesity is higher among males (17.22%). Improvement of socio economic status produces higher prevalence of obesity. Khulna division has the highest prevalence of obesity compared to other divisions. Literate people are more likely to be obese. Prevalence of obesity increases with educational attainment. Among the respondents who work in urban areas 22.53% are obese which is comparitively greater than those who work in rural areas. From the above table it can be concluded that except for religion and age group all other factors are associated with obesity at 10% level of significance.

3.2 Logistic Regression Model

3.2.1 Identifying Potential Confounders

First, a logistic model is fitted including only the covariate socio economic status to assess the crude association between obesity and socio economic status.

Table 3.2: Crude association between obesity and socio economic status

Factor	COR	P-value	95% CI
Socio economic status			
Poor	1	-	-
Middle	1.04	0.759	0.82,1.30
Rich	1.55	0.001	1.28,1.86
Intercept	.16	0.001	0.14,0.19

From Table 3.2 it seems that socio economic status has a significant effect on obesity. For the people of middle income group, odds of being obese is not significantly different from poor people as 95% confidence interval of crude odds ratio includes 1. Among the rich people crude odds of being obese is 55% higher compared to poor people at 5% level of significance. Here association is measured by using crude odds ratio. To establish the association between obesity and economic status it is essential to adjust the odds ratio by the confounders. Table 3.3 will give those potential confounders.

Table 3.3: Stratum specific and adjusted association between obesity and socio economic status.

Confounder categories	Socio economic status			
	Middle OR(95% CI)	Rich OR(95% CI)	Middle AOR(95% CI)	Rich AOR(95% CI)
Division			1.04(0.83-1.31)	1.55(1.29-1.87)
Dhaka	1.20(0.81-1.77	1.48(1.07-2.06)		
Chittagong	1.11(0.68-1.82)	1.30(0.87-1.96)		
Barisal	0.82(0.14-4.99)	2.95(0.89-9.78)		
Khulna	0.35(0.10-1.24)	0.76(0.30-1.92)		
Rajshahi	1.03(0.57-1.85)	2.09(1.31-3.35)		
Rangpur	1.17(0.61-2.25)	1.73(0.98-3.08)		
Sylhet	0.73(0.35-1.51)	1.53(0.90-2.58)		
Gender			1.03(0.82-1.30)	1.53(1.27-1.84)
Female	1.33(0.87-2.03)	1.74(1.21-2.49)		
Male	0.93(0.71-1.22)	1.45(1.17-1.80)		
Literacy			1.02(0.81-1.29)	1.50(1.24-1.81)
Illiterate	1.07(0.59-1.91)	1.77(1.10-2.87)		
Literate	1.01(0.79-1.30)	1.46(1.19-1.78)		
Educational status			1.05(0.83-1.32)	1.42(1.17-1.71)
No education	0.85(0.62-1.15)	1.34(1.04-1.73)		
Primary	1.43(0.96-2.13)	1.55(1.12-2.15)		
Secondary or higher	1.27(0.60-2.71)	1.55(0.88-2.73)		

Table 3.3 continued from previous page

Confounder categories	Socio economic status			
	Middle OR(95% CI)	Rich OR(95% CI)	Middle AOR(95% CI)	Rich AOR(95% CI)
Marital status			1.04(0.82-1.30)	1.53(1.27-1.84)
Married	1.45(0.66-3.17)	1.67(0.89-3.13)		
Others	1.00(0.79-1.27)	1.52(1.25-1.85)		
Occupation type			1.09(0.86-1.37)	1.53(1.27-1.85)
Physical labor	0.95(0.56-1.61)	1.42(0.90-2.25)		
Mild labor	1.23(0.94-1.60)	1.59(1.28-1.97)		
Professional	0.39(0.15-1.03)	1.20(0.63-2.30)		
Job residence			1.02(0.81-1.28)	1.50(1.24-1.81)
Rural	1.01(0.80-1.28)	1.51(1.24-1.83)		
Urban	1.05(0.43-2.58)	1.39(0.64-3.02)		
Asset			1.04(0.82-1.30)	1.37(1.13-1.66)
Poor	1.07(0.73-1.58)	1.54(1.09-2.18)		
Middle	1.39(0.88-2.19)	1.77(1.19-2.65)		
Rich	0.82(0.57-1.20)	1.10(0.84-1.45)		
Food security			1.03(0.82-1.30)	1.50(1.25-1.81)
Insecure	0.73(0.28-1.90)	1.10(0.45-2.68)		
Secure	1.05(0.83-1.33)	1.53(1.26-1.85)		

From the above table it can be concluded that except division all other confounders are potentially significant, as for rich people AORs differ form COR. Among the rich people odds of being obese decreases when adjusted by any of the confounders seperately, except occupation type. Odds ratios are significantly different from 1 event after adjusting by the confounders. For any potential confounder

stratum specific odds ratios are different which also indicates suitability of being a potential confounder. Now to determine the association between obesity and socio economic status, a logistic model is fitted along with the potential confounders.

