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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018468
Article Type:	Research
Date Submitted by the Author:	04-Jul-2017
Complete List of Authors:	Chowdhury, Muhammad Abdul Baker; University of Florida Adnan, Md. Mohiuddin; Georgia Southern University, Biostatistics Hassan, Md Zakiul; International Centre for Diarrhoeal Disease Research, Infectious Diseases Division
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	obesity, reproductive women, body mass index, trends, risk factors

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Trends, prevalence, and risk factors in overweight and obesity among women of reproductive age in Bangladesh, 1999-2014

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Abstract

Objective: To determine trends in prevalence and risk factors of overweight and obesity among Bangladeshi reproductive age women during 1999-2014.

Design: Nationally representative data from repeated cross-sectional Bangladesh Demographic and Health Survey (BDHS) in 1999, 2004, 2007, 2011, and 2014 were analyzed.

Setting: Country of Bangladesh.

Participants: Women age 15- 49 years**.**

Main outcome measures: The primary outcome was the study participants' body mass index (BMI).

Results: A total of 58,192 women whose body mass index (BMI) was available were included in the analysis. The prevalence of overweight and obesity among reproductive age women increased significantly from 7.53% (95% CI: 6.83, 8.29) and 1.82% (CI: 1.48, 2.24) in 1999 to 28.37% (CI: 27.49, 29.28) and 10.77% (CI: 10.22, 11.35) in 2014, respectively. Age, education, wealth index, watching TV, and contraceptive use were associated with overweight and obesity in both urban and rural areas.

Conclusions: Overweight and obesity prevalence increased significantly among Bangladeshi reproductive age women. Developing effective low cost strategies to address the increasing burden of obesity are high priority.

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Strengths and limitations of this study

- To our knowledge, this is the first study in Bangladesh to compare long-term (15 years) trends in prevalence and risk factors associated with overweight/obesity in rural and urban women using nationally representative data
- The study compared World Health Organization (WHO) recommended Asian standard BMI classification with International BMI classification, which is lacking in prior studies. The prevalence of overweight and obesity using the Asian-specific guidelines was 2.10 to 2.5 times higher than prevalence estimates based on the international guidelines.
- Analysis accounted for complex survey design (clustering, stratification, weights) which gives accurate estimates for the country population. Survey year as a predictor for the first time in Bangladeshi population which provides incremental change in BMI over time
- The surveys did not include data on diet, fruits, and vegetables intake and physical activity, which are important predictors of overweight, and obesity. Results not replicable for older women's and no data for men

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Introduction

Obesity is a growing global public health concern [1]. An estimated two billion adults were reported to have overweight or obesity in 2014 with a worldwide prevalence of 39% [1,2]. Obesity increases the risk of many serious chronic health condition such as hypertension, prediabetes, type 2 diabetes, dyslipidemia, cardiovascular diseases (CVDs), certain cancers, and metabolic syndrome [2-4]. With a J-shaped (slight upward trend with a low BMI and steep increase with higher BMI) relationship between body mass index(BMI) and mortality, obesity has a high risk of mortality [5].

While the impact of overweight and obesity epidemic in developed countries has been highlighted [6], recent studies demonstrate that the prevalence of obesity has increased significantly in many developing countries [7]. It has been projected that the trend of overweight and obesity will continue to rise in the developing world [8]. Bangladesh, a low-income country in South East Asian region, has also observed an increasing prevalence of overweight and obesity. Like many developing countries, Bangladesh has experienced demographic and nutritional changes amongst the population such as changing lifestyle (e.g. high calorie food intake, sedentary life style) and urbanization. The rate of serious chronic health conditions in Bangladesh has increased steadily and death attributable to chronic conditions climbed from 8% in 1986 to 68% in 2006 [6]. Traditionally, infectious diseases [9] and under-nutrition [10] were major public health problems in the country and less attention has focused on overweight and obesity by public health officials.

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Data on the overweight and obesity trend in Bangladesh are sparse. Few of the studies that reported the prevalence of obesity were cross-sectional and data were limited to one year or less [11] and included only a specific group of participants (e.g. diabetic patients, schoolchildren etc.) [12]. Further, the change in sociodemographic factors associated with rising incidence of overweight and obesity in Bangladesh has not been well studied. Moreover, the scale to determine BMI categories varied widely in prior studies and most used scales other than the World Health Organization (WHO) recommended Asian standard BMI classification.

Overweight and obesity vary significantly between men and women [13]. Reproductive-age women have higher rates of overweight and obese and are more adversely affected by obesity-related complications [14]. This gender difference is mainly due to general weight gain during the child bearing years, gestational weight gain and/or weight retention and adverse lifestyle, risk factors associated with pregnancy and the postpartum period [15]. Maternal obesity increases the risk of numerous complications of pregnancy, labor, and birth for both mother and neonate, including diabetes and hypertensive disorders [14,16]. Compared with normal weight, maternal overweight is associated with a higher risk of cesarean delivery and a higher incidence of anesthetic and postoperative complications [17]. Low Apgar scores, macrosomia, and neural tube defects are also more frequent in infants of obese mothers than in infants of normal-weight mothers [17].

Understanding the obesity trend and identifying modifiable sociodemographic factors responsible for overweight and obesity among this high-risk group may help design feasible

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public health interventions to reduce the burden of obesity and associated adverse health outcomes. We, therefore, used nationally representative data from the Bangladesh Demographic and Health Survey (BDHS) to estimate the trends in overweight and obesity and to identify socio-demographic factors associated with overweight and obesity among reproductive-age women in Bangladesh over a 15-year period between 1999 and 2014.

Methods

Data sources

We analyzed publicly available data from the 1999, 2004, 2007, 2011, and 2014 BDHS. The BDHS is a nationally representative series of cross-sectional surveys of the non-institutionalized Bangladeshi population. It was developed over decades, progressively adopting standardized demographic and health survey questionnaire items designed to provide data for monitoring the population and health situation in Bangladesh since 1993 [18].

Sampling design and sample size

All BDHS surveys used a two-staged stratified sampling procedure. The first stage involved the selection of clusters consisting of enumeration areas using systematic random sampling based on probability proportional to population size which was based on the master sampling frame of the 2001 and 2011 population and housing census prepared by the Bangladesh Bureau of Statistics [19]. The second stage involved a household listing operation in all selected clusters, followed by the systematic random sampling of the households listed in each cluster. The details of the BDHS methods are available elsewhere [18]. The surveys include 10544, 11440, 10996, 17842, and 17863 women, from 1999, 2004, 2007, 2011, and 2014 survey year, respectively. We excluded participants below 15 years of age, participants with missing values

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for measured height and weight, and women who were pregnant at the time of the survey. After applying exclusion criteria, the total sample consisted of 58,192women.

Outcome

The outcome variable of this study was BMI calculated as weight in kilograms divided by height in meters squared. In our main analysis, we used BMI classifications recommended by WHO for Asian population: normal weight (18.5 to <23.0), moderate risk or overweight (23.0 to <27.5), and high risk or obese (≥27.5)[20]. We also conducted analyses using WHO and National Institutes of Health BMI classification for the general population: underweight (<18.5), normal weight (18.5 to <25.0), overweight (25.0 to <30.0), and obese (≥30.0) [21].

Covariates

We choose covariate hypothesized to be associated with overweight and obesity based on literature review. Socio-demographic characteristics included age (15-24, 25-34, 35-44, and 45+), marital status (married, not married), education(no education, primary, secondary, and higher), place of residence (rural, urban), geographic region south (Barishal), southeast (Chittagong), central (Dhaka), west (Khulna), mid-western corner (Rajshahi), northwest (Rangpur), and east (Sylhet), wealth index (poorest, poorer, middle, rich, and richest), employment status (yes, no), watching TV at least once a week (yes or no), number of living children (0, 1–2, 3–4, and ≥5), number of household members (1–2, 3–4, and ≥5), contraceptive use (not using any method, using pill, and other methods), and survey year. Survey year was treated as categorical variable.

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Statistical analysis

Descriptive statistics (e.g. mean, frequencies) were calculated to define the characteristics of the participants for the survey years. All five surveys were this appended given that a similar survey protocol in terms of design, scope, coverage, sampling, data collection, coding, and weighting was used across surveys. This approach simplified reporting estimates and improved statistical power of the analyses. The distributions of BMI at each survey year was presented and compared with rural and urban population using kernel density plots. The trend over the 15-year period of BMI was assessed by linear regression with time interval (survey year) as primary predictor. The nature, strength, and direction of the association between the women's socio-demographic characteristics and the BMI categories was assessed using multinomial logistic regression models with adjusted risk ratios (ARR) and 95% confidence intervals (CI) for urban and rural study participants separately. All analysis was performed using the statistical software, StataMP13.0 version (StataCorp LP, College Station, TX). The "svy" procedures were used to adjust for the sample stratification and clustering effect in all further analyses at the time of each survey. We used forward, backward and stepwise model selection procedures to select the best predicting model. Variance inflation factor was also calculated to check the collinearity of the predictor variables and the outcome for both urban and rural sample (**TableS4**).

Ethical approval and consent

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council, Dhaka, Bangladesh. All study participants provided written informed consent.

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Results

Socio-demographic characteristics

A total of 68,685 women participated across the five surveys. BMI data was available for 62,059 study participants and the response rates of the survey ranged between 96.9 and 98.6% from 1999 to 2014 **(TableS1)**. We examined the changes in the shape of BMI distributions among Bangladeshi reproductive-age women between 1999, 2004, 2007, 2011, and 2014 using Kernel density plot by urban and rural areas **(Figure 1).** Both urban and rural BMI distribution curves appear to be skewed to the right over the 15-year period indicating a gradual increase in BMI. **Table 1** shows the socioeconomic and demographic characteristics of the study participants across survey years. Over time, the mean age of study participants increased from 25 (±6.63) to 32(±9.12) years. There was a significant reduction in the proportion of women with no education from 45 to 26% ($p<0.001$) between 1999 and 2014. Similarly, the proportion of women with higher education increased almost two-fold (4.19% to 8.32%). The frequency of watching television increased approximately 1.6 times and the proportion of working women almost doubled (18.81 vs. 34.15%) over the study period. There was a significant change in the family structure during the study period. Five or more living children per women dropped from 12.63% to 8.11%.

Trends in overweight and obesity

Trends in overweight and obesity prevalence over the study period is presented in **Figure 2**. The overall prevalence of overweight-increased almost four fold (7.53 to 28.37%) and prevalence of obesity increased almost five-fold (1.82 to 10.77%) over the fifteen-year period. The prevalence of BMI categories by place of residence is presented in **Figure 3.** In urban areas, the prevalence

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of underweight went down to 12.21% in 2014 from 21.09% in 1999 and in rural areas; it dropped to 29.74% in 2014 from 48.18% in 1999. There was a 1.76 and 3.5-fold increase in overweight, 5.12, and 7.23-fold increase in obesity in the prevalence of overweight and obesity in urban and rural areas respectively (**Figure 3**).

Prevalence of overweight and obesity

Table S2 shows the overall prevalence of BMI categories by age groups and place of residence. The prevalence of individuals with overweight and obesity increased across the five survey years, for women residing in both urban and rural areas across all age groups. The prevalence of underweight and normal weight decreased in both rural and urban areas. Based on the Asian BMI cutoffs, the overall prevalence of overweight in rural and urban women increased from 19.08% (95% CI: 16.95, 21.42) and 5.02% (95% CI: 4.33, 5.83) in 1999 to 33.74% (95% CI: 32.19, 35.32) and 26.24% (95% CI: 25.17, 27.34) in 2014, respectively. Similarly, the prevalence of obesity increased from 5.52% (95% CI: 4.32, 7.04) and 1.02% (95% CI: 0.72, 1.44) in 1999 to 19.32% (95% CI: 18.01, 20.69) and 7.37% (95% CI: 6.82, 7.97) in 2014 in urban and rural areas, respectively. The highest increase of overweight was observed among women age 35-44 years from 15.79% and 6.10 % in 1999 to 37.62% and 30.09% in 2014 in urban and rural areas, respectively. The prevalence of obesity increased almost three fold among women aged 25-34 years from 7.47% and 1.37 % in 1999 to 21.23% and 8.28% in 2014 in urban and rural areas, respectively. The prevalence estimates of BMI for urban and rural women differed when the international BMI cutoffs were used **(TableS3).** A sharp decline was also observed in underweight (urban- 29.73% to 12.2%; rural- 48.18% to 21.08%) during 1999 to 2014 applying the international BMI standard. Across urban and rural and all survey years, the prevalence of

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overweight and obesity using the Asian-specific guidelines was 2.10 to 2.5 times higher than prevalence estimates based on the international guidelines **(FigureS1).**

Risk factors of overweight or obesity

The association of overweight and obesity with adjusted for participants' socio-demographic risk factors for urban and rural women is presented in **Table 2**.Overall, the risk factors of overweight and obesity differed between urban and rural women. Increasing age was found to be associated with higher overweight and obesity risk among both rural and urban residents though the association was stronger among urban residents. The highest overweight (ARR: 3.14, 95% CI: 2.74, 3.59) and obesity (ARR: 6.77, 95% CI: 5.56, 8.24) risk were for the urban women in the age group 35-44 years compared to the women 15-24 years. The risk of overweight and obesity were found to be high for urban women with higher educational level, married, higher social status, and women whose husband had a higher educational level. In terms of wealth index, there was significant risk variation between urban and rural study participants. The middle, richer, and richest rural women had of 1.63, 2.55, and 5.85 higher odds of being overweight compared to the women in the poorest wealth index group. The odds of being obese was found to be 2.30, 3.94, and 7.88 times higher for middle, richer, and richest rural women, respectively. Married women in urban areas were found to have a higher 27% overweight (ARR: 1.27, 95% CI: 1.04, 1.56) and 41% higher obesity (ARR: 1.41, 95% CI: 1.07, 1.86) risk compared to the not married women. Marital status was not significantly associated with overweight or obesity for rural women's. Watching TV at least once in a week was an independent risk factor for overweight and obesity among both urban and rural women and the risk was stronger among urban women. In the adjusted model, women who watched TV at

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least once a week had 28% (ARR: 1.28, 95% CI: 1.13, 1.45) and 72% (ARR: 1.72, 95% CI: 1.43, 2.07) higher risk of being overweight and obese, respectively as of women who do not watch TV at least once in a week.

Women's employment status was only associated with overweight or obesity for urban residents. Working urban women had a lower probability of being overweight (ARR: 0.79, 95% CI: 0.71, 0.89) or obese (ARR: 0.54, 95% CI: 0.46, 0.64) compared to those who were not engaged in any type of work. Women of rural areas with more than five or more household members had a lower probability of being overweight (ARR: 0.71, 95% CI: 0.60, 0.84) and obese (ARR: 0.61, 95% CI: 0.45, 0.81) compared to women who had only one or two household members. As compared to the 2004 survey, the risk of being overweight significantly increased with each subsequent survey years in urban and rural areas. For the increase of one survey period, the risk of overweight and obesity was much stronger in rural areas compared to urban areas after adjusting for all predictors. For example, in the most recent 2014 survey the odds of 4.47 (95% CI: 3.59, 5.57) being obese among rural women was as of 2004 survey whereas, in 2014 urban women had odds of 3.23 (95% CI: 2.71, 3.86) being obese in 2014 compare to the 2004 survey.

Discussion

We identified an increasing trend of overweight and obesity among Bangladeshi reproductive-age women with a five-fold increase of obesity between 1999 and 2014. This trend suggests that Bangladesh may continue to experience obesity epidemic in future highlighting the risk of adverse health outcome associated with overweight and obesity. Overweight and obesity put women at elevated risk for a myriad of adverse health outcomes, including cardiovascular

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disease, diabetes, kidney disease, and obesity-related cancers [3,4,22]. These women are also more likely to develop pregnancy complications, such as gestational diabetes, hypertensive disorders of pregnancy, cesarean section delivery and adverse fetal outcome [14,16]. Bangladesh though made substantial progress in reducing death from pregnancy-related complications in the last couple of decades, it still remains very high and the increasing trend of obesity among reproductive age women may create new challenges [23,24].

Our findings of increasing prevalence of overweight and obesity over the years is consistent with the findings from neighboring countries as well as current trends in most developing countries, and across the globe [2]. This trend could be explained by substantial changes in lifestyle including change in eating habits with more energy-dense food intake and sedentary lifestyle with reduced physical activity patterns [25]. These changes have been observed in Bangladesh with rapid economic growth, urbanization, modernization, and globalization of the food market [26].

We found the highest increase in the prevalence of overweight and obesity among women aged 35-44 years. Studies from other low-income countries showed that older women (aged 45-49) are at greatest risk of overweight and obesity [27]. Because we did not include women aged more than 49 years of age in this analysis, the actual number of obese women might be much higher in Bangladesh. Our study also showed that the increasing rate of overweight and obesity was more marked in rural areas than urban areas whereas the rate of reduction of undernutrition was much higher in urban areas. This disparity may be the result of multiple

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factors. Reduction in poverty leads to improvement in the nutritional status [28]. Haddad *et al*. have shown that increase in income at the household and national levels can significantly improve the nutritional status [29]. Bangladesh has made progress in increasing per-capita income, particularly since the second half of the 1990s when growth in per-capita income accelerated to 3.6% per year [30]. However, this income growth has primarily occurred among the rich and decreased among the poor, widening the gap between the richest and the poorest [31]. The income Gini coefficient (measures income inequality and a greater value represents greater inequality) shows an increase from 0.432 in 1995 to 0.451 in 2000 and to 0.458 in 2010 mostly because of increasing inequality between urban and rural areas [31]. Therefore, this income inequality between the rich and the poor and between urban and rural populations, and the decline in food consumption could, in part, explain the slow reduction of number of underweight women in urban areas. Our data showed that over last 15 years' the number of educated and employed women increased significantly in Bangladesh, however, this increase primarily occurred in urban areas. Because educational status and employment are both negatively associated with obesity, this might explain the variation in overweight and obesity between urban and rural women [32].

We determined that educational status including the husband's educational status, marital status, wealth index, self-reported hours of television watched, and employment status were significantly associated with overweight and obesity. Our study showed that compared to women who have no education, women with higher educational status were at increased risk of overweight and obesity. Highly educated women are more likely to have a sedentary job requiring less physical activity and hence increases the chance of weight gain. Studies from

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other developing countries have also shown a positive association between level of education and obesity, however, a negative association between the two variables has also been observed primarily in developed countries [32]. Our findings that wealthier women are more to be overweight or obese are consistent with studies done in other low and middle-income countries [33]. This is likely due to increasing wealth in lower income countries results in greater access to food, an escape from physical labor and therefore a higher risk of obesity.

We found that television watching was an independent predictor of overweight and obesity. Television viewing has been used as a proxy measure for sitting time and studies that follow participants over long periods of time have consistently found that people who spend more time watching television are more likely to gain weight [34]. Unemployed Bangladeshi women spend a significant amount of time watching television as a leisure activity and with the economic growth increasing access to television suggest that viewing television may further increase which may further contribute obesity of this group.

Because geographical, ethnic, and cultural variation have large impacts on trends of overweight and obesity, we used Asian BMI standard instead of international guidelines. We found that the prevalence estimate of overweight and obesity using Asian BMI category across all survey years were 2.10 to 2.50 times higher compared to estimates based on the international guidelines. Evidence have shown that Asian populations are at an increased risk of cardio metabolic disorders at lower BMI levels than other ethnic groups, which has been attributed to a considerably higher body fat percentage [35]. For that reason, in 2004 the WHO recommended lowering the BMI cut-offs for Asian adults, for overweight from 25 to 23 kg/m^2 and for obesity from 30 to 27.5 kg/m^2 in anticipation of the increased health risks [20]. Therefore, previous

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reports that focuses international BMI classification in estimating overweight and obesity prevalence may have undermined actual risk.

Our analysis has several limitations. We used secondary cross-sectional data limiting our ability to identify a causal relationship. Moreover, the dataset lack some key variables including food habit, physical activity, and smoking. Evidence showed that these factors strongly influence weight gain and may interact with other predictors of obesity such as wealth and education. However, the study included representative sample across Bangladesh including both urban and rural women and used Asian BMI category for the analysis strengthening our evidence base.

Conclusion

Overweight and obesity continue to increase among Bangladeshi reproductive-age women between 1999 and 2014. Several sociodemographic factors including age, education, wealth index, marital status, television watching and employment status were associated with the increasing trend of overweight and obesity. The prevalence and risk factors varied between urban and rural women. Further research should focus on identifying other behavioral risk factors associated with overweight and obesity and identify feasible interventions to include those most at risk including older, higher educated and wealthy women.