3.2.2 Final Logistic Regression Model

Table 3.4: Association between obesity and socio economic status after adjusting for the confounders.

Risk factors	Odds Ratio	P-value	95% CI
Income			
Poor	1	-	-
Middle	1.06	0.643	0.84,1.34
Rich	1.28	0.013	1.05,1.56
Gender			
Female	1	-	-
Male	1.19	0.067	0.99,1.44
Literacy			
Illiterate	1	-	-
Literate	1.12	0.372	0.87,1.44
Educational status			
No education	1	-	-
Primary	1.19	0.078	0.98,1.44
Secondary or higher	1.88	0.001	1.42,2.48
Marital status			
Married	1	-	-
Others	0.98	0.904	0.76,1.27

Table 3.4 continued from previous page

Risk factors	Odds Ratio	P-value	95% CI
Occupation type			
Physical labor	1	-	-
Mild labor	1.59	0.001	1.27,2.00
Professional	1.72	0.003	1.21,2.46
Job residence			
Rural	1	-	-
Urban	1.26	0.093	0.96,1.65
Asset			
Poor	1	-	-
Middle	1.47	0.001	1.17,1.84
Rich	1.52	0.001	1.24,1.86
Food security			
Insecure	1	-	-
Secure	1.32	0.165	0.89,1.96
Intercept	.05	0.001	0.03,0.09

Table 3.4 provides statistically significant evidence that among the rich people odds of being obese is 28% higher compared to poor people at 5% level of significance. People of middle income group are no more than likely to be obese than poor. Educational status, occupation type and asset are the risk factors that have significant effect on obesity at 5% level of significance.

3.2.3 Performance Measure of Final Fitted Model

Area under curve (AUC) of the receiving operating characteristic (ROC) is calculated for measuring model performance. The area under the ROC curve is considered as an index of accuracy. A model with higher area under the curve is preferable.

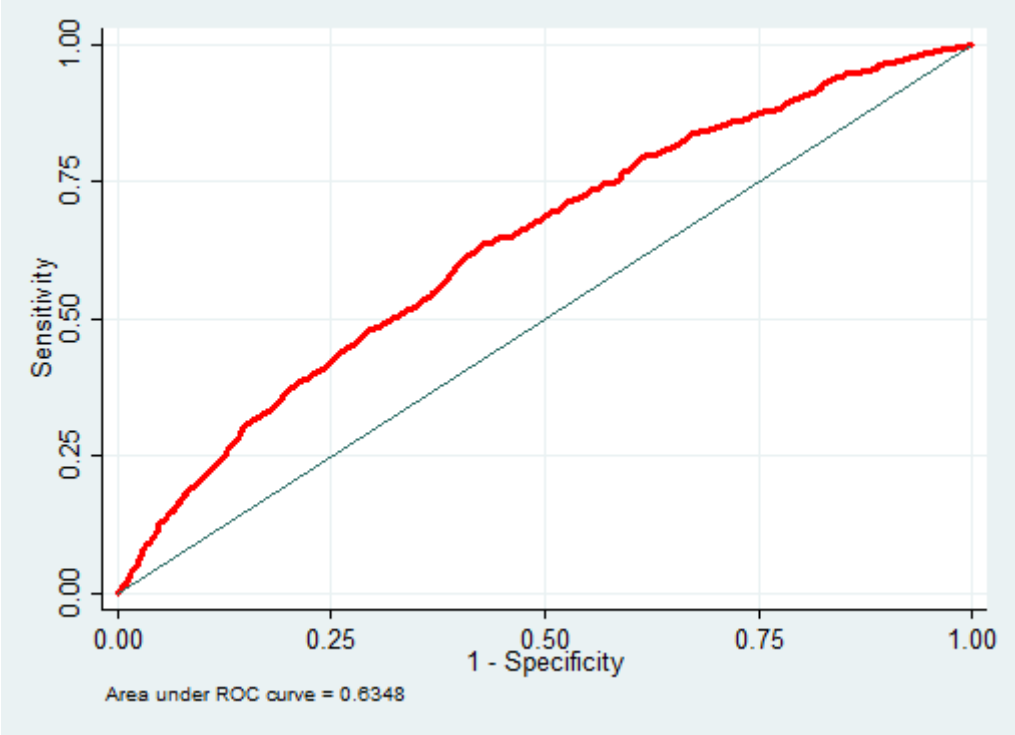

Figure 3.3: ROC curve for final fitted model.

From figure 3.3 it seems that the area under the curve is 63.6%. Prediction accuracy of the given model is 63.4%.

3.3 Prediction Using Conditional Inference Tree

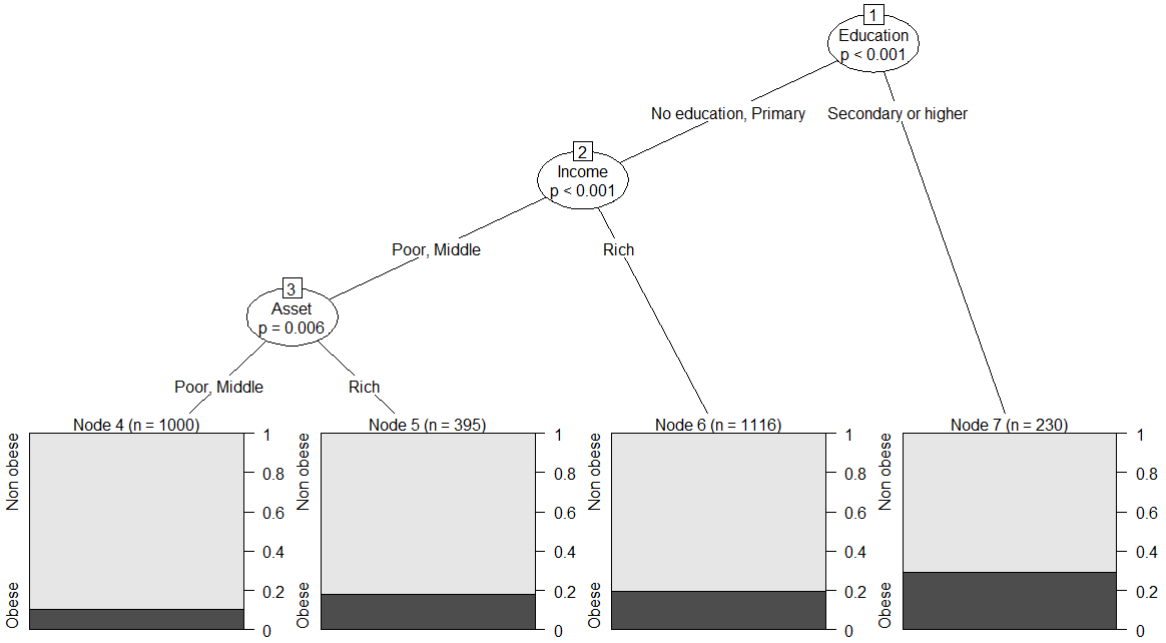

Figure 3.4: Conditional inference tree for obesity

Above figure is produced based on 60% training observation. Bonferroni-adjusted P-values are giving the evidence of significant splittings. This classification tree describes that educational attainment is the most important factor in determining whether a person is obese or not. 230 people of training data set belongs to secondary and higher education group. Among these 230, 29.1% people are predicted to be obese. Income and assets play a vital role only when people have no education or primary education. Node 6 indicates that 19.6% people are predicted to be obese who have no education or primary level education and belongs to rich group.

3.4 Concentration Indices

Table 3.5: Concentration indices.

	Concentration index	P-value
Overall	0.107	0.001
Division		
Dhaka	0.090	0.016
Chittagong	0.061	0.187
Barisal	0.263	0.037
Khulna	-0.036	0.751
Rajshahi	0.181	0.001
Rongpur	0.128	0.056
Sylhet	0.120	0.029
Gender		
Female	0.128	0.002
Male	0.096	0.001
Job residence		
Rural	0.101	0.001
Urban	0.065	0.264

Table 3.5 indicates significant evidence that obesity is concentrated among the people of richest income group compared to the poor. Only in Chittagong and Khulna divisions obesity is equally distributed across the income groups. A higher CI value among women indicates more inequality is observed among women compared to men. More inequality is also observed among the rural people who work in rural areas compared to the rural people who work in urban areas.