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Tables

Table 1. Socio-demographic characteristics of the study participants by survey, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Age, mean(SD)	25.88 (6.63)	30.56 (9.36)	30.94 (9.3)	31.23 (9.22)	31.37 (9.12)	<0.001
Age group, n (%)						<0.001
15-24	2148 (47.05)	3303 (31.82)	2996 (30.29)	4557 (28.72)	4433 (27.04)	
25-34	2007 (41.52)	3533 (33.77)	3344 (33.13)	5603 (34.19)	5969 (36.44)	
35-44	486 (10.61)	2598 (24.39)	2747 (26.69)	4321 (26.2)	4435 (26.05)	
45+	38 (0.81)	1055 (10.02)	1040 (9.89)	1792 (10.89)	1787 (10.47)	
Educational level, n (%)						<0.001
No education	2002 (44.62)	4158 (42.44)	3326 (34.85)	4386 (28.59)	4039 (25.68)	
Primary	1364 (29.14)	3070 (29.07)	3014 (29.67)	4857 (30.04)	4875 (29.24)	
Secondary	1072 (22.05)	2629 (23.52)	2983 (29.52)	5731 (34.3)	6153 (36.76)	
Higher	241 (4.19)	632 (4.97)	801 (5.96)	1299 (7.07)	1557 (8.32)	
Place of residence, n (%)						<0.001
Urban	1275 (17.76)	3593 (22.58)	3858 (22.81)	5709 (26.1)	5764 (28.41)	
Rural	3404 (82.24)	6896 (77.42)	6269 (77.19)	11000 (73.9)	11000 (71.59)	
Geographic region, n (%)						<0.001
Barisal	434 (6.48)	1252 (6.33)	1327 (6.01)	1819 (5.45)	1982 (6.19)	
Chittagong	937 (20.08)	1869 (17.56)	1775 (18.23)	2616 (18)	2639 (18.29)	
Dhaka	1123 (31.05)	2376 (31.27)	2178 (31.5)	2795 (32.18)	2893 (34.96)	
Khulna	760 (11.42)	1583 (12.32)	1589 (12.77)	2488 (12.4)	2460 (10.51)	
Rajshahi	889 (24.48)	2374 (26.35)	1933 (25.31)	4703 (26.73)	4769 (23.56)	
Sylhet	536 (6.49)	1035 (6.17)	1325 (6.18)	1852 (5.25)	1881 (6.49)	
Marital status, n (%)						<0.001
Not married	130 (2.71)	859 (7.93)	822 (7.7)	1091 (6.6)	1014 (5.95)	
Married	4549 (97.29)	9630 (92.07)	9305 (92.3)	15000 (93.4)	16000 (94.05)	
Urban						
BMI, Kg/m2						<0.001
Mean (SD)	20.78 (4.51)	21.52 (5.06)	22.24 (5.44)	23 (4.87)	23.7 (5.06)	
BMI categories, n (%)						<0.001
Underweight	385 (29.74)	903 (24.84)	787 (19.54)	879 (13.46)	738 (12.21)	
Normal weight	585 (45.65)	1573 (44.47)	1629 (41.73)	2298 (41.4)	1996 (34.73)	
Overweight	237 (19.09)	801 (21.87)	1010 (26.88)	1729 (30.62)	1971 (33.74)	
Obese	68 (5.53)	316 (8.81)	432 (11.85)	803 (14.52)	1059 (19.32)	
Overweight or obese	305 (24.61)	1117 (30.68)	1442 (38.73)	2532 (45.14)	3030 (53.06)	
Rural						
BMI, Kg/m2						<0.001
Mean (SD)	18.97 (2.42)	19.76 (2.72)	20.18 (2.83)	20.82 (3.29)	21.71 (3.62)	
BMI categories, n (%)						<0.001
Underweight	1636 (48.19)	2581 (36.9)	2107 (32.45)	2940 (27.83)	2353 (21.09)	
Normal weight	1560 (45.76)	3422 (49.82)	3135 (50.72)	5138 (48.59)	4926 (45.3)	

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Table 1. Socio-demographic characteristics of the study participants by survey, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Overweight	174 (5.03)	762 (11.36)	851 (13.88)	1997 (18.97)	2780 (26.24)	
Obese	34 (1.02)	131 (1.92)	176 (2.96)	489 (4.62)	801 (7.38)	
Overweight or obese	208 (6.05)	893 (13.28)	1027 (16.83)	2486 (23.58)	3581 (33.62)	
Wealth index, n (%)						0.1665
Poorest	NA	1865 (19.85)	1636 (19.19)	2811 (18.29)	2999 (18.55)	
Poorer	NA	1880 (19.92)	1822 (19.35)	2995 (19.47)	3102 (18.95)	
Middle	NA	1960 (19.77)	1910 (19.72)	3129 (20.07)	3382 (20.04)	
Richer	NA	2098 (20.38)	2043 (20.85)	3472 (20.83)	3534 (21.21)	
Richest	NA	2686 (20.08)	2716 (20.88)	3866 (21.34)	3607 (21.24)	
Watch TV (once a week), n (%)						<0.001
No	2946 (66.99)	5459 (54.5)	5138 (53.2)	8149 (51.61)	7997 (48.83)	
Yes	1732 (33.01)	5027 (45.5)	4985 (46.8)	8120 (48.39)	8626 (51.17)	
Currently working, n (%)						
No	3839 (81.19)	8098 (76.85)	7068 (67.12)	14000 (86.62)	11000 (65.85)	
Yes	840 (18.81)	2390 (23.15)	3055 (32.88)	2216 (13.38)	5398 (34.15)	
Number of living children, n (%)						<0.001
0	67 (1.46)	1017 (9.39)	930 (8.78)	1371 (8.53)	1385 (7.96)	
1-2	2669 (56.66)	4590 (43.15)	4769 (47.11)	8236 (50.09)	8857 (53.48)	
3-4	1358 (29.25)	3312 (32.45)	3111 (31.61)	5102 (31.64)	5013 (30.45)	
>5	585 (12.63)	1570 (15.01)	1317 (12.5)	1564 (9.74)	1369 (8.11)	
Number of household member, n (%)						<0.001
1-2	46 (1.03)	382 (3.71)	405 (4.11)	694 (4.46)	834 (5.27)	
3-4	1208 (26.22)	3079 (30.31)	3171 (32.63)	5633 (34.65)	6224 (37.36)	
>5	3425 (72.75)	7028 (65.99)	6551 (63.25)	9946 (60.89)	9566 (57.36)	
Contraceptive use, n (%)						<0.001
Not using	2060 (44.71)	4422 (41.76)	4555 (44.02)	6260 (38.76)	6227 (37.19)	
Pills	1352 (2.904)	2641 (2.606)	2734 (2.835)	4385 (2.725)	4476 (2.717)	
Other	1267 (26.25)	3426 (32.18)	2838 (27.63)	5628 (33.99)	5921 (35.64)	
Husband education, n (%)						<0.001
No education	1851 (42.48)	3818 (39.16)	3342 (35.92)	4833 (31.73)	4764 (29.5)	
Primary	1102 (24.24)	2629 (25.34)	2610 (25.78)	4362 (26.89)	4503 (27.1)	
Secondary	1098 (23.05)	2691 (24.43)	2660 (25.94)	4680 (27.93)	4884 (29.71)	
Higher	549 (10.23)	1342 (11.07)	1501 (12.37)	2390 (13.46)	2471 (13.69)	

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Table 2. Association of overweight and obesity with socio demographic characteristics by place of residence, BDHS 1999-2014

	Urban				Rural			
	Overweight vs. healthy		Obese vs. healthy		Overweight vs. healthy		Obese vs. healthy	
Age group	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
15-24	Ref		Ref		Ref		Ref	
25-34	2.39 (2.11, 2.7)	0.000	4.04 (3.34, 4.87)	0.00	2.09 (1.9, 2.31)	0.000	3.23 (2.67, 3.91)	0.000
35-44	3.14 (2.74, 3.59)	0.000	6.77 (5.56, 8.24)	0.00	2.45 (2.2, 2.73)	0.000	4.06 (3.3, 4.99)	0.000
45+	2.59 (2.15, 3.12)	0.000	6.22 (4.88, 7.92)	0.00	2.47 (2.14, 2.86)	0.000	3.69 (2.87, 4.74)	0.000
Education level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (1.06, 1.41)	0.006	1.25 (1.01, 1.54)	0.03	1.11 (1.01, 1.23)	0.023	1.22 (1.02, 1.46)	0.026
Secondary	1.41 (1.2, 1.65)	0.000	1.61 (1.29, 2.02)	0.00	1.15 (1.03, 1.3)	0.014	1.27 (1.04, 1.55)	0.019
Higher	1.61 (1.3, 1.99)	0.000	1.42 (1.07, 1.9)	0.02	1.12 (0.92, 1.36)	0.238	0.92 (0.67, 1.27)	0.649
Marital status								
Not married	Ref							
Married	1.27 (1.04, 1.56)	0.018	1.41 (1.07, 1.86)	0.01	NA	NA	NA	NA
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	1.15 (0.87, 1.52)	0.317	0.99 (0.58, 1.7)	0.99	1.32 (1.17, 1.49)	0.000	1.45 (1.11, 1.9)	0.006
Middle	1.65 (1.29, 2.11)	0.000	1.63 (1.02, 2.61)	0.04	1.65 (1.46, 1.87)	0.000	2.3 (1.78, 2.97)	0.000
Richer	1.88 (1.49, 2.37)	0.000	2.55 (1.64, 3.96)	0.00	2.46 (2.16, 2.8)	0.000	3.94 (3.05, 5.1)	0.000
Richest	2.83 (2.24, 3.57)	0.000	5.58 (3.6, 8.63)	0.00	3.38 (2.9, 3.94)	0.000	7.88 (5.93, 10.46)	0.000
Watch TV (once a week)								
No	Ref		Ref		Ref		Ref	
Yes	1.28 (1.13, 1.45)	0.000	1.72 (1.43, 2.07)	0.00	1.25 (1.15, 1.35)	0.000	1.4 (1.22, 1.62)	0.000
Currently working								
No	Ref		Ref					
Yes	0.79 (0.71, 0.89)	0.000	0.54 (0.46, 0.64)	0.00	NA	NA	NA	NA
Number of household member								
1-2					Ref		Ref	
3-4	NA	NA	NA	NA	0.86 (0.72, 1.02)	0.093	0.86 (0.64, 1.16)	0.353
>5	NA	NA	NA	NA	0.71 (0.6, 0.84)	0.000	0.61 (0.45, 0.81)	0.001
Contraceptive use								
Not using	Ref				Ref		Ref	
Pills	0.96 (0.85, 1.09)	0.605	0.79 (0.67, 0.94)	0.01	1.06 (0.98, 1.16)	0.130	0.83 (0.7, 0.97)	0.022
Other	1.07 (0.95, 1.2)	0.237	1.04 (0.9, 1.2)	0.55	1.08 (0.99, 1.18)	0.053	0.94 (0.82, 1.09)	0.459
Husband education								
No education	Ref		Ref		Ref		Ref	
Primary	1.11 (0.95, 1.29)	0.164	1.12 (0.89, 1.4)	0.32	1.07 (0.97, 1.18)	0.132	1.22 (1.01, 1.47)	0.037
Secondary	1.18 (1.01, 1.37)	0.031	1.32 (1.05, 1.65)	0.02	1.2 (1.08, 1.34)	0.001	1.51 (1.25, 1.82)	0.000
Higher	1.55 (1.28, 1.88)	0.000	1.94 (1.49, 2.52)	0.00	1.46 (1.25, 1.69)	0.000	1.98 (1.55, 2.53)	0.000
Survey year								
2004	Ref		Ref		Ref		Ref	
2007	1.23 (1.07, 1.42)	0.003	1.35 (1.11, 1.64)	0.00	1.19 (1.06, 1.35)	0.004	1.49 (1.15, 1.93)	0.002
2011	1.43 (1.26, 1.63)	0.000	1.68 (1.4, 2)	0.00	1.71 (1.54, 1.9)	0.000	2.5 (2, 3.13)	0.000
2014	2.07 (1.81, 2.37)	0.000	3.23 (2.71, 3.86)	0.00	2.6 (2.33, 2.89)	0.000	4.47 (3.59, 5.57)	0.000

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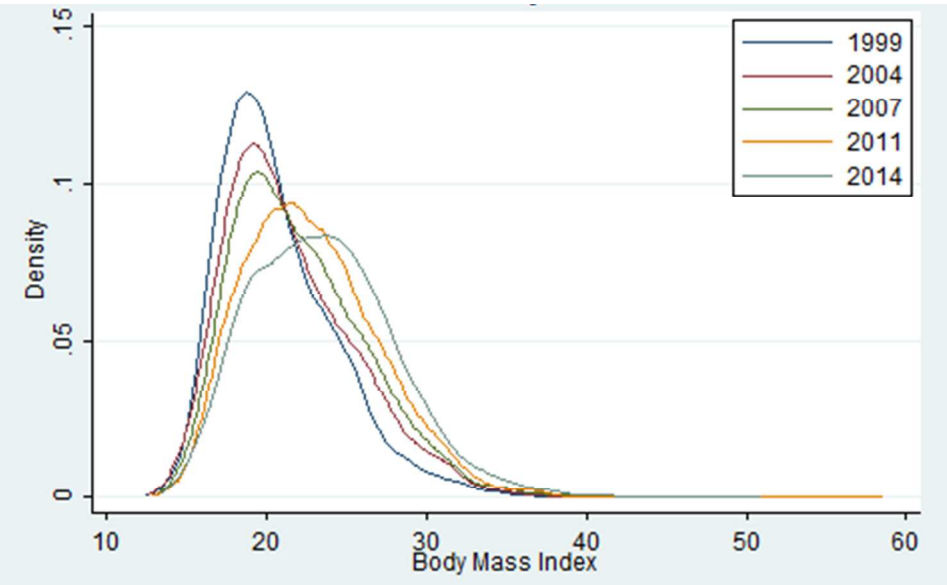
Figures

Figure 1. Kernel density plot of the distribution of BMI for reproductive women in 1999, 2004, 2007, 2011, and 2014.

(a) Urban



(b) Rural

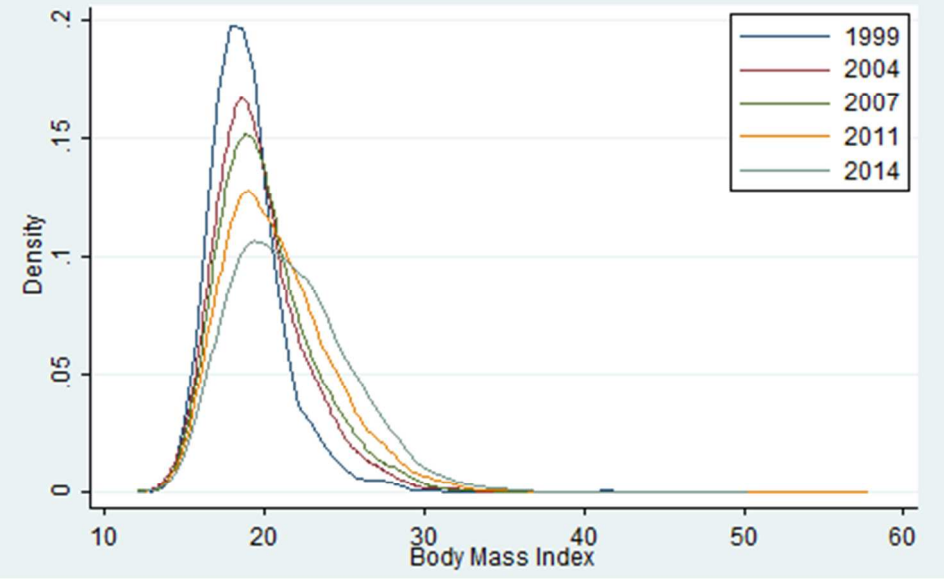


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Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014.

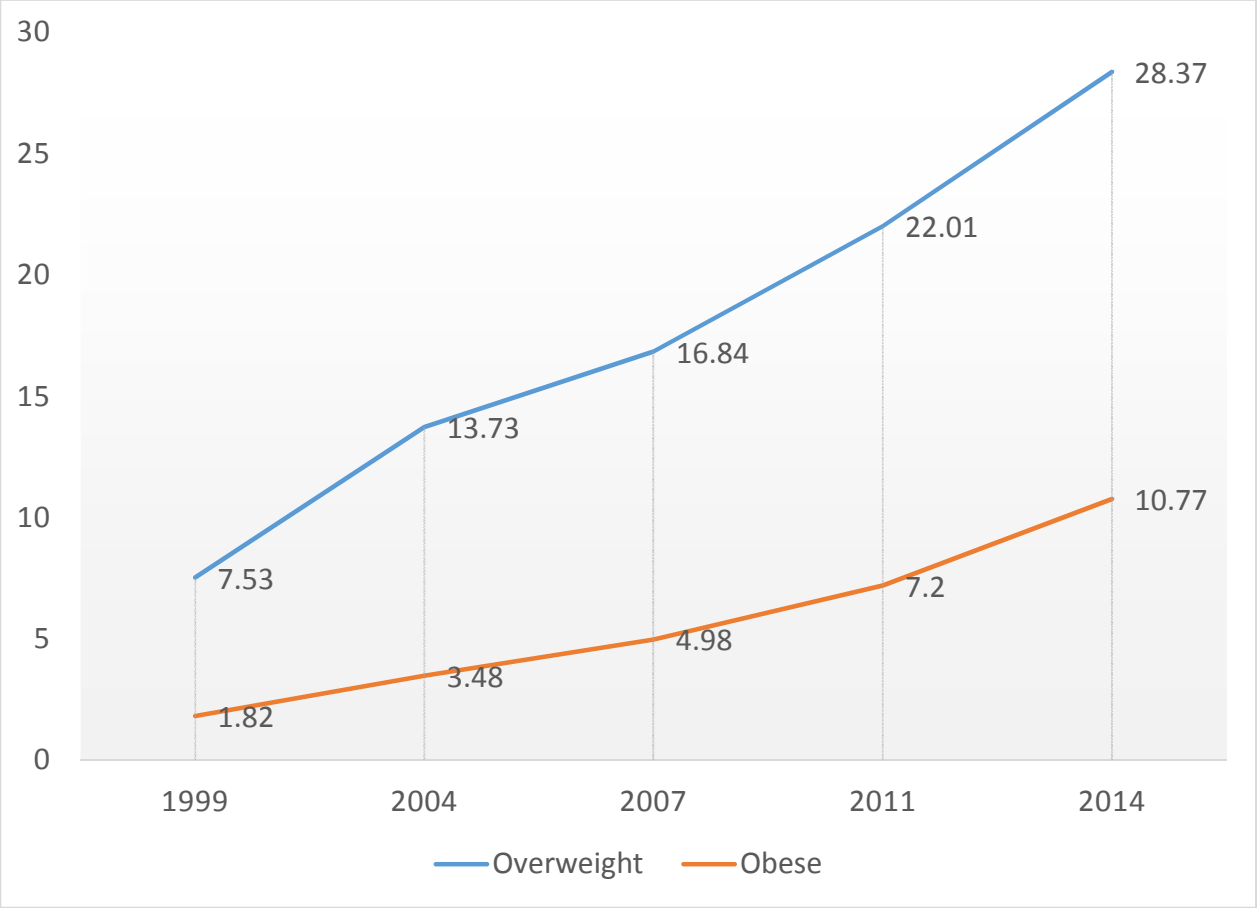

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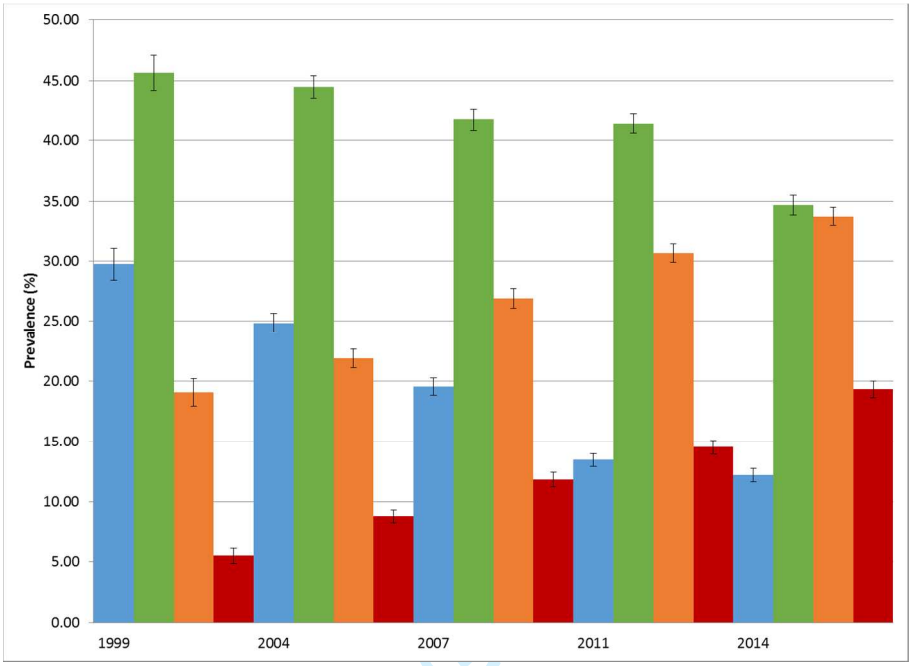
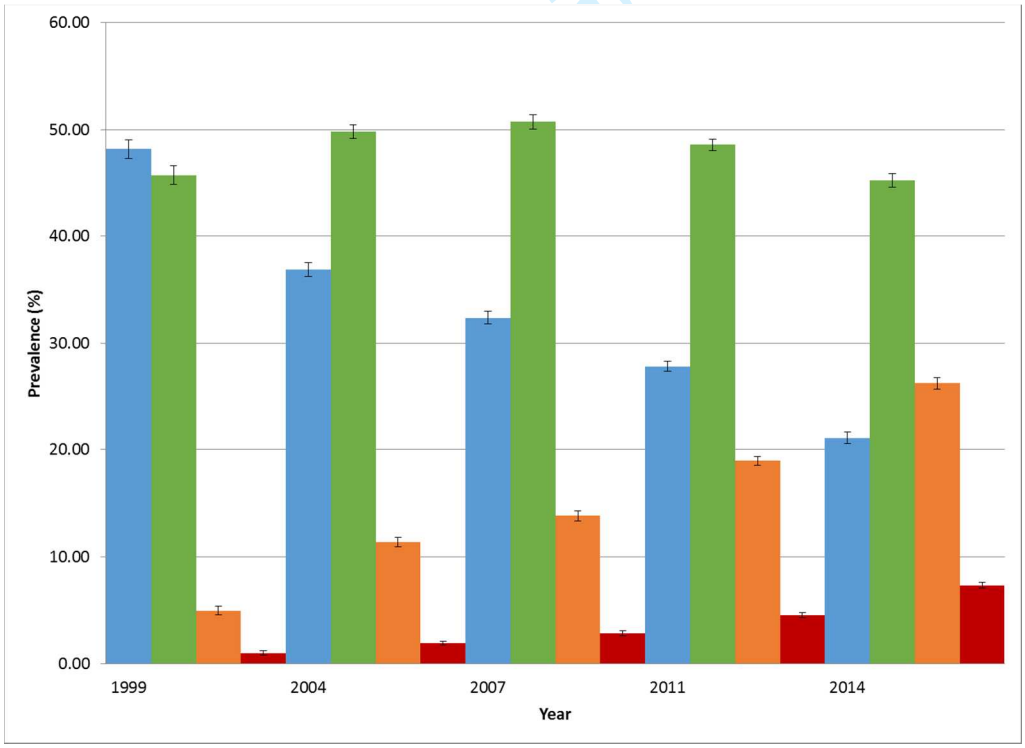
Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

(a) Urban



(b) Rural



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List of Abbreviations

ARR	Adjusted risk ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Ethical approval and consent

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Informed consent was obtained from each participant of the survey before enrolling in the survey by using the Introduction and Consent form of the survey. It was also explained that the information will be kept strictly confidential and will not be shared with anyone except members of the survey team.

Consent to publish: Not Applicable

Availability of data

The datasets used for the current study are publicly available from http://dhsprogram.com/data/available-datasets.cfm.

Funding: None

Acknowledgement: We gratefully acknowledge DHS for allowing us to use the data.

Disclosure/ Conflict of interest: None

Author contribution: MABC conceptualized of the study and designed the analytical approach, performed the data analyses and interpreted the findings, and led the writing of the article. **MMA** were involved in the literature search and drafting the manuscript. **ZH** Helped conceptualize the study literature, variable selection, editing and drafting the manuscript. Revised the manuscript critically for important intellectual content, and final approval of the version to be submitted. All authors helped write the manuscript. All authors read and approved the final manuscript.

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Supplements

Table S1. Summary characteristics of the sample by survey year, BDHS 1999-2014

Variable	1999-00	2004	2007	2011	2014
Initial sample of the survey, n	10544	11440	10996	17842	17863
BMI available, n	5055	11176	10836	17309	17683
Pregnant women, n	376	678	709	1036	1059
Final working sample, n	4679	10489	10127	16273	16624
Response rate, %	96.9	98.6	98.4	97.9	97.9

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Table S2. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014

		Urban					Rural				
	Age groups	1999	2004	2007	2011	2014	1999	2004	2007	2011	2014
Underweight	15-24	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	25-34	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	35-44	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	45+	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	Overall	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	15-24	50.62 (46.22, 55.01)	53.21 (49.83, 56.56)	50.64 (47.17, 54.11)	53.98 (50.91, 57.02)	45.47 (42.22, 48.77)	47.42 (44.89, 49.95)	53.54 (51.33, 55.74)	55.29 (52.86, 57.69)	52.08 (50.14, 54)	50.84 (48.49, 53.18)
	25-34	41.45 (37.43, 45.59)	44.68 (41.65, 47.75)	41.3 (38.23, 44.45)	37.8 (35.15, 40.51)	32.71 (30.19, 35.34)	46.8 (44.08, 49.54)	51.15 (48.95, 53.35)	51.6 (49.21, 53.98)	48.32 (46.57, 50.08)	44.57 (42.49, 46.67)
	35-44	45.09 (35.42, 55.14)	37.9 (34.44, 41.5)	35.36 (32.17, 38.68)	34 (31.08, 37.05)	27.75 (24.94, 30.74)	35.71 (30.86, 40.88)	46.98 (44.42, 49.55)	47.49 (44.83, 50.16)	47.15 (45.16, 49.15)	42.17 (39.77, 44.61)
	45+	19.96 (4.12, 59.13)	33.66 (28.29, 39.49)	36.66 (31.3, 42.36)	37.87 (33.33, 42.63)	32.15 (27.54, 37.14)	35.62 (20.55, 54.2)	40.37 (36.59, 44.27)	41.94 (37.8, 46.2)	43.56 (40.47, 46.71)	41.06 (37.55, 44.66)
	Overall	45.64 (42.81, 48.51)	44.47 (42.65, 46.3)	41.72 (39.93, 43.53)	41.39 (39.8, 43)	34.72 (33.15, 36.33)	45.76 (44.03, 47.49)	49.82 (48.55, 51.08)	50.72 (49.36, 52.08)	48.58 (47.56, 49.61)	45.29 (44.05, 46.53)
Overweight	15-24	14.31 (11.51, 17.65)	12.51 (10.46, 14.89)	17.63 (15.1, 20.47)	20.18 (17.81, 22.79)	25.42 (22.67, 28.38)	3.36 (2.58, 4.37)	6.7 (5.67, 7.89)	9.56 (8.19, 11.14)	11.81 (10.63, 13.1)	17.95 (16.33, 19.7)
	25-34	23.9 (20.55, 27.6)	25.73 (23.15, 28.49)	28.99 (26.19, 31.96)	35.56 (32.95, 38.26)	37.7 (35.09, 40.38)	6.74 (5.49, 8.24)	12.09 (10.72, 13.6)	15.66 (14, 17.48)	22.03 (20.61, 23.52)	29.31 (27.47, 31.23)
	35-44	15.79 (9.58, 24.92)	26.82 (23.77, 30.11)	33.17 (30.02, 36.48)	35.55 (32.57, 38.66)	37.62 (34.59, 40.74)	6.1 (4.06, 9.08)	15.05 (13.29, 17)	15.67 (13.83, 17.71)	22.4 (20.78, 24.1)	30.09 (27.93, 32.34)
	45+	26.19 (3.91, 75.55)	23.39 (18.71, 28.83)	27.28 (22.51, 32.65)	30.3 (26.11, 34.84)	31.21 (26.62, 36.19)	3.4 (0.47, 20.56)	15 (12.32, 18.14)	16.66 (13.73, 20.07)	20.06 (17.69, 22.67)	27.57 (23.99, 31.47)
	Overall	19.08 (16.95, 21.42)	21.87 (20.42, 23.39)	26.87 (25.28, 28.53)	30.62 (29.14, 32.14)	33.74 (32.19, 35.32)	5.02 (4.33, 5.83)	11.35 (10.57, 12.18)	13.87 (12.96, 14.84)	18.96 (18.18, 19.78)	26.24 (25.17, 27.34)
Obese	15-24	2.3 (1.28, 4.1)	3.44 (2.4, 4.92)	4.31 (3.07, 6.02)	5.67 (4.44, 7.22)	8.09 (6.49, 10.05)	0.82 (0.46, 1.44)	0.83 (0.51, 1.35)	1.18 (0.75, 1.86)	2.08 (1.59, 2.71)	3.74 (3.01, 4.64)
	25-34	7.47 (5.54, 10)	8.65 (7.03, 10.6)	12.33 (10.41, 14.55)	15.39 (13.48, 17.52)	21.23 (18.96, 23.69)	1.37 (0.86, 2.18)	2.47 (1.86, 3.29)	3.52 (2.72, 4.55)	5.51 (4.76, 6.36)	8.28 (7.32, 9.36)
	35-44	10.68 (5.53, 19.6)	13.86 (11.59, 16.48)	17.26 (14.78, 20.07)	20.9 (18.41, 23.62)	25.24 (22.51, 28.19)	0.68 (0.17, 2.71)	2.56 (1.83, 3.56)	3.88 (2.99, 5.02)	5.68 (4.83, 6.66)	9.74 (8.53, 11.1)
	45+	17.94 (2.42, 65.83)	12.66 (9.27, 17.07)	15.53 (11.73, 20.29)	19.25 (15.73, 23.34)	26.01 (21.83, 30.67)	NA	2.05 (1.2, 3.49)	4.14 (2.69, 6.32)	5.94 (4.64, 7.58)	7.77 (6.2, 9.69)
	Overall	5.52 (4.32, 7.04)	8.81 (7.84, 9.88)	11.85 (10.71, 13.08)	14.51 (13.41, 15.69)	19.32 (18.01, 20.69)	1.02 (0.72, 1.44)	1.92 (1.59, 2.31)	2.95 (2.52, 3.45)	4.61 (4.2, 5.06)	7.37 (6.82, 7.97)

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Table S3. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014 **(International cutoff)**

	Urban					Rural				
	1999	2004	2007	2011	2014	1999-00	2004	2007	2011	2014
Underweight	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	60.28 (55.93, 64.48)	60.8 (57.48, 64.02)	62.4 (58.97, 65.72)	66.43 (63.53, 69.2)	59.81 (56.54, 62.98)	49.84 (47.3, 52.37)	58.05 (55.85, 60.21)	61.86 (59.48, 64.18)	59.97 (58.06, 61.85)	61.91 (59.64, 64.13)
	55.78 (51.59, 59.89)	57.51 (54.44, 60.52)	56.31 (53.15, 59.41)	57.53 (54.77, 60.23)	51.95 (49.19, 54.7)	51.45 (48.72, 54.17)	59.71 (57.54, 61.85)	60.19 (57.82, 62.51)	61.03 (59.3, 62.73)	60.12 (58.05, 62.16)
	53.39 (43.32, 63.19)	50.67 (47.04, 54.3)	52.6 (49.17, 56)	51.3 (48.14, 54.45)	44.95 (41.78, 48.16)	39.23 (34.25, 44.44)	56.17 (53.61, 58.7)	57.42 (54.77, 60.02)	61.14 (59.16, 63.07)	59.66 (57.26, 62.01)
	19.96 (4.12, 59.13)	43.23 (37.44, 49.21)	50.28 (44.61, 55.94)	52.82 (48.04, 57.55)	45.45 (40.36, 50.64)	35.62 (20.55, 54.2)	50.06 (46.14, 53.98)	54.54 (50.29, 58.72)	55.41 (52.25, 58.52)	56.51 (52.71, 60.24)
	57.4 (54.54, 60.21)	55.43 (53.6, 57.24)	56.33 (54.52, 58.14)	57.89 (56.29, 59.47)	51.49 (49.82, 53.16)	49.17 (47.44, 50.9)	57.33 (56.08, 58.57)	59.43 (58.09, 60.75)	60.14 (59.13, 61.15)	60.11 (58.89, 61.32)
Overweight	5.82 (4.11, 8.17)	6.59 (5.15, 8.41)	8.67 (6.88, 10.86)	11.08 (9.32, 13.12)	15.63 (13.42, 18.13)	1.28 (0.82, 2.01)	2.91 (2.25, 3.75)	3.82 (2.96, 4.91)	5.34 (4.55, 6.25)	9.52 (8.33, 10.87)
	14.07 (11.39, 17.26)	17.65 (15.41, 20.15)	21.33 (18.84, 24.05)	24.61 (22.29, 27.09)	31.22 (28.7, 33.85)	2.95 (2.14, 4.05)	5 (4.13, 6.05)	9.64 (8.32, 11.15)	13.06 (11.92, 14.29)	19.1 (17.61, 20.68)
	13.61 (7.8, 22.66)	22.23 (19.39, 25.35)	25.93 (23.03, 29.06)	30.21 (27.36, 33.23)	33.2 (30.3, 36.23)	3.28 (1.86, 5.7)	7.67 (6.37, 9.21)	8.91 (7.5, 10.55)	12.01 (10.77, 13.37)	18.54 (16.79, 20.42)
	44.14 (12.09, 81.39)	21.23 (16.77, 26.51)	21.68 (17.25, 26.88)	24.62 (20.76, 28.93)	30.73 (26.28, 35.57)	3.4 (0.47, 20.56)	6.38 (4.69, 8.62)	7.07 (5.22, 9.52)	11.55 (9.72, 13.67)	17.18 (14.72, 19.95)
	10.57 (8.92, 12.47)	15.87 (14.59, 17.23)	19.18 (17.78, 20.66)	22.25 (20.93, 23.63)	27.56 (26.11, 29.06)	2.19 (1.73, 2.77)	5.1 (4.57, 5.69)	7.39 (6.71, 8.13)	10.39 (9.79, 11.03)	16.14 (15.3, 17.02)
Obese	1.13 (0.49, 2.59)	1.78 (1.05, 2.99)	1.51 (0.85, 2.66)	2.33 (1.58, 3.43)	3.55 (2.47, 5.07)	0.48 (0.23, 0.99)	0.12 (0.03, 0.39)	0.36 (0.15, 0.81)	0.66 (0.4, 1.08)	1.1 (0.75, 1.6)
	2.97 (1.81, 4.84)	3.9 (2.85, 5.32)	4.99 (3.83, 6.49)	6.61 (5.34, 8.16)	8.48 (6.98, 10.25)	0.51 (0.22, 1.13)	1.01 (0.63, 1.59)	0.95 (0.55, 1.64)	1.77 (1.37, 2.29)	2.95 (2.37, 3.67)
	4.56 (1.61, 12.27)	5.68 (4.25, 7.54)	7.27 (5.66, 9.28)	8.94 (7.26, 10.96)	12.46 (10.37, 14.9)	.	0.74 (0.4, 1.37)	0.72 (0.4, 1.29)	2.08 (1.59, 2.72)	3.81 (3.04, 4.76)
	.	5.25 (3.2, 8.51)	7.51 (4.96, 11.21)	9.98 (7.38, 13.36)	13.18 (10.08, 17.06)	.	0.99 (0.43, 2.26)	1.13 (0.49, 2.58)	2.61 (1.78, 3.81)	2.71 (1.88, 3.9)
	2.28 (1.54, 3.38)	3.85 (3.21, 4.61)	4.93 (4.2, 5.78)	6.38 (5.63, 7.23)	8.72 (7.79, 9.76)	0.43 (0.25, 0.74)	0.65 (0.47, 0.9)	0.72 (0.52, 1.01)	1.62 (1.38, 1.9)	2.64 (2.31, 3.03)

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Table S4. Variance inflation (VIF) values of final models of urban and rural women, BDHS 1999-2014

Variables	VIF- Urban	VIF-Rural
Age	1.09	1.29
Education	2.03	1.97
Marital status	1.18	1.12
Wealth index	1.49	1.69
Watching TV at least once a week	1.29	1.32
Currently working	1.08	1.04
No· of household members	1.04	1.05
Contraceptive use	1.12	1.09
Husband education	2.03	1.71
Survey year	1.02	1.05

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Figure S1. Prevalence of BMI categories International cutoff

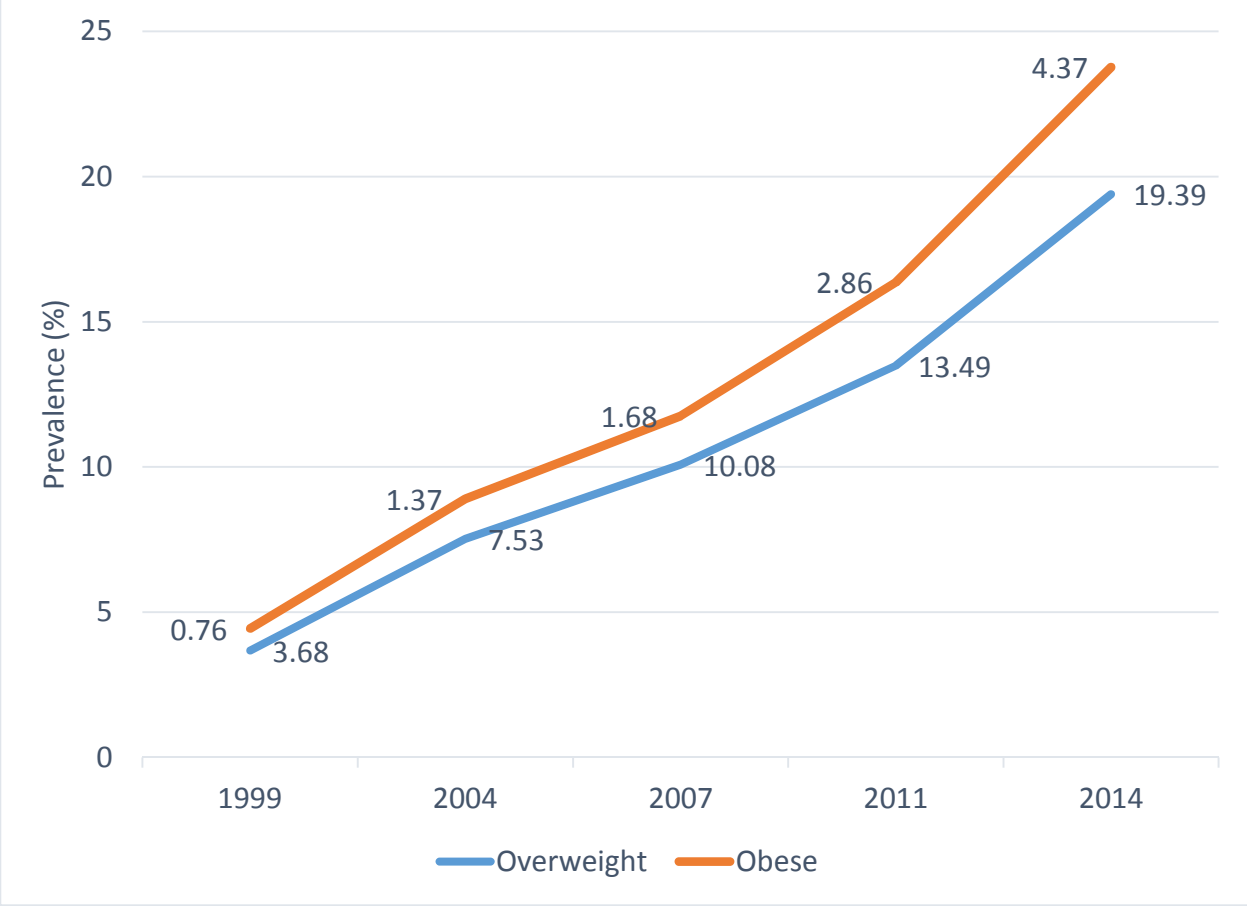

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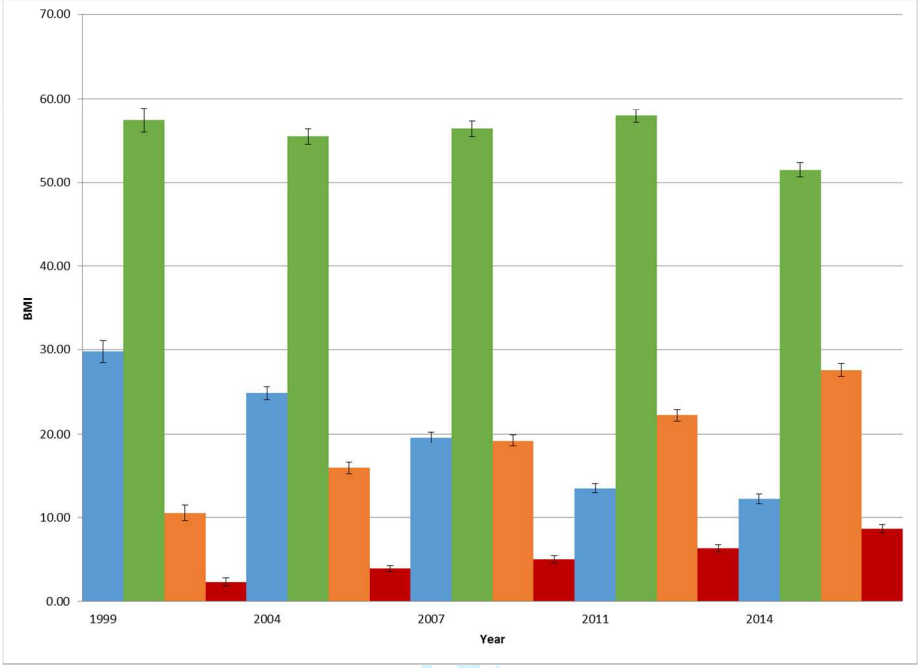
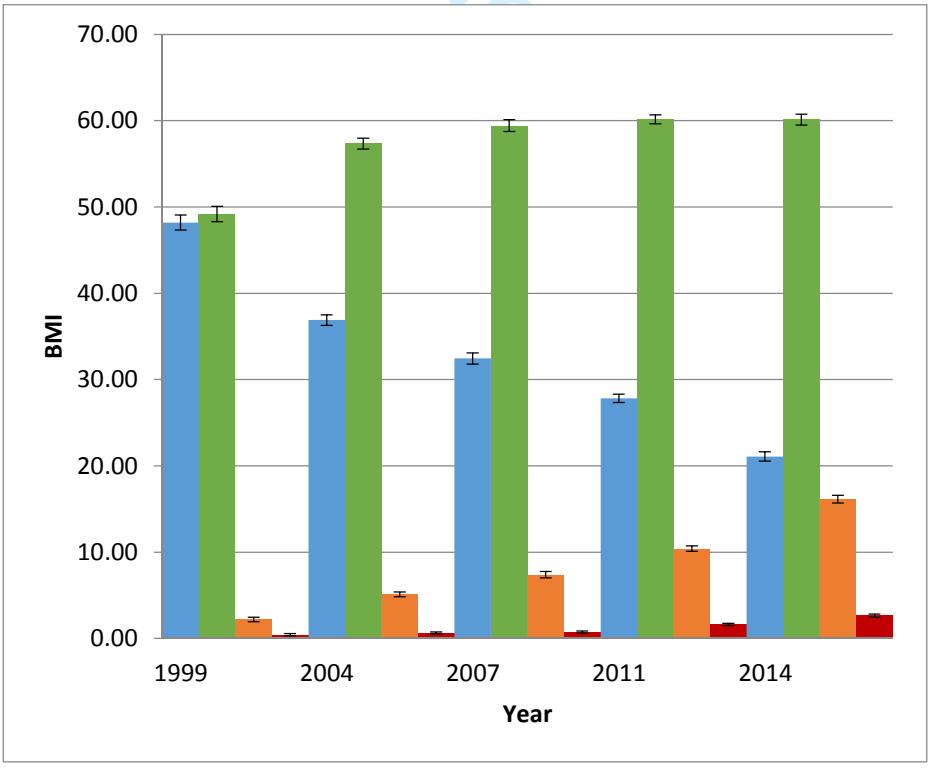
Figure S2. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014 (International cutoff).