Chapter 4

Discussion

4.1 Discussion

This study explores the prevalence of obesity in rural Bangladesh. It emphasizes how obesity is associated with the economic status in rural Bangladesh and how the confounders affect the relation. From stratum specific logistic regression it is seen that among the rich rural women the odds of being obese is 74% higher compared to poor rural women, whereas among the rich rural men odds of being obese is 45% higher compared to poor rural men. This provides evidence that the effect of economic status works differently according to gender. From the final logistic regression model it is found that income, educational attainment, occupation category and assets are the potential indicators of obesity. Rich rural people are 1.28 times more likely to be obese compared to poor rural people. The higher the education level, the higher the risk of obesity. Odds of being obese is 88% higher among people who attain secondary or higher education compared to uneducated people. Conditional classification tree provides an understandable picture of obesity classification among several groups. Income and asset play a less significant role in determining obesity if an individual attains secondary or higher education. But there is a great impact

of income and asset on obesity, only when an individual has no or only primary education. Positive concentration index, 1.07 with P-value .001 indicates unequal distribution of obesity across income group. Obesity is concentrated among the richest people compared to poor.

Chowdhury et al. (2013) had shown that in recent years Bangladesh achieved a dramatical improvement in public health sector. Sarma et al. (2016) showed that with a growing economy Bangladesh will soon face a major problem of obesity. Because of recent growing economy and urbanization in Bangladesh, situations in rural society may also change. Biswas et al. (2019) showed in his paper that obesity is more common in educated and wealthy Bangladeshi people starting from 2007. Biswas et al. (2016) showed that obesity is concentrated among richest people.

4.2 Limitation and Further Scope

Information about respondent's food habits and weekly exercise duration are not included in this study. Inclusion of these two most important risk factors will provide more insight into obesity. Random forest can be applied to obtain a better prediction of obesity.

Chapter 5

Conclusion

This study is answering the question that how socio economic status is associated with obesity in rural Bangladesh. Our finding that overweight and obesity is concentrated more among the rich is consistent with the findings from other studies but it is contradictory with the study conducted in urban setting of Bangladesh Tanwi et al. (2019). With the economic transition, higher SES people have more accessibility and affordability to change their food consumption pattern to energy-dense food. Prevalence of obesity is apparently higher in coastal divisions, whereas lower north divisions. Educated people are at high risk of obesity as they get easy access to desk jobs, which lower their physical activity. There should be budget allocated in national health policy for raising awareness against "obesity and its adverse health effects".

5.1 Policy Measures

Environmental and social changes linked with development and lack of supportive policies in different sectors such as health, environment, agriculture, food processing, marketing, distribution, education, transport, urban planning are affecting in the changes in dietary and physical activity patterns. Obesity and overweight as well as their related non-communicable diseases, are largely preventable. In order to preventing overweight and obesity, supportive communities and environments are fundamental in shaping publics choice by making the choice of regular physical activity and healthier foods and it should be most accessible, affordable and available. Some policies can there be implied to reduce the overweight and obesity from rural Bangladesh:

(1) the rising obesity in Bangladesh is due to lack of consciousness about health benets of physical exercise. Raising awareness about physical tness training and providing proper nutritional diet chart may reduce the proportion of obese people in Bangladesh.

(2) According to recent survey; depression, anxiety, dissatisfaction in personal life, career; people are getting monotonous with their life. These lead to less physical activities and results in overweight. Proper counseling of depression and establishing more and more tness club, yoga institute may help to encourage people for physical activities.

(3) The reason behind more obesity in the people of coastal areas compare to north is increasing soil and water salinity. Salt makes the human body lethargic, which ultimately leads to less physical movement and overweight.

(4) Growing obesity in educated group is another issue of concern. Because of their desk job or own business, their physical movement has become limited. Ensuring health diet available at work place and establishing tness club in work place may reduce obesity among educated group.

(5) Implying tax on sugar sweetened beverages, as sugar is considered as white poison. It not only accumulates fat in the human body, but also makes rise to other diseases.

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