(a) Urban



(b) Rural



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BMJ Open

Trends, prevalence, and risk factors in overweight and obesity among women of reproductive age in Bangladesh: a pooled analysis of five national cross-sectional surveys

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018468.R1
Article Type:	Research
Date Submitted by the Author:	13-Feb-2018
Complete List of Authors:	Chowdhury, Muhammad Abdul Baker; University of Florida, Emergency Medicine Adnan, Md. Mohiuddin; University of Mississippi Medical Center, Department of Data Science Hassan, Md Zakiul; International Centre for Diarrhoeal Disease Research, Infectious Diseases Division
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	obesity, reproductive women, body mass index, trends, risk factors

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Trends, prevalence, and risk factors in overweight and obesity among women of reproductive age in Bangladesh: a pooled analysis of five national cross-sectional surveys

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Abstract

Objective: To determine trends the prevalence and risk factors of overweight and obesity among Bangladeshi reproductive-age women from 1999-2014.

Design: The study team analyzed nationally representative data from repeated cross-sectional Bangladesh Demographic and Health Survey (BDHS) in 1999, 2004, 2007, 2011, and 2014.

Setting: Country of Bangladesh.

Participants: Women age 15- 49 years**.**

Primary outcome: Overweight/ Obesity.

Results: A total of 58,192 women whose body mass index (BMI) was available were included in the analysis. The prevalence of overweight and obesity among reproductive-age women increased significantly from 7.53% (95% CI: 6.83, 8.29) and 1.82% (CI: 1.48, 2.24) in 1999 to 28.37% (CI: 27.49, 29.28) and 10.77% (CI: 10.22, 11.35) in 2014, respectively. Age, education, wealth index, watching TV, and contraceptive use were associated with overweight and obesity in both urban and rural areas.

Conclusions: Overweight and obesity prevalence increased significantly among Bangladeshi reproductive-age women between 1999 and 2014. Development of effective low-cost strategies to address the increasing burden of obesity should be a high priority.

Keywords: Body mass index (BMI), overweight, obesity, trends, BDHS, Bangladesh.

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Strengths and limitations of this study

- To our knowledge, this is the first study in Bangladesh to compare longitudinal (15 years) trends in prevalence and risk factors associated with overweight/obesity in rural and urban women using nationally representative data.
- The analysis accounted for complex survey design (clustering, stratification, sample weights) which gives accurate estimates for the country population. Survey year was used a as a predictor for the first time in Bangladeshi population which provides incremental change in overweight/ obesity over time
- The surveys did not include responses on diet, fruit and vegetable - intake or physical activity, which are important predictors of overweight, and obesity. The surveys collected body mass index data for reproductive-age (15-49 years) women, therefore, the results may not be generalizable to older women's (>49 years) or for men.

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Introduction

Obesity is a growing global public health concern[1]. An estimated two billion adults were reported to have overweight or obesity in 2014 with a worldwide prevalence of 39%[1,2]. Obesity increases the risk of many serious chronic health conditions such as hypertension, prediabetes, type 2 diabetes, dyslipidemia, cardiovascular diseases, certain cancers, and metabolic syndrome[2-4]. With a J-shaped (slight upward trend with a low BMI and steep increase with higher BMI) relationship between body mass index(BMI) and mortality, obesity has a high risk of mortality[5].

While the impact of overweight and obesity epidemic in developed countries has been highlighted [6], recent studies demonstrate that the prevalence of obesity has increased significantly in many developing countries[7]. This trend of increasing overweight and obesity will likely continue to rise in the developing world [8].Bangladesh, a low-income country in South East Asia, has also observed an increasing prevalence of overweight and obesity. Like many developing countries, Bangladesh has experienced demographic and nutritional changes amongst the population such as changing lifestyle (e.g. high calorie food intake, sedentary life style) and urbanization. The rate of serious chronic health conditions in Bangladesh has increased steadily and death attributable to chronic conditions climbed from 8% in 1986 to 68% in 2006[6]. Traditionally, infectious diseases[9] and under-nutrition[10] were major public health problems in the country and less attention has focused on overweight and obesity by public health officials.

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Data on the overweight and obesity trend in Bangladesh are sparse. Few of the studies that reported the prevalence of obesity were cross-sectional and data were limited to one year or less[11] and included only specific participants (e.g. diabetic patients, schoolchildren etc.) [12]. Further, the change in sociodemographic factors associated with the rising incidence of overweight and obesity in Bangladesh has not been well studied. Moreover, the scale to determine BMI categories varied widely in prior studies and most used scales other than the World Health Organization (WHO) recommended Asian standard BMI classification.

Overweight and obesity vary significantly between men and women[13]. Reproductive-age women have higher rates of overweight and obesity and are more adversely affected by obesity-related complications [14]. This gender difference is mainly due to general weight gain during child bearing years, gestational weight gain and/or weight retention, adverse lifestyle, or risk factors associated with pregnancy and the postpartum period [15].Maternal obesity increases the risk of numerous complications of pregnancy, labor, and birth for both mother and child, including diabetes and hypertensive disorders [14,16]. Compared with normal weight, maternal overweight is associated with a higher risk of cesarean delivery and a higher incidence of anesthetic and postoperative complications[17,18]. Low Apgar scores, macrosomia, and neural tube defects are also more frequent in infants of obese mothers compared with infants of normal-weight mothers [17,18].

Understanding the obesity trend and identifying modifiable sociodemographic factors responsible for overweight and obesity among this high-risk group may help inform the development of feasible public health interventions to reduce the burden of obesity and

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associated adverse health outcomes. We used nationally representative data from the Bangladesh Demographic and Health Survey (BDHS) to estimate the trends in overweight and obesity and to identify socio-demographic factors associated with overweight and obesity among reproductive-age women in Bangladesh over a 15-year period between 1999 and 2014.

Method

Data sources

We analyzed publicly available data from the 1999, 2004, 2007, 2011, and 2014 BDHS. The BDHS is a nationally representative series of cross-sectional surveys of the non-institutionalized Bangladeshi population. It was developed over decades, progressively adopting standardized demographic and health survey items designed to provide data for monitoring the population and health situation in Bangladesh. The Bangladesh Ministry of Health and Family Welfare and the National Institute of Population Research and Training (NIPORT), has been conducting the survey at three year intervals since 1993[19].

Sampling design and sample size

All BDHS surveys used a two-staged stratified sampling procedure. In the first stage, enumeration areas were selected with a probability proportional to population size. Population size was based on the master sampling frame of the 2001 and 2011 population and housing census prepared by the Bangladesh Bureau of Statistics [20]. In the second stage, systematic household sampling was conducted from each sampling unit to provide a statistically reliable estimate of key demographic and health-related variables. The details of the BDHS methods are available elsewhere [19]. The surveys include 10544, 11440, 10996, 17842, and 17863 women, from the 1999, 2004, 2007, 2011, and 2014 surveys, respectively. We excluded participants

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below 15 years of age, participants with missing values for measured height and weight, and women who were pregnant at the time of the survey. After applying exclusion criteria, the total sample consisted of 58,192 women.

Outcome

The primary outcome variable of this study was BMI calculated as weight in kilograms divided by height in meters squared. In the analysis, we used BMI classifications recommended by WHO for Asian population: normal weight (18.5 to <23.0), moderate risk or overweight (23.0 to <27.5), and high risk or obese (≥27.5) [21]. We also conducted analyses using WHO and National Institutes of Health BMI classification for the general population: underweight (<18.5), normal weight (18.5 to <25.0), overweight (25.0 to <30.0), and obese (≥30.0)[22].

Covariates

We choose covariates hypothesized to be associated with overweight and obesity based on literature review. Socio-demographic characteristics included age (15-24, 25-34, 35-44, 45+), marital status (married, not married), education (no education, primary, secondary, and higher), place of residence (rural, urban), geographic region (south (Barishal), southeast (Chittagong), central (Dhaka), west (Khulna), mid-western corner (Rajshahi), northwest (Rangpur), and east (Sylhet)), wealth index (poorest, poorer, middle, rich, and richest), employment status (yes, no), watching TV at least once a week (yes or no), number of living children (0, 1–2, 3–4, and ≥5), number of household members (1–2, 3–4, and ≥5), contraceptive use (not using any method, using pill, and other methods), and survey year. Survey year was treated as a categorical variable. The BDHS surveys provide a household wealth index estimated using multiple household and asset variables. Principle component analysis was used for the

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estimation. The household level variables include having electricity, type and source of drinking water, access to a sanitation facility, availability of cooking fuel, main roof material, main wall material and floor material. The asset variables are having wardrobe, table, chair or bench, watch or clock, radio, television, bicycle, motorcycle, sewing machine, telephone and land ownership.

Statistical analysis

Descriptive statistics (e.g. mean, frequencies) were calculated to define the characteristics of survey participants. All five surveys were appended given that a similar survey protocol in terms of design, scope, coverage, sampling, data collection, coding, and weighting was used across surveys. This approach simplified reporting estimates and improved statistical power of the analyses. The distributions of BMI at each survey year were compared between rural and urban populations using kernel density plots. The BMI trend over the 15-year period was assessed by linear regression with time interval (survey year) as primary predictor. The nature, strength, and direction of the association between women's' socio-demographic characteristics and the BMI categories was assessed using multinomial logistic regression models with adjusted risk ratios (ARR) and 95% confidence intervals (CI) for urban and rural study participants separately. All analysis was performed using the statistical software, StataMP13.0 version (StataCorp LP, College Station, TX). We used the "svy" procedures to adjust for the sample stratification and clustering effect in all further analyses at the time of each survey. We used forward, backward, and stepwise model selection procedures to select the best predicting model. Variance inflation factor was also calculated to check the collinearity of the predictor variables and the outcome for both urban and rural sample (**Table S1**).

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Ethical approval

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council, Dhaka, Bangladesh.

Results

Socio-demographic characteristics

A total of 68,685 women participated across the five surveys. BMI data was available for 62,059 study participants and the survey response rates ranged between 96.9% and 98.6% from 1999 to 2014 **(Table S2)**. We examined the changes in the shape of BMI distributions among Bangladeshi reproductive-age women between 1999, 2004, 2007, 2011, and 2014 using Kernel density plot by urban and rural areas **(Figure 1).** Both urban and rural BMI distribution curves appear to be skewed to the right over the 15-year period indicating a gradual increase in BMI. **Table 1** shows the socioeconomic and demographic characteristics of study participants across survey years. Over time, the mean age of study participants increased from 25 (±6.63) to 32 (±9.12) years. There was a significant reduction in the proportion of women with no education from 45% to 26% ($p<0.001$) between 1999 and 2014. Similarly, the proportion of women with higher education increased almost two-fold (4.19% to 8.32%). The frequency of watching television increased approximately 1.6 times and the proportion of working-women almost doubled (18.81 vs. 34.15%) over the study period. There was a significant change in the family structure during the study period. Five or more living children per women dropped from 12.63% to 8.11%.

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Trends in overweight and obesity

We present trends in overweight and obesity prevalence over the study period in **Figure 2**. The overall prevalence of overweight-increased almost four fold (7.53% to 28.37%) and prevalence of obesity increased almost five-fold (1.82% to 10.77%) over the fifteen-year period. **Figure 3** demonstrates the prevalence of BMI categories by place of residence**.** In urban areas, the prevalence of underweight declined to 12.21% in 2014 from 29.74% in 1999 and in rural areas, it dropped to 21.09% in 2014 from 48.18% in 1999. There was a 1.76 and 3.5-fold increase in overweight, 5.12, and 7.23-fold increase in obesity in the prevalence of overweight and obesity in urban and rural areas, respectively (**Figure 3**).

Prevalence of overweight and obesity

Table S3 shows the overall prevalence of BMI categories by age groups and place of residence. The prevalence of individuals with overweight and obesity increased across the five survey years for women residing in both urban and rural areas across all age groups. The prevalence of underweight and normal weight decreased in both rural and urban areas. Based on the Asian BMI cutoffs, the overall prevalence of overweight in rural and urban women increased from 19.08% (95% CI: 16.95, 21.42) and 5.02% (95% CI: 4.33, 5.83) in 1999 to 33.74% (95% CI: 32.19, 35.32) and 26.24% (95% CI: 25.17, 27.34) in 2014, respectively. Similarly, the prevalence of obesity increased from 5.52% (95% CI: 4.32, 7.04) and 1.02% (95% CI: 0.72, 1.44) in 1999 to 19.32% (95% CI: 18.01, 20.69) and 7.37% (95% CI: 6.82, 7.97) in 2014 in urban and rural areas, respectively. The steepest increase of overweight was observed among women age 35-44 years from 15.79% and 6.10 % in 1999 to 37.62% and 30.09% in 2014 in urban and rural areas, respectively. The prevalence of obesity increased almost three fold among women aged 25-34

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years from 7.47% and 1.37% in 1999 to 21.23% and 8.28% in 2014 in urban and rural areas, respectively. The prevalence estimates of BMI for urban and rural women differed when the international BMI cutoffs were used **(Table S4).** A sharp decline was also observed in underweight (urban- 29.73% to 12.2%; rural- 48.18% to 21.08%) during 1999 to 2014 applying the international BMI standard. Across urban and rural and all survey years, the prevalence of overweight and obesity using the Asian-specific guidelines was 2.10 to 2.5 times higher than prevalence estimates based on the international guidelines **(Figure S1, S2).**

Risk factors of overweight or obesity

The adjusted association of overweight and obesity is presented in **Table 2**. Overall, the risk factors of overweight and obesity differed between urban and rural women. Increasing age was associated with higher overweight and obesity risk among both rural and urban residents though the association was stronger among urban residents. The highest overweight (ARR: 3.14, 95% CI: 2.74, 3.59) and obesity (ARR: 6.77, 95% CI: 5.56, 8.24) risk were for the urban women in the age group 35-44 years compared to women 15-24 years of age. The risk of overweight and obesity were high for urban women with higher educational level, married women, higher social status, and women whose husband had a higher educational level. In terms of wealth index, there was significant risk variation between urban and rural study participants. The middle, richer, and richest rural women had of 1.63, 2.55, and 5.85 higher odds of being overweight compared to the women in the poorest wealth index group. The odds of being obese was 2.30, 3.94, and 7.88 times higher for middle, richer, and richest rural women, respectively. Married women in urban areas had a 27% higher risk of overweight (ARR: 1.27, 95% CI: 1.04, 1.56) and 41% higher obesity (ARR: 1.41, 95% CI: 1.07, 1.86) risk compared

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with unmarried women. Marital status was not significantly associated with overweight or obesity in rural women. Watching TV at least once a week was an independent risk factor for overweight and obesity among both urban and rural women and the risk was stronger among urban women. In the adjusted model, women who watched TV at least once a week had 28% (ARR: 1.28, 95% CI: 1.13, 1.45) and 72% (ARR: 1.72, 95% CI: 1.43, 2.07) higher risk of being overweight and obese, respectively compared with women who do not watch TV at least once a week.

Women's employment status was only associated with overweight or obesity for urban residents. Working urban women had a lower probability of being overweight (ARR: 0.79, 95% CI: 0.71, 0.89) or obese (ARR: 0.54, 95% CI: 0.46, 0.64) compared with those who do not work. Women in rural areas with five or more household members had a lower probability of being overweight (ARR: 0.71, 95% CI: 0.60, 0.84) and obese (ARR: 0.61, 95% CI: 0.45, 0.81) compared with women with two or fewer household members. Compared to the 2004 survey, the risk of being overweight significantly increased with each subsequent survey year in urban and rural areas. For the increase of one survey period, the risk of overweight and obesity was much stronger in rural areas compared with urban areas after adjusting for all predictors. For example, in the most recent 2014 survey, the odds of being overweight was 2.60 (95% CI: 2.33, 2.89) and 2.07 (95% CI: 1.18, 2.37) times higher among rural and urban women respectively as compared to 2004 survey year. Similarly, the odds of being were and 4.47 (95% CI: 3.59, 5.57) 3.23 (95% CI: 2.71, 3.86) times higher for rural and urban women respectively as of 2004 survey year.

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Discussion

We identified an increasing trend of overweight and obesity among Bangladeshi reproductive-age women with a five-fold increase of obesity between 1999 and 2014. This trend suggests that Bangladesh may continue to experience an obesity epidemic and highlights the risk of future adverse health outcome associated with overweight and obesity. Overweight and obesity puts women at increased risk of many adverse health outcomes, including cardiovascular disease, diabetes, kidney disease, and obesity-related cancers[3,4,23]. These women are also more likely to develop pregnancy complications, such as gestational diabetes, hypertensive disorders of pregnancy, cesarean section delivery and adverse fetal outcome[14,16]. Although Bangladesh has made substantial progress in reducing death from pregnancy-related complications in the last several decades, pregnancy-associated risks remain high. The increasing trend of obesity among reproductive-age women may create new challenges[24,25]. Our findings of an increasing longitudinal prevalence of overweight and obesity is consistent with findings from neighboring countries, current trends in most developing countries, as well as across the globe[2]. This trend could be explained by substantial lifestyle changes including changes in eating habits with more energy-dense food intake and sedentary lifestyles with reduced physical activity patterns[26]. These changes have been observed in Bangladesh with rapid economic growth, urbanization, modernization, and globalization of the food market[27].

We found the highest increase in the prevalence of overweight and obesity among women aged 35-44 years. Studies from other low-income countries showed that older women (aged 45-49) are at greatest risk of overweight and obesity[28]. Because we did not include women

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older than 49 years of age, the actual number of obese women might be much higher in Bangladesh. Our study also showed that the increasing rate of overweight and obesity was more marked in rural areas than urban areas whereas the rate of decline of undernutrition was much higher in urban areas. This disparity may be the result of multiple factors. Reduction in poverty leads to improvement in the nutritional status [29]. For example, Haddad *et al*. showed that an increase in income at the household and national levels can significantly improve nutritional status[30]. Bangladesh has made progress in increasing per-capita income, particularly since the second half of the 1990s when growth in per-capita income accelerated to 3.6% per year[31]. However, this income growth has primarily occurred among the rich and decreased among the poor, widening the gap between the richest and the poorest[32]. The income Gini coefficient (measures income inequality and a greater value represents greater inequality) shows an increase from 0.432 in 1995 to 0.451 in 2000 and to 0.458 in 2010 mostly because of increasing inequality between urban and rural areas[32]. Therefore, this income inequality between the rich and the poor and between urban and rural populations, and the decline in food consumption could partly explain the slow reduction of the number of underweight women in urban areas. Our data showed that over the last 15 years, the number of educated and employed urban women increased significantly in Bangladesh. Because educational status and employment are both negatively associated with obesity, this might explain the variation in overweight and obesity between urban and rural women[33].

We determined that educational status including the husband's educational status, marital status, wealth index, self-reported hours of television watching, and employment status were significantly associated with overweight and obesity. Our study showed that compared with

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women who have no education women with higher educational status were at increased risk of overweight and obesity. Highly educated women are more likely to have a sedentary job requiring less physical activity and hence have an increased risk of weight gain. Studies from other developing countries also demonstrate a positive association between level of education and obesity, however, a negative association between the two variables has been observed primarily in developed countries[33]. Our findings that wealthier women are more likely to be overweight or obese are consistent with studies done in other low and middle-income countries[34]. This is likely due to the fact that increasing wealth in lower income countries results in greater access to food, an escape from physical labor and a higher risk of obesity.

We found that television watching was an independent predictor of overweight and obesity. Television viewing has been used as a proxy for sitting time and studies that follow participants over long periods of time have consistently found that people who spend more time watching television are more likely to gain weight[35]. Unemployed Bangladeshi women spend a significant amount of time watching television as a leisure activity. Moreover, with the economic growth increasing access to television suggest that viewing television may further increase which may further contribute obesity of this group.

Because geographical, ethnic, and cultural variation have large impacts on trends of overweight and obesity, we used the Asian BMI standard instead of international guidelines. The prevalence estimate of overweight and obesity using the Asian BMI category across all survey years was 2.10 to 2.50 times higher compared with estimates based on the international guidelines. Evidence have shown that Asian populations are at an increased risk of cardio-metabolic disorders at lower BMI levels than other ethnic groups, attributed to a considerably

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higher body fat percentage[36]. For this reason, in 2004 the WHO recommended lowering the BMI cut-offs for Asian adults for overweight from 25 to 23 kg/m^2 and for obesity from 30 to 27.5 kg/m^2 [21]. Previous reports that used international BMI classification in estimating overweight and obesity prevalence in Asians may have underestimated adverse health risks.

Our analysis has several limitations. We used secondary cross-sectional data limiting our ability to identify a causal relationship between predictors and overweight and obesity. Moreover, the dataset lacks some key variables including eating habits, physical activity, and smoking. Evidence showed that these factors strongly influence weight gain and may interact with other predictors of obesity such as wealth and education. However, the study included representative sample across Bangladesh including both urban and rural women and used the Asian BMI category for the analysis strengthening our evidence base.

Conclusion

Overweight and obesity increased among Bangladeshi reproductive-age women between 1999 and 2014. Sociodemographic factors including age, education, wealth index, marital status, television watching, and employment status were associated with the increased trend of overweight and obesity. The prevalence and risk factors of overweight and obesity varied between urban and rural women. Further research should focus on identifying other behavioral risk factors associated with overweight and obesity and identify feasible interventions for those most at risk.

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Tables

Table 1. Socio-demographic characteristics of the study participants by survey year, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Age, mean(SD)	25.88 (6.63)	30.56 (9.36)	30.94 (9.3)	31.23 (9.22)	31.37 (9.12)	<0.001
Age group, n (%)						<0.001
15-24	2148 (47.05)	3303 (31.82)	2996 (30.29)	4557 (28.72)	4433 (27.04)	
25-34	2007 (41.52)	3533 (33.77)	3344 (33.13)	5603 (34.19)	5969 (36.44)	
35-44	486 (10.61)	2598 (24.39)	2747 (26.69)	4321 (26.2)	4435 (26.05)	
45+	38 (0.81)	1055 (10.02)	1040 (9.89)	1792 (10.89)	1787 (10.47)	
Educational level, n (%)						<0.001
No education	2002 (44.62)	4158 (42.44)	3326 (34.85)	4386 (28.59)	4039 (25.68)	
Primary	1364 (29.14)	3070 (29.07)	3014 (29.67)	4857 (30.04)	4875 (29.24)	
Secondary	1072 (22.05)	2629 (23.52)	2983 (29.52)	5731 (34.3)	6153 (36.76)	
Higher	241 (4.19)	632 (4.97)	801 (5.96)	1299 (7.07)	1557 (8.32)	
Place of residence, n (%)						<0.001
Urban	1275 (17.76)	3593 (22.58)	3858 (22.81)	5709 (26.1)	5764 (28.41)	
Rural	3404 (82.24)	6896 (77.42)	6269 (77.19)	11000 (73.9)	11000 (71.59)	
Geographic region, n (%)						<0.001
Barisal	434 (6.48)	1252 (6.33)	1327 (6.01)	1819 (5.45)	1982 (6.19)	
Chittagong	937 (20.08)	1869 (17.56)	1775 (18.23)	2616 (18)	2639 (18.29)	
Dhaka	1123 (31.05)	2376 (31.27)	2178 (31.5)	2795 (32.18)	2893 (34.96)	
Khulna	760 (11.42)	1583 (12.32)	1589 (12.77)	2488 (12.4)	2460 (10.51)	
Rajshahi	889 (24.48)	2374 (26.35)	1933 (25.31)	4703 (26.73)	4769 (23.56)	
Sylhet	536 (6.49)	1035 (6.17)	1325 (6.18)	1852 (5.25)	1881 (6.49)	
Marital status, n (%)						<0.001
Not married	130 (2.71)	859 (7.93)	822 (7.7)	1091 (6.6)	1014 (5.95)	
Married	4549 (97.29)	9630 (92.07)	9305 (92.3)	15000 (93.4)	16000 (94.05)	
Urban						
BMI, Kg/m2						<0.001
Mean (SD)	20.78 (4.51)	21.52 (5.06)	22.24 (5.44)	23 (4.87)	23.7 (5.06)	
BMI categories, n (%)						<0.001
Underweight	385 (29.74)	903 (24.84)	787 (19.54)	879 (13.46)	738 (12.21)	
Normal weight	585 (45.65)	1573 (44.47)	1629 (41.73)	2298 (41.4)	1996 (34.73)	
Overweight	237 (19.09)	801 (21.87)	1010 (26.88)	1729 (30.62)	1971 (33.74)	
Obese	68 (5.53)	316 (8.81)	432 (11.85)	803 (14.52)	1059 (19.32)	
Overweight or obese	305 (24.61)	1117 (30.68)	1442 (38.73)	2532 (45.14)	3030 (53.06)	
Rural						
BMI, Kg/m2						<0.001
Mean (SD)	18.97 (2.42)	19.76 (2.72)	20.18 (2.83)	20.82 (3.29)	21.71 (3.62)	
BMI categories, n (%)						<0.001
Underweight	1636 (48.19)	2581 (36.9)	2107 (32.45)	2940 (27.83)	2353 (21.09)	
Normal weight	1560 (45.76)	3422 (49.82)	3135 (50.72)	5138 (48.59)	4926 (45.3)	
Overweight	174 (5.03)	762 (11.36)	851 (13.88)	1997 (18.97)	2780 (26.24)	

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Table 1. Socio-demographic characteristics of the study participants by survey year, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Obese	34 (1.02)	131 (1.92)	176 (2.96)	489 (4.62)	801 (7.38)	
Overweight or obese	208 (6.05)	893 (13.28)	1027 (16.83)	2486 (23.58)	3581 (33.62)	
Wealth index, n (%)						0.1665
Poorest	NA	1865 (19.85)	1636 (19.19)	2811 (18.29)	2999 (18.55)	
Poorer	NA	1880 (19.92)	1822 (19.35)	2995 (19.47)	3102 (18.95)	
Middle	NA	1960 (19.77)	1910 (19.72)	3129 (20.07)	3382 (20.04)	
Richer	NA	2098 (20.38)	2043 (20.85)	3472 (20.83)	3534 (21.21)	
Richest	NA	2686 (20.08)	2716 (20.88)	3866 (21.34)	3607 (21.24)	
Watch TV (once a week), n (%)						<0.001
No	2946 (66.99)	5459 (54.5)	5138 (53.2)	8149 (51.61)	7997 (48.83)	
Yes	1732 (33.01)	5027 (45.5)	4985 (46.8)	8120 (48.39)	8626 (51.17)	
Currently working, n (%)						
No	3839 (81.19)	8098 (76.85)	7068 (67.12)	14000 (86.62)	11000 (65.85)	
Yes	840 (18.81)	2390 (23.15)	3055 (32.88)	2216 (13.38)	5398 (34.15)	
Number of living children, n (%)						<0.001
0	67 (1.46)	1017 (9.39)	930 (8.78)	1371 (8.53)	1385 (7.96)	
1-2	2669 (56.66)	4590 (43.15)	4769 (47.11)	8236 (50.09)	8857 (53.48)	
3-4	1358 (29.25)	3312 (32.45)	3111 (31.61)	5102 (31.64)	5013 (30.45)	
>5	585 (12.63)	1570 (15.01)	1317 (12.5)	1564 (9.74)	1369 (8.11)	
Number of household member, n (%)						<0.001
1-2	46 (1.03)	382 (3.71)	405 (4.11)	694 (4.46)	834 (5.27)	
3-4	1208 (26.22)	3079 (30.31)	3171 (32.63)	5633 (34.65)	6224 (37.36)	
>5	3425 (72.75)	7028 (65.99)	6551 (63.25)	9946 (60.89)	9566 (57.36)	
Contraceptive use, n (%)						<0.001
Not using	2060 (44.71)	4422 (41.76)	4555 (44.02)	6260 (38.76)	6227 (37.19)	
Pills	1352 (2.904)	2641 (2.606)	2734 (2.835)	4385 (2.725)	4476 (2.717)	
Other	1267 (26.25)	3426 (32.18)	2838 (27.63)	5628 (33.99)	5921 (35.64)	
Husband education, n (%)						<0.001
No education	1851 (42.48)	3818 (39.16)	3342 (35.92)	4833 (31.73)	4764 (29.5)	
Primary	1102 (24.24)	2629 (25.34)	2610 (25.78)	4362 (26.89)	4503 (27.1)	
Secondary	1098 (23.05)	2691 (24.43)	2660 (25.94)	4680 (27.93)	4884 (29.71)	
Higher	549 (10.23)	1342 (11.07)	1501 (12.37)	2390 (13.46)	2471 (13.69)	

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Table 2. Association of overweight and obesity with socio demographic characteristics by place of residence, BDHS 1999-2014

	Urban				Rural			
	Overweight vs. healthy		Obese vs. healthy		Overweight vs. healthy		Obese vs. healthy	
Age group	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
15-24	Ref		Ref		Ref		Ref	
25-34	2.39 (2.11, 2.70)	0.000	4.04 (3.34, 4.87)	0.00	2.09 (1.9, 2.31)	0.000	3.23 (2.67, 3.91)	0.000
35-44	3.14 (2.74, 3.59)	0.000	6.77 (5.56, 8.24)	0.00	2.45 (2.2, 2.73)	0.000	4.06 (3.30, 4.99)	0.000
45+	2.59 (2.15, 3.12)	0.000	6.22 (4.88, 7.92)	0.00	2.47 (2.14, 2.86)	0.000	3.69 (2.87, 4.74)	0.000
Education level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (1.06, 1.41)	0.006	1.25 (1.01, 1.54)	0.03	1.11 (1.01, 1.23)	0.023	1.22 (1.02, 1.46)	0.026
Secondary	1.41 (1.20, 1.65)	0.000	1.61 (1.29, 2.02)	0.00	1.15 (1.03, 1.30)	0.014	1.27 (1.04, 1.55)	0.019
Higher	1.61 (1.30, 1.99)	0.000	1.42 (1.07, 1.90)	0.02	1.12 (0.92, 1.36)	0.238	0.92 (0.67, 1.27)	0.649
Marital status								
Not married	Ref							
Married	1.27 (1.04, 1.56)	0.018	1.41 (1.07, 1.86)	0.01	NA	NA	NA	NA
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	1.15 (0.87, 1.52)	0.317	0.99 (0.58, 1.70)	0.99	1.32 (1.17, 1.49)	0.000	1.45 (1.11, 1.90)	0.006
Middle	1.65 (1.29, 2.11)	0.000	1.63 (1.02, 2.61)	0.04	1.65 (1.46, 1.87)	0.000	2.30 (1.78, 2.97)	0.000
Richer	1.88 (1.49, 2.37)	0.000	2.55 (1.64, 3.96)	0.00	2.46 (2.16, 2.8)	0.000	3.94 (3.05, 5.10)	0.000
Richest	2.83 (2.24, 3.57)	0.000	5.58 (3.6, 8.63)	0.00	3.38 (2.9, 3.94)	0.000	7.88 (5.93, 10.46)	0.000
Watch TV (once a week)								
No	Ref		Ref		Ref		Ref	
Yes	1.28 (1.13, 1.45)	0.000	1.72 (1.43, 2.07)	0.00	1.25 (1.15, 1.35)	0.000	1.4 (1.22, 1.62)	0.000
Currently working								
No	Ref		Ref					
Yes	0.79 (0.71, 0.89)	0.000	0.54 (0.46, 0.64)	0.00	NA	NA	NA	NA
Number of household member								
1-2					Ref		Ref	
3-4	NA	NA	NA	NA	0.86 (0.72, 1.02)	0.093	0.86 (0.64, 1.16)	0.353
>5	NA	NA	NA	NA	0.71 (0.60, 0.84)	0.000	0.61 (0.45, 0.81)	0.001
Contraceptive use								
Not using	Ref				Ref		Ref	
Pills	0.96 (0.85, 1.09)	0.605	0.79 (0.67, 0.94)	0.01	1.06 (0.98, 1.16)	0.130	0.83 (0.70, 0.97)	0.022
Other	1.07 (0.95, 1.20)	0.237	1.04 (0.9, 1.20)	0.55	1.08 (0.99, 1.18)	0.053	0.94 (0.82, 1.09)	0.459
Husband education								
No education	Ref		Ref		Ref		Ref	
Primary	1.11 (0.95, 1.29)	0.164	1.12 (0.89, 1.4)	0.32	1.07 (0.97, 1.18)	0.132	1.22 (1.01, 1.47)	0.037
Secondary	1.18 (1.01, 1.37)	0.031	1.32 (1.05, 1.65)	0.02	1.2 (1.08, 1.34)	0.001	1.51 (1.25, 1.82)	0.000
Higher	1.55 (1.28, 1.88)	0.000	1.94 (1.49, 2.52)	0.00	1.46 (1.25, 1.69)	0.000	1.98 (1.55, 2.53)	0.000
Survey year								
2004	Ref		Ref		Ref		Ref	
2007	1.23 (1.07, 1.42)	0.003	1.35 (1.11, 1.64)	0.00	1.19 (1.06, 1.35)	0.004	1.49 (1.15, 1.93)	0.002
2011	1.43 (1.26, 1.63)	0.000	1.68 (1.40, 2.00)	0.00	1.71 (1.54, 1.90)	0.000	2.50 (2.00, 3.13)	0.000
2014	2.07 (1.81, 2.37)	0.000	3.23 (2.71, 3.86)	0.00	2.60 (2.33, 2.89)	0.000	4.47 (3.59, 5.57)	0.000

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Figure legends

Figure 1. Kernel density plot of the distribution of BMI for reproductive-age women in 1999, 2004, 2007, 2011, and 2014

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

Figure S1. Prevalence of BMI categories International cutoff

Figure S2. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014 (International cutoff)

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List of Abbreviations

ARR	Adjusted risk ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Ethical approval and consent

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Informed consent was obtained from each participant of the survey before enrolling in the survey by using the Introduction and Consent form of the survey. It was also explained that the information will be kept strictly confidential and will not be shared with anyone except members of the survey team.

Consent to publish: Not Applicable

Availability of data/ Data sharing statement

The datasets used for the current study are publicly available from http://dhsprogram.com/data/available-datasets.cfm.

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

Acknowledgement: We gratefully acknowledge DHS for allowing us to use the data.

Disclosure/ Conflict of interest: None

Author contribution: MC conceptualized the study and designed the analytical approach, performed the data analyses and interpreted the findings, and led the writing of the article. **MA** was involved in the literature search and drafting the manuscript. **ZH** helped conceptualize the study literature, variable selection, editing and drafting the manuscript. Revised the manuscript critically for important intellectual content, and final approval of the version to be submitted. All authors helped write the manuscript. All authors read and approved the final manuscript.

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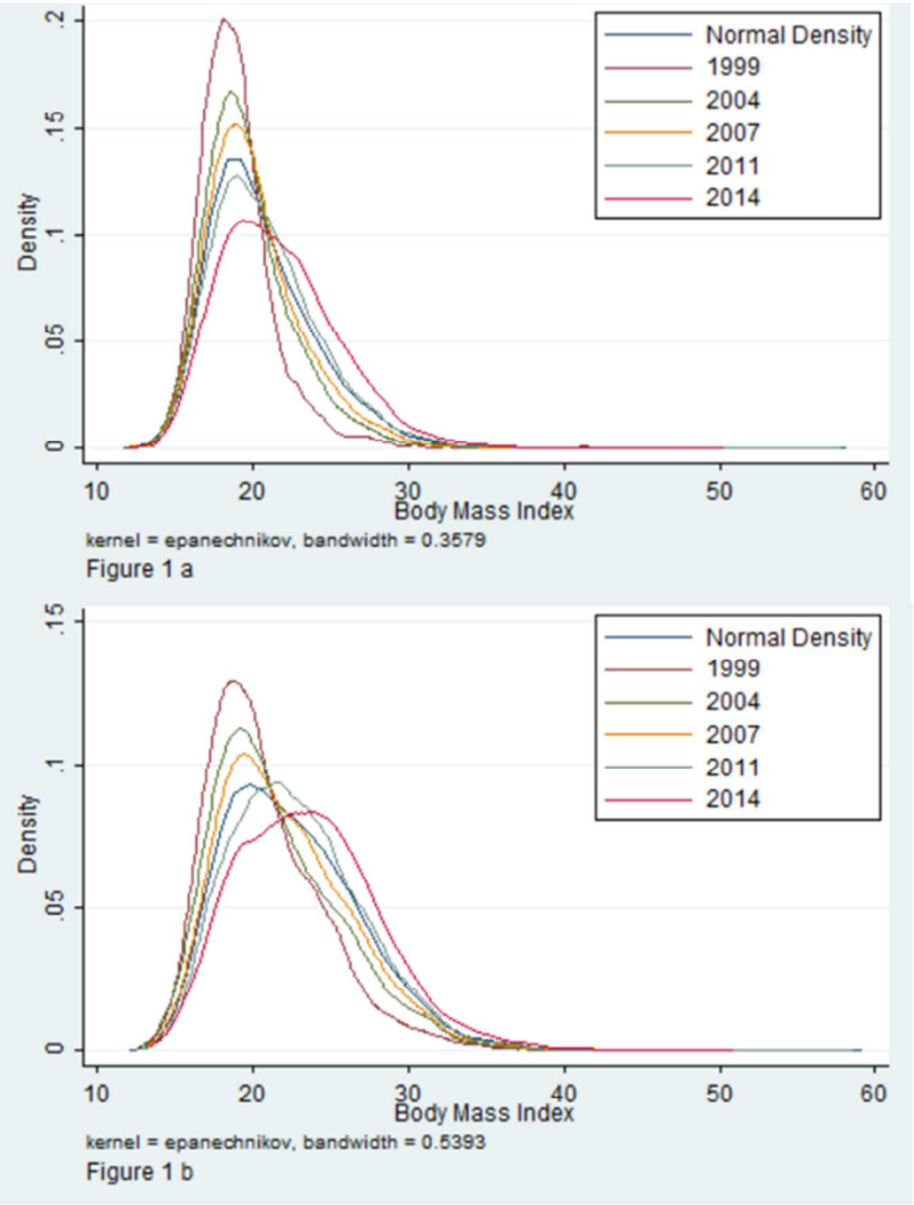

Figure 1. Kernel density plot of the distribution of BMI for reproductive-age women in 1999, 2004, 2007, 2011, and 2014

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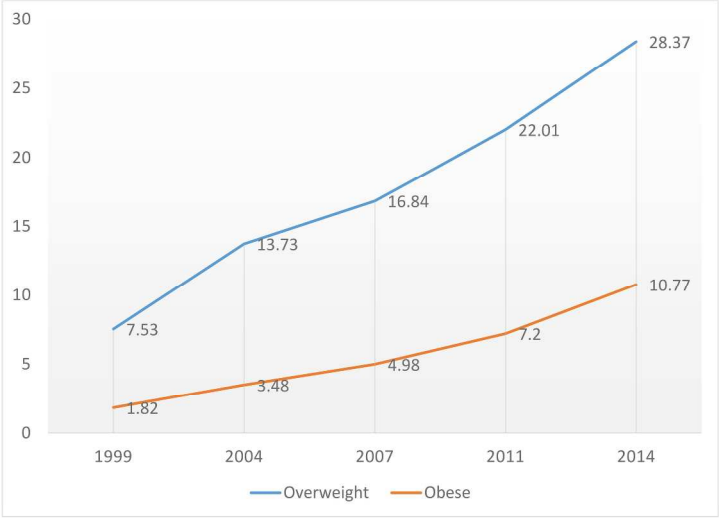

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

279x361mm (300 x 300 DPI)

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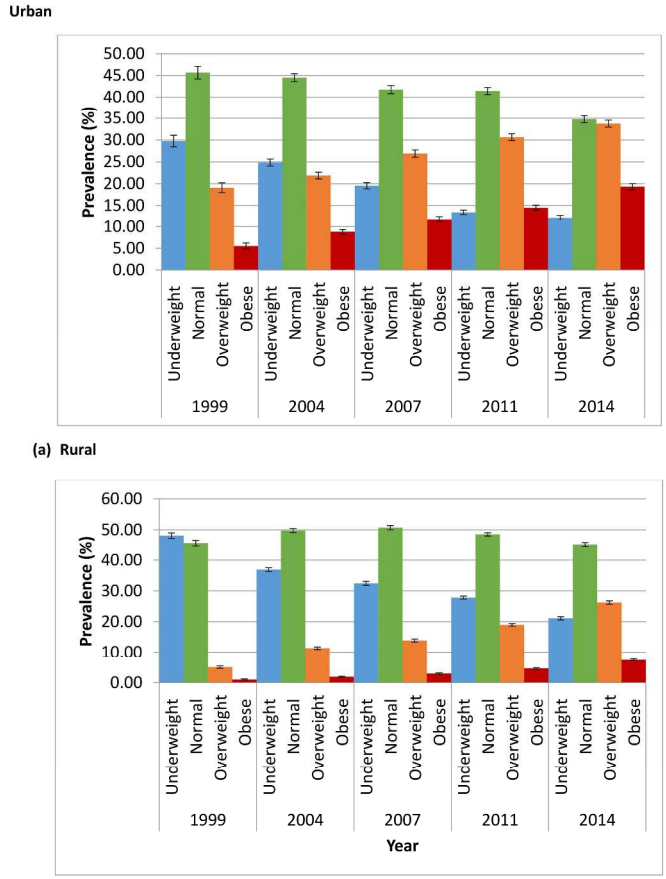

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

279x361mm (300 x 300 DPI)

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Supplements

Table S1. Variance inflation (VIF) values of final models of urban and rural women, BDHS 1999-2014

Variables	VIF- Urban	VIF-Rural
Age	1.09	1.29
Education	2.03	1.97
Marital status	1.18	1.12
Wealth index	1.49	1.69
Watching TV at least once a week	1.29	1.32
Currently working	1.08	1.04
No· of household members	1.04	1.05
Contraceptive use	1.12	1.09
Husband education	2.03	1.71
Survey year	1.02	1.05

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Table S2. Summary characteristics of the sample by survey year, BDHS 1999-2014

Variable	1999-00	2004	2007	2011	2014
Initial sample of the survey, n	10544	11440	10996	17842	17863
BMI available, n	5055	11176	10836	17309	17683
Pregnant women, n	376	678	709	1036	1059
Final working sample, n	4679	10489	10127	16273	16624
Response rate, %	96.9	98.6	98.4	97.9	97.9

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Table S3. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014

		Urban					Rural				
	Age groups	1999	2004	2007	2011	2014	1999	2004	2007	2011	2014
Underweight	15-24	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	25-34	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	35-44	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	45+	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	Overall	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	15-24	50.62 (46.22, 55.01)	53.21 (49.83, 56.56)	50.64 (47.17, 54.11)	53.98 (50.91, 57.02)	45.47 (42.22, 48.77)	47.42 (44.89, 49.95)	53.54 (51.33, 55.74)	55.29 (52.86, 57.69)	52.08 (50.14, 54)	50.84 (48.49, 53.18)
	25-34	41.45 (37.43, 45.59)	44.68 (41.65, 47.75)	41.3 (38.23, 44.45)	37.8 (35.15, 40.51)	32.71 (30.19, 35.34)	46.8 (44.08, 49.54)	51.15 (48.95, 53.35)	51.6 (49.21, 53.98)	48.32 (46.57, 50.08)	44.57 (42.49, 46.67)
	35-44	45.09 (35.42, 55.14)	37.9 (34.44, 41.5)	35.36 (32.17, 38.68)	34 (31.08, 37.05)	27.75 (24.94, 30.74)	35.71 (30.86, 40.88)	46.98 (44.42, 49.55)	47.49 (44.83, 50.16)	47.15 (45.16, 49.15)	42.17 (39.77, 44.61)
	45+	19.96 (4.12, 59.13)	33.66 (28.29, 39.49)	36.66 (31.3, 42.36)	37.87 (33.33, 42.63)	32.15 (27.54, 37.14)	35.62 (20.55, 54.2)	40.37 (36.59, 44.27)	41.94 (37.8, 46.2)	43.56 (40.47, 46.71)	41.06 (37.55, 44.66)
	Overall	45.64 (42.81, 48.51)	44.47 (42.65, 46.3)	41.72 (39.93, 43.53)	41.39 (39.8, 43)	34.72 (33.15, 36.33)	45.76 (44.03, 47.49)	49.82 (48.55, 51.08)	50.72 (49.36, 52.08)	48.58 (47.56, 49.61)	45.29 (44.05, 46.53)
Overweight	15-24	14.31 (11.51, 17.65)	12.51 (10.46, 14.89)	17.63 (15.1, 20.47)	20.18 (17.81, 22.79)	25.42 (22.67, 28.38)	3.36 (2.58, 4.37)	6.7 (5.67, 7.89)	9.56 (8.19, 11.14)	11.81 (10.63, 13.1)	17.95 (16.33, 19.7)
	25-34	23.9 (20.55, 27.6)	25.73 (23.15, 28.49)	28.99 (26.19, 31.96)	35.56 (32.95, 38.26)	37.7 (35.09, 40.38)	6.74 (5.49, 8.24)	12.09 (10.72, 13.6)	15.66 (14, 17.48)	22.03 (20.61, 23.52)	29.31 (27.47, 31.23)
	35-44	15.79 (9.58, 24.92)	26.82 (23.77, 30.11)	33.17 (30.02, 36.48)	35.55 (32.57, 38.66)	37.62 (34.59, 40.74)	6.1 (4.06, 9.08)	15.05 (13.29, 17)	15.67 (13.83, 17.71)	22.4 (20.78, 24.1)	30.09 (27.93, 32.34)
	45+	26.19 (3.91, 75.55)	23.39 (18.71, 28.83)	27.28 (22.51, 32.65)	30.3 (26.11, 34.84)	31.21 (26.62, 36.19)	3.4 (0.47, 20.56)	15 (12.32, 18.14)	16.66 (13.73, 20.07)	20.06 (17.69, 22.67)	27.57 (23.99, 31.47)
	Overall	19.08 (16.95, 21.42)	21.87 (20.42, 23.39)	26.87 (25.28, 28.53)	30.62 (29.14, 32.14)	33.74 (32.19, 35.32)	5.02 (4.33, 5.83)	11.35 (10.57, 12.18)	13.87 (12.96, 14.84)	18.96 (18.18, 19.78)	26.24 (25.17, 27.34)
Obese	15-24	2.3 (1.28, 4.1)	3.44 (2.4, 4.92)	4.31 (3.07, 6.02)	5.67 (4.44, 7.22)	8.09 (6.49, 10.05)	0.82 (0.46, 1.44)	0.83 (0.51, 1.35)	1.18 (0.75, 1.86)	2.08 (1.59, 2.71)	3.74 (3.01, 4.64)
	25-34	7.47 (5.54, 10)	8.65 (7.03, 10.6)	12.33 (10.41, 14.55)	15.39 (13.48, 17.52)	21.23 (18.96, 23.69)	1.37 (0.86, 2.18)	2.47 (1.86, 3.29)	3.52 (2.72, 4.55)	5.51 (4.76, 6.36)	8.28 (7.32, 9.36)
	35-44	10.68 (5.53, 19.6)	13.86 (11.59, 16.48)	17.26 (14.78, 20.07)	20.9 (18.41, 23.62)	25.24 (22.51, 28.19)	0.68 (0.17, 2.71)	2.56 (1.83, 3.56)	3.88 (2.99, 5.02)	5.68 (4.83, 6.66)	9.74 (8.53, 11.1)
	45+	17.94 (2.42, 65.83)	12.66 (9.27, 17.07)	15.53 (11.73, 20.29)	19.25 (15.73, 23.34)	26.01 (21.83, 30.67)	NA	2.05 (1.2, 3.49)	4.14 (2.69, 6.32)	5.94 (4.64, 7.58)	7.77 (6.2, 9.69)
	Overall	5.52 (4.32, 7.04)	8.81 (7.84, 9.88)	11.85 (10.71, 13.08)	14.51 (13.41, 15.69)	19.32 (18.01, 20.69)	1.02 (0.72, 1.44)	1.92 (1.59, 2.31)	2.95 (2.52, 3.45)	4.61 (4.2, 5.06)	7.37 (6.82, 7.97)

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4

Table S4. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014 **(International cutoff)**

	Urban					Rural				
	1999	2004	2007	2011	2014	1999-00	2004	2007	2011	2014
Underweight	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	60.28 (55.93, 64.48)	60.8 (57.48, 64.02)	62.4 (58.97, 65.72)	66.43 (63.53, 69.2)	59.81 (56.54, 62.98)	49.84 (47.3, 52.37)	58.05 (55.85, 60.21)	61.86 (59.48, 64.18)	59.97 (58.06, 61.85)	61.91 (59.64, 64.13)
	55.78 (51.59, 59.89)	57.51 (54.44, 60.52)	56.31 (53.15, 59.41)	57.53 (54.77, 60.23)	51.95 (49.19, 54.7)	51.45 (48.72, 54.17)	59.71 (57.54, 61.85)	60.19 (57.82, 62.51)	61.03 (59.3, 62.73)	60.12 (58.05, 62.16)
	53.39 (43.32, 63.19)	50.67 (47.04, 54.3)	52.6 (49.17, 56)	51.3 (48.14, 54.45)	44.95 (41.78, 48.16)	39.23 (34.25, 44.44)	56.17 (53.61, 58.7)	57.42 (54.77, 60.02)	61.14 (59.16, 63.07)	59.66 (57.26, 62.01)
	19.96 (4.12, 59.13)	43.23 (37.44, 49.21)	50.28 (44.61, 55.94)	52.82 (48.04, 57.55)	45.45 (40.36, 50.64)	35.62 (20.55, 54.2)	50.06 (46.14, 53.98)	54.54 (50.29, 58.72)	55.41 (52.25, 58.52)	56.51 (52.71, 60.24)
	57.4 (54.54, 60.21)	55.43 (53.6, 57.24)	56.33 (54.52, 58.14)	57.89 (56.29, 59.47)	51.49 (49.82, 53.16)	49.17 (47.44, 50.9)	57.33 (56.08, 58.57)	59.43 (58.09, 60.75)	60.14 (59.13, 61.15)	60.11 (58.89, 61.32)
Overweight	5.82 (4.11, 8.17)	6.59 (5.15, 8.41)	8.67 (6.88, 10.86)	11.08 (9.32, 13.12)	15.63 (13.42, 18.13)	1.28 (0.82, 2.01)	2.91 (2.25, 3.75)	3.82 (2.96, 4.91)	5.34 (4.55, 6.25)	9.52 (8.33, 10.87)
	14.07 (11.39, 17.26)	17.65 (15.41, 20.15)	21.33 (18.84, 24.05)	24.61 (22.29, 27.09)	31.22 (28.7, 33.85)	2.95 (2.14, 4.05)	5 (4.13, 6.05)	9.64 (8.32, 11.15)	13.06 (11.92, 14.29)	19.1 (17.61, 20.68)
	13.61 (7.8, 22.66)	22.23 (19.39, 25.35)	25.93 (23.03, 29.06)	30.21 (27.36, 33.23)	33.2 (30.3, 36.23)	3.28 (1.86, 5.7)	7.67 (6.37, 9.21)	8.91 (7.5, 10.55)	12.01 (10.77, 13.37)	18.54 (16.79, 20.42)
	44.14 (12.09, 81.39)	21.23 (16.77, 26.51)	21.68 (17.25, 26.88)	24.62 (20.76, 28.93)	30.73 (26.28, 35.57)	3.4 (0.47, 20.56)	6.38 (4.69, 8.62)	7.07 (5.22, 9.52)	11.55 (9.72, 13.67)	17.18 (14.72, 19.95)
	10.57 (8.92, 12.47)	15.87 (14.59, 17.23)	19.18 (17.78, 20.66)	22.25 (20.93, 23.63)	27.56 (26.11, 29.06)	2.19 (1.73, 2.77)	5.1 (4.57, 5.69)	7.39 (6.71, 8.13)	10.39 (9.79, 11.03)	16.14 (15.3, 17.02)
Obese	1.13 (0.49, 2.59)	1.78 (1.05, 2.99)	1.51 (0.85, 2.66)	2.33 (1.58, 3.43)	3.55 (2.47, 5.07)	0.48 (0.23, 0.99)	0.12 (0.03, 0.39)	0.36 (0.15, 0.81)	0.66 (0.4, 1.08)	1.1 (0.75, 1.6)
	2.97 (1.81, 4.84)	3.9 (2.85, 5.32)	4.99 (3.83, 6.49)	6.61 (5.34, 8.16)	8.48 (6.98, 10.25)	0.51 (0.22, 1.13)	1.01 (0.63, 1.59)	0.95 (0.55, 1.64)	1.77 (1.37, 2.29)	2.95 (2.37, 3.67)
	4.56 (1.61, 12.27)	5.68 (4.25, 7.54)	7.27 (5.66, 9.28)	8.94 (7.26, 10.96)	12.46 (10.37, 14.9)	.	0.74 (0.4, 1.37)	0.72 (0.4, 1.29)	2.08 (1.59, 2.72)	3.81 (3.04, 4.76)
	.	5.25 (3.2, 8.51)	7.51 (4.96, 11.21)	9.98 (7.38, 13.36)	13.18 (10.08, 17.06)	.	0.99 (0.43, 2.26)	1.13 (0.49, 2.58)	2.61 (1.78, 3.81)	2.71 (1.88, 3.9)
	2.28 (1.54, 3.38)	3.85 (3.21, 4.61)	4.93 (4.2, 5.78)	6.38 (5.63, 7.23)	8.72 (7.79, 9.76)	0.43 (0.25, 0.74)	0.65 (0.47, 0.9)	0.72 (0.52, 1.01)	1.62 (1.38, 1.9)	2.64 (2.31, 3.03)

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Figure S1. Prevalence of BMI categories International cutoff

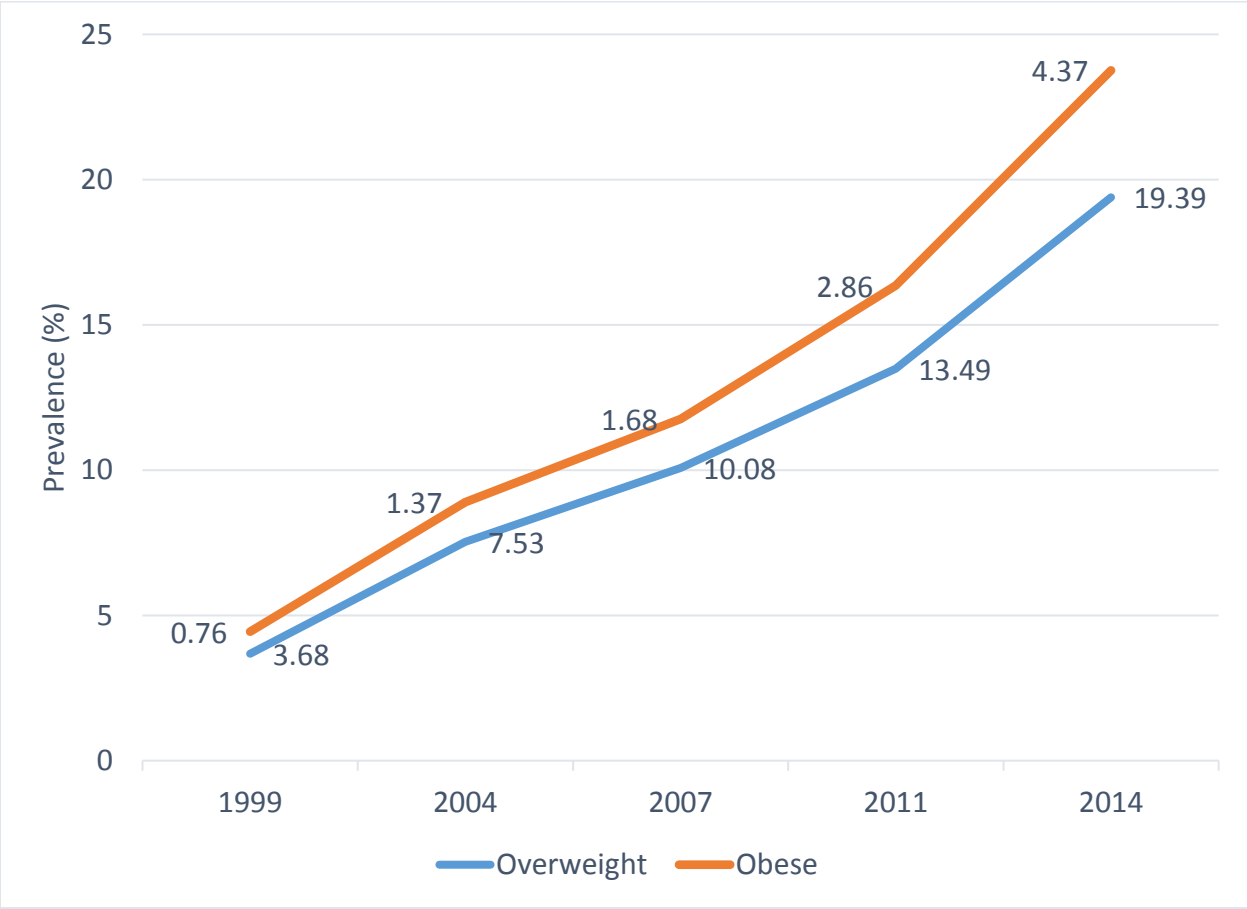

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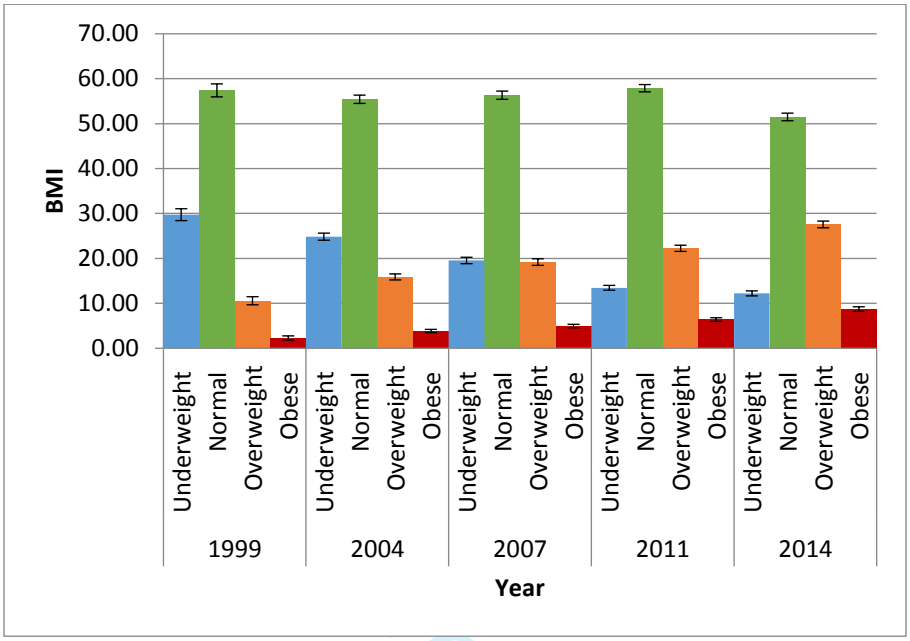
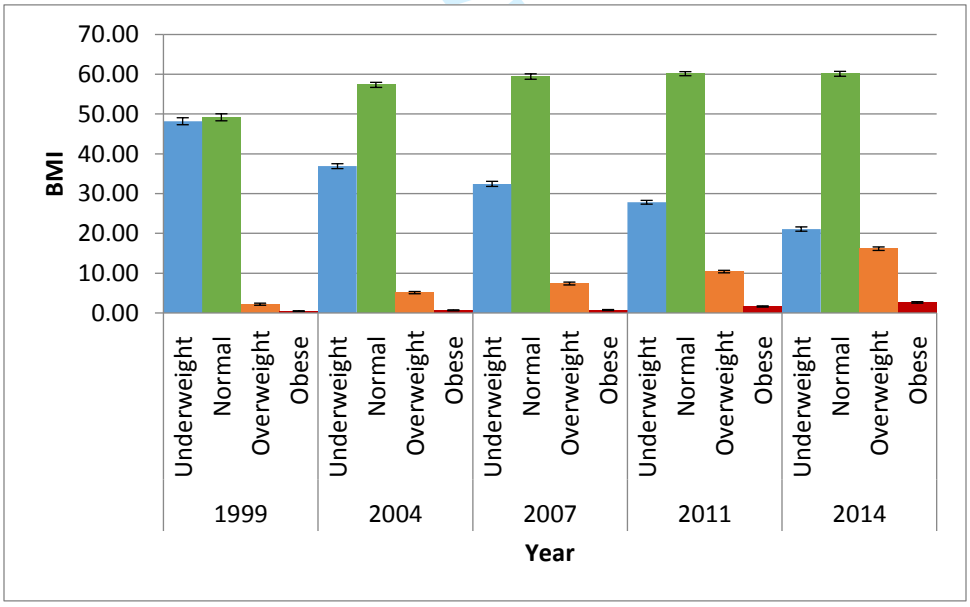
Figure S2. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014 (International cutoff).

(a) Urban



(b) Rural



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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	5 - 6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Not applicable
Bias	9	Describe any efforts to address potential sources of bias	Not applicable
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	6-8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8

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		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6- 9
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3, 14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	14-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

Trends, prevalence, and risk factors in overweight and obesity among women of reproductive age in Bangladesh: a pooled analysis of five national cross-sectional surveys

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018468.R2
Article Type:	Research
Date Submitted by the Author:	02-May-2018
Complete List of Authors:	Chowdhury, Muhammad Abdul Baker; University of Florida, Emergency Medicine Adnan, Md. Mohiuddin; University of Mississippi Medical Center, Department of Data Science Hassan, Md Zakiul; International Centre for Diarrhoeal Disease Research, Infectious Diseases Division
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	obesity, reproductive women, body mass index, trends, risk factors

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Trends, prevalence, and risk factors in overweight and obesity among women of reproductive age in Bangladesh: a pooled analysis of five national cross-sectional surveys

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Abstract

Objective: To determine the trends, prevalence, and risk factors of overweight and obesity among Bangladeshi women of reproductive-age from 1999-2014.

Design: We analyzed nationally representative data from the 1999, 2004, 2007, 2011, and 2014 cross-sectional Bangladesh Demographic and Health Surveys (BDHS).

Setting: Bangladesh.

Participants: Women aged 15- 49 years**.**

Primary outcome: Overweight/Obesity.

Results: A total of 58,192 women were included in the analysis. The prevalence of overweight and obesity among reproductive-age women increased significantly from 7.53% (95% CI: 6.83, 8.29) and 1.82% (CI: 1.48, 2.24) in 1999 to 28.37% (CI: 27.49, 29.28) and 10.77% (CI: 10.22, 11.35) in 2014, respectively. Age, education, wealth index, watching TV, and contraceptive use were associated with overweight and obesity in both urban and rural areas.

Conclusions: Overweight and obesity prevalence increased significantly among Bangladeshi women of reproductive-age between 1999 and 2014. Development of effective low-cost strategies to address the increasing burden of obesity should be a high priority.

Keywords: Body mass index (BMI), overweight, obesity, trends, BDHS, Bangladesh.

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Strengths and limitations of this study

- To our knowledge, this is the first study in Bangladesh to compare longitudinal (15 years) trends in the prevalence and risk factors associated with overweight/obesity in women using nationally representative data.
- The analysis accounted for a complex survey design (clustering, stratification, sample weights) which gives accurate estimates for the population. Importantly, survey year was used as a predictor which highlights incremental changes in overweight/ obesity over time.
- The surveys did not include responses on diet, fruit or vegetable intake, or physical activity, which are important predictors of overweight, and obesity. The surveys collected body mass index for reproductive-aged (15-49 years) women, therefore, the results may not be generalizable to women older than 49 years or men.

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Introduction

Obesity is a growing global public health concern[1]. An estimated two billion adults were reported to have overweight or obesity in 2014 with a worldwide prevalence of 39%[1,2]. Obesity increases the risk of many serious chronic health conditions such as hypertension, prediabetes, type 2 diabetes, dyslipidemia, cardiovascular diseases, certain cancers, and metabolic syndrome[2-4]. With a J-shaped (slight upward trend with a low BMI and steep increase with higher BMI) relationship between body mass index (BMI) and mortality, obesity is associated with a high risk of mortality[5].

While the impact of the overweight and obesity epidemic in developed countries has been highlighted [6], recent studies demonstrate that the prevalence of obesity has increased significantly in many developing countries[7]. This trend of increasing overweight and obesity will likely continue to rise in the developing world [8]. Bangladesh, a low-income country in South East Asia, has also observed an increasing prevalence of overweight and obesity. Like many developing countries, Bangladesh has experienced demographic and nutritional changes amongst the population such as changing lifestyle (e.g. high calorie food intake, sedentary life style) and urbanization. The rate of serious chronic health conditions in Bangladesh has increased steadily and death attributable to chronic conditions climbed from 8% in 1986 to 68% in 2006[6]. Traditionally, infectious diseases[9] and under-nutrition[10] were major public health problems in the country and little attention was focused on overweight and obesity by public health officials.

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Data on the overweight and obesity trend in Bangladesh are sparse. Few studies that reported the prevalence of obesity were cross-sectional and data were limited to one year or less[11] and included only specific participants (e.g. diabetic patients, schoolchildren etc.) [12]. Further, sociodemographic trends associated with the rising incidence of overweight and obesity in Bangladesh has not been well studied. Further, the scale to determine BMI categories varied widely in prior studies and most used scales other than the World Health Organization (WHO) recommended Asian standard BMI classification.

Reproductive-age women have higher rates of overweight and obesity and are more adversely affected by obesity-related complications than men[13]. This gender difference is mainly due to general weight gain during child bearing years, gestational weight gain and/or weight retention, adverse lifestyle, or risk factors associated with pregnancy and the postpartum period [14]. Maternal obesity increases the risk of numerous complications of pregnancy, labor, and birth for both mother and child, including diabetes and hypertensive disorders [13,15]. Compared with normal weight, maternal overweight is associated with a higher risk of cesarean delivery and a higher incidence of anesthetic and postoperative complications[16,17]. Low Apgar scores, macrosomia, and neural tube defects are also more frequent in infants of obese mothers compared with infants of normal-weight mothers[16,17].

Understanding the obesity trend and identifying modifiable sociodemographic factors responsible for overweight and obesity among this high-risk group may help inform the development of feasible public health interventions to reduce the burden of obesity and associated adverse health outcomes. We used nationally representative data from the

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Bangladesh Demographic and Health Survey (BDHS) to estimate the trends in overweight and obesity and to identify socio-demographic factors associated with overweight and obesity among reproductive-age women in Bangladesh between 1999 and 2014.

Methods

Data sources

We analyzed publicly available data from the 1999, 2004, 2007, 2011, and 2014 BDHS. The BDHS is a nationally representative cross-sectional survey of the non-institutionalized Bangladeshi population. It was developed over decades, progressively adopting standardized demographic and health survey items designed to provide data for monitoring population health in Bangladesh. The Bangladesh Ministry of Health and Family Welfare and the National Institute of Population Research and Training (NIPORT) has been conducting the survey at three year intervals since 1993[18].

Sampling design and sample size

All BDHS surveys use a two-stage stratified sampling procedure. In the first stage, enumeration areas are selected with a probability proportional to population size. Population size is based on the master sampling frame of the 2001 and 2011 population and housing census prepared by the Bangladesh Bureau of Statistics [19]. In the second stage, systematic household sampling is conducted from each sampling unit to provide a statistically reliable estimate of key demographic and health-related variables. The details of the BDHS methods are available elsewhere [18]. The surveys include 10544, 11440, 10996, 17842, and 17863 women, from the 1999, 2004, 2007, 2011, and 2014 surveys, respectively. We excluded participants below 15 years of age, participants with missing values for measured height and weight, and women who

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were pregnant at the time of the survey. After applying exclusion criteria, the total sample consisted of 58,192 women.

Outcome

The primary outcome variable of this study was BMI calculated as weight in kilograms divided by height in meters squared. In the analysis, we used BMI classifications recommended by WHO for Asian population: normal weight (18.5 to <23.0), moderate risk or overweight (23.0 to <27.5), and high risk or obese (≥27.5) [20]. We also conducted analyses using WHO and National Institutes of Health BMI classification for the general population: underweight (<18.5), normal weight (18.5 to <25.0), overweight (25.0 to <30.0), and obese (≥30.0)[21].

Covariates

We choose covariates associated with overweight and obesity based on literature review[11,22]. Socio-demographic characteristics included age (15-24, 25-34, 35-44, and 45+), marital status (married, not married), education (no education, primary, secondary, and higher), place of residence (rural, urban), geographic region (south (Barishal), southeast (Chittagong), central (Dhaka), west (Khulna), mid-western (Rajshahi), northwest (Rangpur), and east (Sylhet)), wealth index (poorest, poorer, middle, rich, and richest), employment status (yes, no), watching TV at least once a week (yes or no), number of living children (0, 1–2, 3–4, and ≥5), number of household members (1–2, 3–4, and ≥5), contraceptive use (not using any method, using pill, and other methods), and survey year. Survey year was treated as a categorical variable. The BDHS surveys provide a household wealth index estimated using multiple household and asset variables. Principle component analysis was used for the estimation. The household level variables include having electricity, type and source of drinking water, access to a sanitation

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facility, availability of cooking fuel, main roof material, main wall material and floor material. The asset variables are having wardrobe, table, chair or bench, watch or clock, radio, television, bicycle, motorcycle, sewing machine, telephone, and land ownership.

Statistical analysis

Descriptive statistics (e.g. mean, frequencies) were calculated to define the characteristics of survey participants. All five surveys were appended given that a similar survey protocol in terms of design, scope, coverage, sampling, data collection, coding, and weighting was used across surveys. This approach simplified reporting estimates and improved statistical power of the analyses. The distributions of BMI at each survey year were compared between rural and urban populations using kernel density plots. The BMI trend over the 15-year period was assessed by linear regression with survey year as primary predictor. The nature, strength, and direction of the association between women's' socio-demographic characteristics and BMI categories was assessed using multinomial logistic regression models with adjusted risk ratios (ARR) and 95% confidence intervals (CI) for urban and rural study participants separately. All analysis was performed using the statistical software, StataMP13.0 version (StataCorp LP, College Station, TX). We used the "svy" procedures to adjust for the sample stratification and clustering effect in all further analyses at the time of each survey. We used forward, backward, and stepwise model selection procedures to select the best predicting model. Variance inflation factor was calculated to check the collinearity of the predictor variables and the outcome for both urban and rural sample (**Table S1**).

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Patient and Public Involvement

The BDHS questionnaires were based on the MEASURE DHS model questionnaires. These model questionnaires were adapted for use in Bangladesh during a series of meetings with a technical working group (TWG) that consisted of representatives from NIPORT, Mitra and Associates, International Centre for Diarrheal Diseases and Control, Bangladesh (icddr, b), USAID/Bangladesh, and MEASURE DHS. Patients were not directly involved in the study. However, the TWG involved representatives from the government, non-government, ministry of health and family welfare representatives and donor organizations. All of these groups were involved in the study design and questionnaire development. The results will be used by the health researchers and policy makers of the country.

Ethical approval

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council, Dhaka, Bangladesh.

Results

Socio-demographic characteristics

A total of 68,685 women participated across the five surveys. BMI data was available for 62,059 study participants and the survey response rates ranged between 96.9% and 98.6% from 1999 to 2014 **(Table S2)**. We examined the changes in the shape of BMI distributions among Bangladeshi women of reproductive-age in 1999, 2004, 2007, 2011, and 2014 using Kernel density plot by urban and rural areas **(Figure 1).** Both urban and rural BMI distribution curves appear to be skewed to the right over the 15-year period indicating a gradual increase in BMI.

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Table 1 shows the socioeconomic and demographic characteristics of study participants across survey years. Over time, the mean age of study participants increased from 25 (±6.63) to 32 (±9.12) years. There was a significant reduction in the proportion of women with no education from 45% to 26% (p<0.001) between 1999 and 2014. Similarly, the proportion of women with higher education increased almost two-fold (4.19% to 8.32%). The frequency of watching television increased approximately 1.6 times and the proportion of working-women almost doubled (18.81 vs. 34.15%) over the study period. There was a significant change in the family structure during the study period. Five or more living children per women dropped from 12.63% to 8.11%.

Trends in overweight and obesity

We present trends in overweight and obesity prevalence over the study period in **Figure 2**. The overall prevalence of overweight-increased almost four fold (7.53% to 28.37%) and prevalence of obesity increased almost five-fold (1.82% to 10.77%) over the fifteen-year period. **Figure 3** demonstrates the prevalence of BMI categories by place of residence**.** There was a 1.76 and 3.5-fold increase in overweight, 5.12 and 7.23-fold increase in obesity in the prevalence of overweight and obesity in urban and rural areas, respectively (**Figure 3**).

Prevalence of overweight and obesity

Table S3 shows the overall prevalence of BMI categories by age groups and place of residence. The prevalence of individuals with overweight and obesity increased across the five survey years for women residing in both urban and rural areas across all age groups. The prevalence of underweight and normal weight decreased in both rural and urban areas. Based on the Asian

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BMI cutoffs, the overall prevalence of overweight in rural and urban women increased from 19.08% (95% CI: 16.95, 21.42) and 5.02% (95% CI: 4.33, 5.83) in 1999 to 33.74% (95% CI: 32.19, 35.32) and 26.24% (95% CI: 25.17, 27.34) in 2014, respectively. Similarly, the prevalence of obesity increased from 5.52% (95% CI: 4.32, 7.04) and 1.02% (95% CI: 0.72, 1.44) in 1999 to 19.32% (95% CI: 18.01, 20.69) and 7.37% (95% CI: 6.82, 7.97) in 2014 in urban and rural areas, respectively. The steepest increase of overweight was observed among women age 35-44 years from 15.79% and 6.10 % in 1999 to 37.62% and 30.09% in 2014 in urban and rural areas, respectively. The prevalence of obesity increased almost three fold among women aged 25-34 years from 7.47% and 1.37% in 1999 to 21.23% and 8.28% in 2014 in urban and rural areas, respectively. The prevalence estimates of BMI for urban and rural women differed when the international BMI cutoffs were used **(Table S4).** A sharp decline was also observed in underweight (urban- 29.73% to 12.2%; rural- 48.18% to 21.08%) during 1999 to 2014 applying the international BMI standard. Across urban and rural and all survey years, the prevalence of overweight and obesity using the Asian-specific guidelines was 2.10 to 2.5 times higher than prevalence estimates based on the international guidelines **(Figure S1, S2).**

Risk factors of overweight or obesity

The adjusted association of overweight and obesity is presented in **Table 2**. Overall, the risk factors of overweight and obesity differed between urban and rural women. Increasing age was associated with higher overweight and obesity risk among both rural and urban residents though the association was stronger among urban residents. The highest overweight (ARR: 3.14, 95% CI: 2.74, 3.59) and obesity (ARR: 6.77, 95% CI: 5.56, 8.24) risk were for the urban women in the age group 35-44 years compared to women 15-24 years of age. The risk of

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overweight and obesity were high for urban women with higher educational level, married women, and women whose husband had a higher educational level. In terms of wealth index, there was significant risk variation between urban and rural study participants. The middle, richer, and richest rural women had of 1.63, 2.55, and 5.85 higher odds of being overweight compared to the women in the lowest wealth index group. The odds of being obese was 2.30, 3.94, and 7.88 times higher for middle, richer, and richest rural women, respectively. Married women in urban areas had a 27% (ARR: 1.27, 95% CI: 1.04, 1.56) higher risk of overweight and 41 %(ARR: 1.41, 95% CI: 1.07, 1.86) higher obesity risk compared with unmarried women. Marital status was not significantly associated with overweight or obesity in rural women. Watching TV at least once a week was an independent risk factor for overweight and obesity among both urban and rural women and the risk was stronger among urban women. In the adjusted model, women who watched TV at least once a week had 28% (ARR: 1.28, 95% CI: 1.13, 1.45) and 72% (ARR: 1.72, 95% CI: 1.43, 2.07) higher risk of being overweight and obese, respectively compared with women who do not watch TV at least once a week.

Women's employment status was only associated with overweight or obesity for urban residents. Working urban women had a lower probability of being overweight (ARR: 0.79, 95% CI: 0.71, 0.89) or obese (ARR: 0.54, 95% CI: 0.46, 0.64) compared with those who do not work. Women in rural areas with five or more household members had a lower probability of being overweight (ARR: 0.71, 95% CI: 0.60, 0.84) and obese (ARR: 0.61, 95% CI: 0.45, 0.81) compared with women with two or fewer household members. Compared to the 2004 survey, the risk of being overweight significantly increased with each subsequent survey period in urban and rural areas. For the increase of one survey period, the risk of overweight and obesity

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was much stronger in rural areas compared with urban areas after adjusting for all predictors. For example, in the most recent 2014 survey, the odds of being overweight was 2.60 (95% CI: 2.33, 2.89) and 2.07 (95% CI: 1.18, 2.37) times higher among rural and urban women respectively as compared to 2004 survey year. Similarly, the odds of being obese were and 4.47 (95% CI: 3.59, 5.57) 3.23 (95% CI: 2.71, 3.86) times higher for rural and urban women respectively as of 2004 survey year.

Discussion

We identified an increasing trend of overweight and obesity among Bangladeshi reproductive-age women with a five-fold increase of obesity between 1999 and 2014. Overweight and obesity put women at increased risk of many adverse health outcomes, including cardiovascular disease, diabetes, kidney disease, and obesity-related cancers[3,4,23]. These women are also more likely to develop pregnancy complications, such as gestational diabetes, hypertensive disorders of pregnancy, cesarean section delivery and adverse fetal outcome[13,15]. Although Bangladesh has made substantial progress in reducing death from pregnancy-related complications in the last several decades, pregnancy-associated risks remain high. The increasing trend of obesity among reproductive-age women may create new challenges[24,25].

Our findings of an increasing longitudinal prevalence of overweight and obesity is consistent with findings from neighboring countries, current trends in most developing countries, as well as across the globe[2]. This trend could be explained by substantial lifestyle changes including changes in eating habits with more energy-dense food intake and sedentary lifestyles with reduced physical activity patterns[26]. These changes have been observed in Bangladesh with rapid economic growth, urbanization, modernization, and globalization of the food market[27].

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We found the highest increase in the prevalence of overweight and obesity among women aged 35-44 years. Studies from other low-income countries showed that older women (aged 45-49) are at greatest risk of overweight and obesity[28]. Because we did not include women older than 49 years of age, the actual number of obese women might be much higher in Bangladesh. Our study also showed that the increasing rate of overweight and obesity was more marked in rural areas than urban areas whereas the rate of decline of undernutrition was much higher in urban areas. This disparity may be the result of multiple factors. Our study also showed that the increasing overweight and obesity rates were more marked in rural areas than urban areas and the decline of the undernutrition rate was much higher in urban areas. This disparity between rural and urban areas may be the result of multiple factors, such as a reduction in poverty and increased per-capita income. Bangladesh's per capita income has been growing around 5% per year in the 2000s. This increased per-capita income at household level has improved nutritional status. However, this growth was not equal among the rich and poor. The upward trend of income inequality also exists at all levels: national, rural and urban. The Gini coefficient, a commonly used measure for income inequality, shows an increase from 0.432 in 1995 to 0.458 in 2010. Moreover, urban inequality has increased faster than rural inequality likely explaining the slow reduction of the number of underweight women in urban areas.

Our data showed that over the last 15 years, the number of educated and employed urban women increased significantly in Bangladesh. Because educational status and employment are

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both negatively associated with obesity, this might explain the variation in overweight and obesity between urban and rural women[29].

We determined that educational status including the husband's educational status, marital status, wealth index, self-reported hours of television watching, and employment status were significantly associated with overweight and obesity. Our study showed that compared with women who have no education women with higher educational status were at increased risk of overweight and obesity. Highly educated women are more likely to have a sedentary job requiring less physical activity and hence have an increased risk of weight gain. Studies from other developing countries also demonstrate a positive association between level of education and obesity[22,30], however, a negative association between the two variables has been observed primarily in developed countries[29]. Our findings that wealthier women are more likely to be overweight or obese are consistent with studies done in other low and middle-income countries[22,31]. This is likely due to the fact that increasing wealth in lower income countries results in greater access to food, an escape from physical labor and a higher risk of obesity. We found that television watching was an independent predictor of overweight and obesity. Television viewing has been used as a proxy for sitting time and studies that follow participants over long periods of time have consistently found that people who spend more time watching television are more likely to gain weight[32]. Unemployed Bangladeshi women spend a significant amount of time watching television as a leisure activity. Moreover, with the economic growth increasing access to television suggest that viewing television may further increase which may further contribute obesity of this group.

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Because geographical, ethnic, and cultural variation have large impacts on trends of overweight and obesity, we used the Asian BMI standard instead of international guidelines. The prevalence estimate of overweight and obesity using the Asian BMI category across all survey years was 2.10 to 2.50 times higher compared with estimates based on the international guidelines. Evidence have shown that Asian populations are at an increased risk of cardio-metabolic disorders at lower BMI levels than other ethnic groups, attributed to a considerably higher body fat percentage[33]. For this reason, in 2004 the WHO recommended lowering the BMI cut-offs for Asian adults for overweight from 25 to 23 kg/m^2 and for obesity from 30 to 27.5 kg/m^2 [20]. Previous reports that used international BMI classification in estimating overweight and obesity prevalence in Asians may have underestimated adverse health risks. Our analysis has several limitations. We used secondary cross-sectional data limiting our ability to identify a causal relationship between predictors and overweight and obesity. Moreover, the dataset lacks some key variables including eating habits, physical activity, and smoking. Evidence showed that these factors strongly influence weight gain and may interact with other predictors of obesity such as wealth and education. However, the study included representative sample across Bangladesh including both urban and rural women and used the Asian BMI category for the analysis strengthening our evidence base.

Conclusion

Overweight and obesity increased among Bangladeshi reproductive-age women between 1999 and 2014. Sociodemographic factors including age, education, wealth index, marital status, television watching, and employment status were associated with the increased trend of overweight and obesity. The prevalence and risk factors of overweight and obesity varied

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between urban and rural women. Further research should focus on identifying other behavioral risk factors associated with overweight and obesity and identify feasible interventions for those most at risk.

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Tables

Table 1. Socio-demographic characteristics of the study participants by survey year, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Age, mean(SD)	25.88 (6.63)	30.56 (9.36)	30.94 (9.3)	31.23 (9.22)	31.37 (9.12)	<0.001
Age group, n (%)						<0.001
15-24	2148 (47.05)	3303 (31.82)	2996 (30.29)	4557 (28.72)	4433 (27.04)	
25-34	2007 (41.52)	3533 (33.77)	3344 (33.13)	5603 (34.19)	5969 (36.44)	
35-44	486 (10.61)	2598 (24.39)	2747 (26.69)	4321 (26.2)	4435 (26.05)	
45+	38 (0.81)	1055 (10.02)	1040 (9.89)	1792 (10.89)	1787 (10.47)	
Educational level, n (%)						<0.001
No education	2002 (44.62)	4158 (42.44)	3326 (34.85)	4386 (28.59)	4039 (25.68)	
Primary	1364 (29.14)	3070 (29.07)	3014 (29.67)	4857 (30.04)	4875 (29.24)	
Secondary	1072 (22.05)	2629 (23.52)	2983 (29.52)	5731 (34.3)	6153 (36.76)	
Higher	241 (4.19)	632 (4.97)	801 (5.96)	1299 (7.07)	1557 (8.32)	
Place of residence, n (%)						<0.001
Urban	1275 (17.76)	3593 (22.58)	3858 (22.81)	5709 (26.1)	5764 (28.41)	
Rural	3404 (82.24)	6896 (77.42)	6269 (77.19)	11000 (73.9)	11000 (71.59)	
Geographic region, n (%)						<0.001
Barisal	434 (6.48)	1252 (6.33)	1327 (6.01)	1819 (5.45)	1982 (6.19)	
Chittagong	937 (20.08)	1869 (17.56)	1775 (18.23)	2616 (18)	2639 (18.29)	
Dhaka	1123 (31.05)	2376 (31.27)	2178 (31.5)	2795 (32.18)	2893 (34.96)	
Khulna	760 (11.42)	1583 (12.32)	1589 (12.77)	2488 (12.4)	2460 (10.51)	
Rajshahi	889 (24.48)	2374 (26.35)	1933 (25.31)	4703 (26.73)	4769 (23.56)	
Sylhet	536 (6.49)	1035 (6.17)	1325 (6.18)	1852 (5.25)	1881 (6.49)	
Marital status, n (%)						<0.001
Not married	130 (2.71)	859 (7.93)	822 (7.7)	1091 (6.6)	1014 (5.95)	
Married	4549 (97.29)	9630 (92.07)	9305 (92.3)	15000 (93.4)	16000 (94.05)	
Urban						
BMI, Kg/m2						<0.001
Mean (SD)	20.78 (4.51)	21.52 (5.06)	22.24 (5.44)	23 (4.87)	23.7 (5.06)	
BMI categories, n (%)						<0.001
Underweight	385 (29.74)	903 (24.84)	787 (19.54)	879 (13.46)	738 (12.21)	
Normal weight	585 (45.65)	1573 (44.47)	1629 (41.73)	2298 (41.4)	1996 (34.73)	
Overweight	237 (19.09)	801 (21.87)	1010 (26.88)	1729 (30.62)	1971 (33.74)	
Obese	68 (5.53)	316 (8.81)	432 (11.85)	803 (14.52)	1059 (19.32)	
Overweight or obese	305 (24.61)	1117 (30.68)	1442 (38.73)	2532 (45.14)	3030 (53.06)	
Rural						
BMI, Kg/m2						<0.001
Mean (SD)	18.97 (2.42)	19.76 (2.72)	20.18 (2.83)	20.82 (3.29)	21.71 (3.62)	
BMI categories, n (%)						<0.001
Underweight	1636 (48.19)	2581 (36.9)	2107 (32.45)	2940 (27.83)	2353 (21.09)	
Normal weight	1560 (45.76)	3422 (49.82)	3135 (50.72)	5138 (48.59)	4926 (45.3)	
Overweight	174 (5.03)	762 (11.36)	851 (13.88)	1997 (18.97)	2780 (26.24)	

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Table 1. Socio-demographic characteristics of the study participants by survey year, BDHS 1999-2014

Variables	1999	2004	2007	2011	2014	p-value
Obese	34 (1.02)	131 (1.92)	176 (2.96)	489 (4.62)	801 (7.38)	
Overweight or obese	208 (6.05)	893 (13.28)	1027 (16.83)	2486 (23.58)	3581 (33.62)	
Wealth index, n (%)						0.1665
Poorest	NA	1865 (19.85)	1636 (19.19)	2811 (18.29)	2999 (18.55)	
Poorer	NA	1880 (19.92)	1822 (19.35)	2995 (19.47)	3102 (18.95)	
Middle	NA	1960 (19.77)	1910 (19.72)	3129 (20.07)	3382 (20.04)	
Richer	NA	2098 (20.38)	2043 (20.85)	3472 (20.83)	3534 (21.21)	
Richest	NA	2686 (20.08)	2716 (20.88)	3866 (21.34)	3607 (21.24)	
Watch TV (once a week), n (%)						<0.001
No	2946 (66.99)	5459 (54.5)	5138 (53.2)	8149 (51.61)	7997 (48.83)	
Yes	1732 (33.01)	5027 (45.5)	4985 (46.8)	8120 (48.39)	8626 (51.17)	
Currently working, n (%)						
No	3839 (81.19)	8098 (76.85)	7068 (67.12)	14000 (86.62)	11000 (65.85)	
Yes	840 (18.81)	2390 (23.15)	3055 (32.88)	2216 (13.38)	5398 (34.15)	
Number of living children, n (%)						<0.001
0	67 (1.46)	1017 (9.39)	930 (8.78)	1371 (8.53)	1385 (7.96)	
1-2	2669 (56.66)	4590 (43.15)	4769 (47.11)	8236 (50.09)	8857 (53.48)	
3-4	1358 (29.25)	3312 (32.45)	3111 (31.61)	5102 (31.64)	5013 (30.45)	
>5	585 (12.63)	1570 (15.01)	1317 (12.5)	1564 (9.74)	1369 (8.11)	
Number of household member, n (%)						<0.001
1-2	46 (1.03)	382 (3.71)	405 (4.11)	694 (4.46)	834 (5.27)	
3-4	1208 (26.22)	3079 (30.31)	3171 (32.63)	5633 (34.65)	6224 (37.36)	
>5	3425 (72.75)	7028 (65.99)	6551 (63.25)	9946 (60.89)	9566 (57.36)	
Contraceptive use, n (%)						<0.001
Not using	2060 (44.71)	4422 (41.76)	4555 (44.02)	6260 (38.76)	6227 (37.19)	
Pills	1352 (2.904)	2641 (2.606)	2734 (2.835)	4385 (2.725)	4476 (2.717)	
Other	1267 (26.25)	3426 (32.18)	2838 (27.63)	5628 (33.99)	5921 (35.64)	
Husband education, n (%)						<0.001
No education	1851 (42.48)	3818 (39.16)	3342 (35.92)	4833 (31.73)	4764 (29.5)	
Primary	1102 (24.24)	2629 (25.34)	2610 (25.78)	4362 (26.89)	4503 (27.1)	
Secondary	1098 (23.05)	2691 (24.43)	2660 (25.94)	4680 (27.93)	4884 (29.71)	
Higher	549 (10.23)	1342 (11.07)	1501 (12.37)	2390 (13.46)	2471 (13.69)	

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Table 2. Association of overweight and obesity with socio demographic characteristics by place of residence, BDHS 1999-2014

	Urban				Rural			
	Overweight vs. healthy		Obese vs. healthy		Overweight vs. healthy		Obese vs. healthy	
Age group	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value	RR (95% CI)	p-value
15-24	Ref		Ref		Ref		Ref	
25-34	2.39 (2.11, 2.70)	0.000	4.04 (3.34, 4.87)	0.00	2.09 (1.9, 2.31)	0.000	3.23 (2.67, 3.91)	0.000
35-44	3.14 (2.74, 3.59)	0.000	6.77 (5.56, 8.24)	0.00	2.45 (2.2, 2.73)	0.000	4.06 (3.30, 4.99)	0.000
45+	2.59 (2.15, 3.12)	0.000	6.22 (4.88, 7.92)	0.00	2.47 (2.14, 2.86)	0.000	3.69 (2.87, 4.74)	0.000
Education level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (1.06, 1.41)	0.006	1.25 (1.01, 1.54)	0.03	1.11 (1.01, 1.23)	0.023	1.22 (1.02, 1.46)	0.026
Secondary	1.41 (1.20, 1.65)	0.000	1.61 (1.29, 2.02)	0.00	1.15 (1.03, 1.30)	0.014	1.27 (1.04, 1.55)	0.019
Higher	1.61 (1.30, 1.99)	0.000	1.42 (1.07, 1.90)	0.02	1.12 (0.92, 1.36)	0.238	0.92 (0.67, 1.27)	0.649
Marital status								
Not married	Ref							
Married	1.27 (1.04, 1.56)	0.018	1.41 (1.07, 1.86)	0.01	NA	NA	NA	NA
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	1.15 (0.87, 1.52)	0.317	0.99 (0.58, 1.70)	0.99	1.32 (1.17, 1.49)	0.000	1.45 (1.11, 1.90)	0.006
Middle	1.65 (1.29, 2.11)	0.000	1.63 (1.02, 2.61)	0.04	1.65 (1.46, 1.87)	0.000	2.30 (1.78, 2.97)	0.000
Richer	1.88 (1.49, 2.37)	0.000	2.55 (1.64, 3.96)	0.00	2.46 (2.16, 2.8)	0.000	3.94 (3.05, 5.10)	0.000
Richest	2.83 (2.24, 3.57)	0.000	5.58 (3.6, 8.63)	0.00	3.38 (2.9, 3.94)	0.000	7.88 (5.93, 10.46)	0.000
Watch TV (once a week)								
No	Ref		Ref		Ref		Ref	
Yes	1.28 (1.13, 1.45)	0.000	1.72 (1.43, 2.07)	0.00	1.25 (1.15, 1.35)	0.000	1.4 (1.22, 1.62)	0.000
Currently working								
No	Ref		Ref					
Yes	0.79 (0.71, 0.89)	0.000	0.54 (0.46, 0.64)	0.00	NA	NA	NA	NA
Number of household member								
1-2					Ref		Ref	
3-4	NA	NA	NA	NA	0.86 (0.72, 1.02)	0.093	0.86 (0.64, 1.16)	0.353
>5	NA	NA	NA	NA	0.71 (0.60, 0.84)	0.000	0.61 (0.45, 0.81)	0.001
Contraceptive use								
Not using	Ref				Ref		Ref	
Pills	0.96 (0.85, 1.09)	0.605	0.79 (0.67, 0.94)	0.01	1.06 (0.98, 1.16)	0.130	0.83 (0.70, 0.97)	0.022
Other	1.07 (0.95, 1.20)	0.237	1.04 (0.9, 1.20)	0.55	1.08 (0.99, 1.18)	0.053	0.94 (0.82, 1.09)	0.459
Husband education								
No education	Ref		Ref		Ref		Ref	
Primary	1.11 (0.95, 1.29)	0.164	1.12 (0.89, 1.4)	0.32	1.07 (0.97, 1.18)	0.132	1.22 (1.01, 1.47)	0.037
Secondary	1.18 (1.01, 1.37)	0.031	1.32 (1.05, 1.65)	0.02	1.2 (1.08, 1.34)	0.001	1.51 (1.25, 1.82)	0.000
Higher	1.55 (1.28, 1.88)	0.000	1.94 (1.49, 2.52)	0.00	1.46 (1.25, 1.69)	0.000	1.98 (1.55, 2.53)	0.000
Survey year						eb		
2004	Ref		Ref		Ref		Ref	
2007	1.23 (1.07, 1.42)	0.003	1.35 (1.11, 1.64)	0.00	1.19 (1.06, 1.35)	0.004	1.49 (1.15, 1.93)	0.002
2011	1.43 (1.26, 1.63)	0.000	1.68 (1.40, 2.00)	0.00	1.71 (1.54, 1.90)	0.000	2.50 (2.00, 3.13)	0.000
2014	2.07 (1.81, 2.37)	0.000	3.23 (2.71, 3.86)	0.00	2.60 (2.33, 2.89)	0.000	4.47 (3.59, 5.57)	0.000

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Figure legends

Figure 1. Kernel density plot of the distribution of BMI for reproductive-age women in 1999, 2004, 2007, 2011, and 2014

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

Figure S1. Prevalence of BMI categories International cutoff

Figure S2. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014 (International cutoff)

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List of Abbreviations

ARR	Adjusted risk ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Ethical approval and consent

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Informed consent was obtained from each participant of the survey before enrolling in the survey by using the Introduction and Consent form of the survey. It was also explained that the information will be kept strictly confidential and will not be shared with anyone except members of the survey team.

Consent to publish: Not Applicable

Availability of data/ Data sharing statement

The datasets used for the current study are publicly available from http://dhsprogram.com/data/available-datasets.cfm.

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

Acknowledgement: We gratefully acknowledge DHS for allowing us to use the data.

Disclosure/ Conflict of interest: None

Author contribution: MC conceptualized the study and designed the analytical approach, performed the data analyses and interpreted the findings, and led the writing of the article. **MA** was involved in the literature search and drafting the manuscript. **ZH** helped conceptualize the study literature, variable selection, editing and drafting the manuscript. Revised the manuscript critically for important intellectual content, and final approval of the version to be submitted. All authors helped write the manuscript. All authors read and approved the final manuscript.

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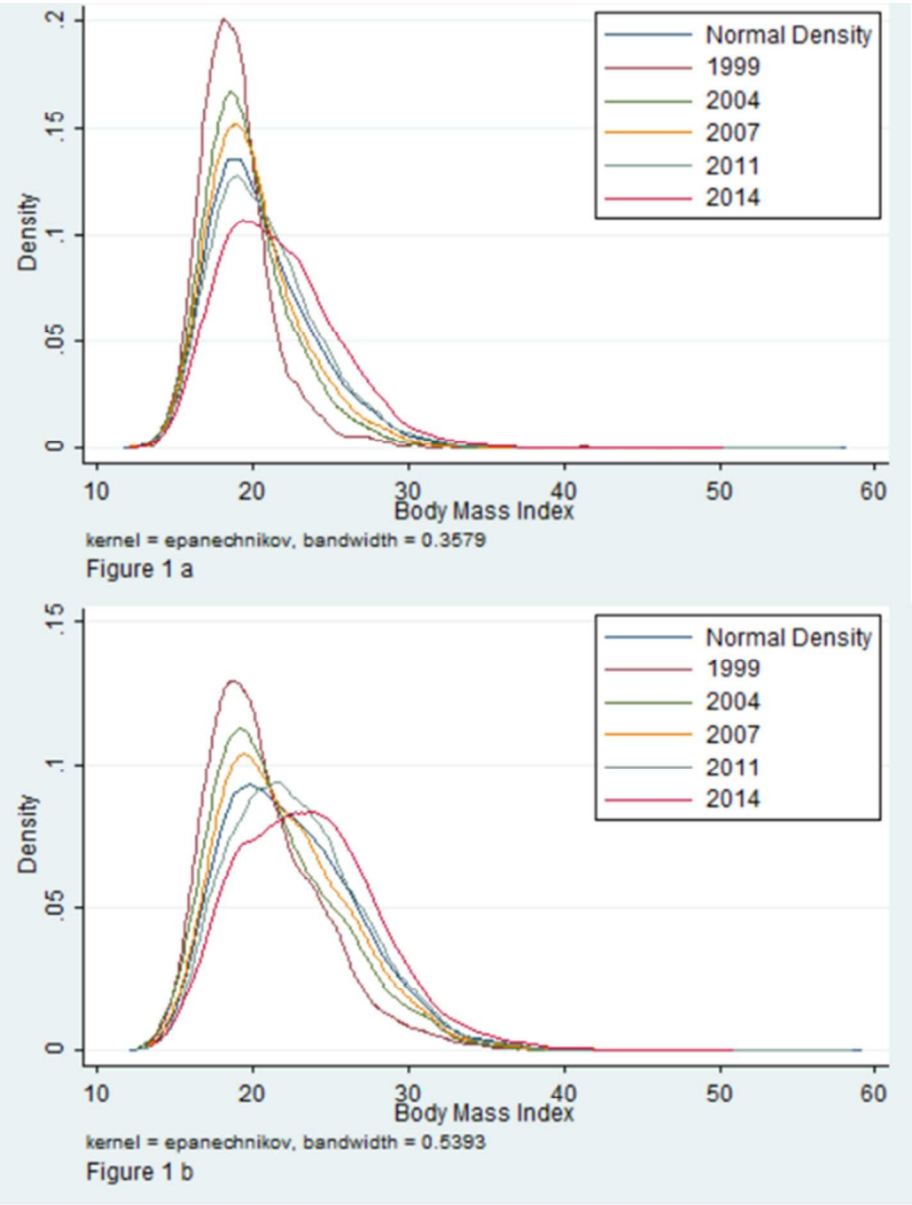

Figure 1. Kernel density plot of the distribution of BMI for reproductive-age women in 1999, 2004, 2007, 2011, and 2014

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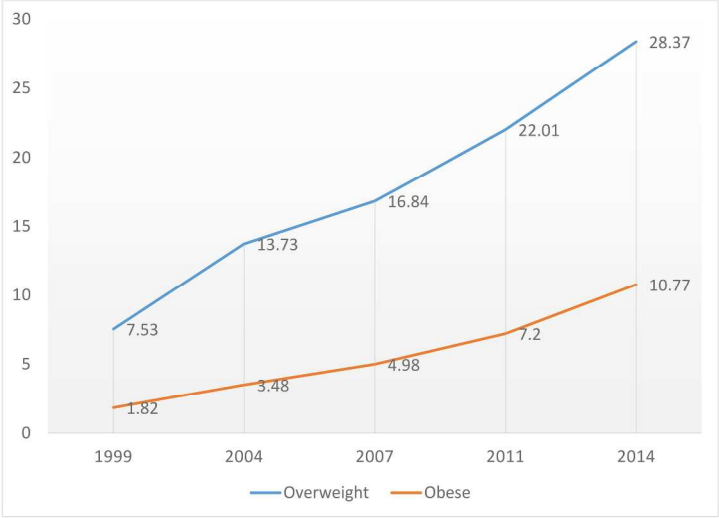

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

Figure 2. Prevalence of overweight and obesity by survey year, BDHS 1999-2014

279x361mm (300 x 300 DPI)

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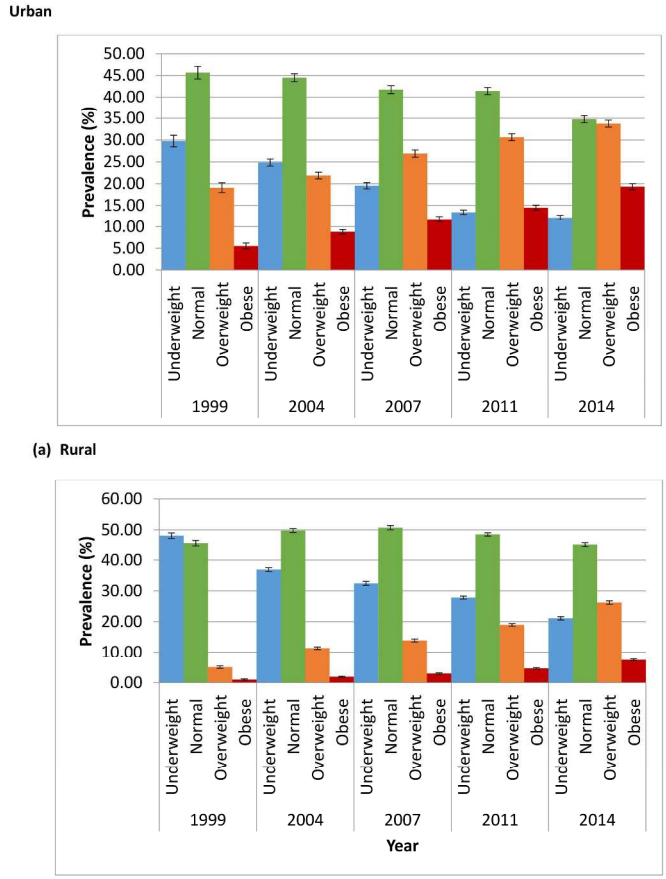

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

Figure 3. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014

279x361mm (300 x 300 DPI)

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Supplements

Table S1. Variance inflation (VIF) values of final models of urban and rural women, BDHS 1999-2014

Variables	VIF- Urban	VIF-Rural
Age	1.09	1.29
Education	2.03	1.97
Marital status	1.18	1.12
Wealth index	1.49	1.69
Watching TV at least once a week	1.29	1.32
Currently working	1.08	1.04
No· of household members	1.04	1.05
Contraceptive use	1.12	1.09
Husband education	2.03	1.71
Survey year	1.02	1.05

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Table S2. Summary characteristics of the sample by survey year, BDHS 1999-2014

Variable	1999-00	2004	2007	2011	2014
Initial sample of the survey, n	10544	11440	10996	17842	17863
BMI available, n	5055	11176	10836	17309	17683
Pregnant women, n	376	678	709	1036	1059
Final working sample, n	4679	10489	10127	16273	16624
Response rate, %	96.9	98.6	98.4	97.9	97.9

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3

Table S3. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014

		Urban					Rural				
	Age groups	1999	2004	2007	2011	2014	1999	2004	2007	2011	2014
Underweight	15-24	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	25-34	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	35-44	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	45+	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	Overall	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	15-24	50.62 (46.22, 55.01)	53.21 (49.83, 56.56)	50.64 (47.17, 54.11)	53.98 (50.91, 57.02)	45.47 (42.22, 48.77)	47.42 (44.89, 49.95)	53.54 (51.33, 55.74)	55.29 (52.86, 57.69)	52.08 (50.14, 54)	50.84 (48.49, 53.18)
	25-34	41.45 (37.43, 45.59)	44.68 (41.65, 47.75)	41.3 (38.23, 44.45)	37.8 (35.15, 40.51)	32.71 (30.19, 35.34)	46.8 (44.08, 49.54)	51.15 (48.95, 53.35)	51.6 (49.21, 53.98)	48.32 (46.57, 50.08)	44.57 (42.49, 46.67)
	35-44	45.09 (35.42, 55.14)	37.9 (34.44, 41.5)	35.36 (32.17, 38.68)	34 (31.08, 37.05)	27.75 (24.94, 30.74)	35.71 (30.86, 40.88)	46.98 (44.42, 49.55)	47.49 (44.83, 50.16)	47.15 (45.16, 49.15)	42.17 (39.77, 44.61)
	45+	19.96 (4.12, 59.13)	33.66 (28.29, 39.49)	36.66 (31.3, 42.36)	37.87 (33.33, 42.63)	32.15 (27.54, 37.14)	35.62 (20.55, 54.2)	40.37 (36.59, 44.27)	41.94 (37.8, 46.2)	43.56 (40.47, 46.71)	41.06 (37.55, 44.66)
	Overall	45.64 (42.81, 48.51)	44.47 (42.65, 46.3)	41.72 (39.93, 43.53)	41.39 (39.8, 43)	34.72 (33.15, 36.33)	45.76 (44.03, 47.49)	49.82 (48.55, 51.08)	50.72 (49.36, 52.08)	48.58 (47.56, 49.61)	45.29 (44.05, 46.53)
Overweight	15-24	14.31 (11.51, 17.65)	12.51 (10.46, 14.89)	17.63 (15.1, 20.47)	20.18 (17.81, 22.79)	25.42 (22.67, 28.38)	3.36 (2.58, 4.37)	6.7 (5.67, 7.89)	9.56 (8.19, 11.14)	11.81 (10.63, 13.1)	17.95 (16.33, 19.7)
	25-34	23.9 (20.55, 27.6)	25.73 (23.15, 28.49)	28.99 (26.19, 31.96)	35.56 (32.95, 38.26)	37.7 (35.09, 40.38)	6.74 (5.49, 8.24)	12.09 (10.72, 13.6)	15.66 (14, 17.48)	22.03 (20.61, 23.52)	29.31 (27.47, 31.23)
	35-44	15.79 (9.58, 24.92)	26.82 (23.77, 30.11)	33.17 (30.02, 36.48)	35.55 (32.57, 38.66)	37.62 (34.59, 40.74)	6.1 (4.06, 9.08)	15.05 (13.29, 17)	15.67 (13.83, 17.71)	22.4 (20.78, 24.1)	30.09 (27.93, 32.34)
	45+	26.19 (3.91, 75.55)	23.39 (18.71, 28.83)	27.28 (22.51, 32.65)	30.3 (26.11, 34.84)	31.21 (26.62, 36.19)	3.4 (0.47, 20.56)	15 (12.32, 18.14)	16.66 (13.73, 20.07)	20.06 (17.69, 22.67)	27.57 (23.99, 31.47)
	Overall	19.08 (16.95, 21.42)	21.87 (20.42, 23.39)	26.87 (25.28, 28.53)	30.62 (29.14, 32.14)	33.74 (32.19, 35.32)	5.02 (4.33, 5.83)	11.35 (10.57, 12.18)	13.87 (12.96, 14.84)	18.96 (18.18, 19.78)	26.24 (25.17, 27.34)
Obese	15-24	2.3 (1.28, 4.1)	3.44 (2.4, 4.92)	4.31 (3.07, 6.02)	5.67 (4.44, 7.22)	8.09 (6.49, 10.05)	0.82 (0.46, 1.44)	0.83 (0.51, 1.35)	1.18 (0.75, 1.86)	2.08 (1.59, 2.71)	3.74 (3.01, 4.64)
	25-34	7.47 (5.54, 10)	8.65 (7.03, 10.6)	12.33 (10.41, 14.55)	15.39 (13.48, 17.52)	21.23 (18.96, 23.69)	1.37 (0.86, 2.18)	2.47 (1.86, 3.29)	3.52 (2.72, 4.55)	5.51 (4.76, 6.36)	8.28 (7.32, 9.36)
	35-44	10.68 (5.53, 19.6)	13.86 (11.59, 16.48)	17.26 (14.78, 20.07)	20.9 (18.41, 23.62)	25.24 (22.51, 28.19)	0.68 (0.17, 2.71)	2.56 (1.83, 3.56)	3.88 (2.99, 5.02)	5.68 (4.83, 6.66)	9.74 (8.53, 11.1)
	45+	17.94 (2.42, 65.83)	12.66 (9.27, 17.07)	15.53 (11.73, 20.29)	19.25 (15.73, 23.34)	26.01 (21.83, 30.67)	NA	2.05 (1.2, 3.49)	4.14 (2.69, 6.32)	5.94 (4.64, 7.58)	7.77 (6.2, 9.69)
	Overall	5.52 (4.32, 7.04)	8.81 (7.84, 9.88)	11.85 (10.71, 13.08)	14.51 (13.41, 15.69)	19.32 (18.01, 20.69)	1.02 (0.72, 1.44)	1.92 (1.59, 2.31)	2.95 (2.52, 3.45)	4.61 (4.2, 5.06)	7.37 (6.82, 7.97)

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Table S4. Prevalence of BMI categories of reproductive women by age and place of residence in Bangladesh, BDHS 1999 - 2014 **(International cutoff)**

	Urban					Rural				
	1999	2004	2007	2011	2014	1999-00	2004	2007	2011	2014
Underweight	32.75 (28.78, 36.98)	30.81 (27.83, 33.97)	27.4 (24.41, 30.61)	20.14 (17.89, 22.6)	20.99 (18.44, 23.79)	48.38 (45.86, 50.92)	38.91 (36.79, 41.08)	33.95 (31.7, 36.26)	34.01 (32.2, 35.87)	27.45 (25.42, 29.58)
	27.16 (23.64, 31)	20.91 (18.54, 23.5)	17.35 (15.12, 19.83)	11.23 (9.68, 13)	8.34 (6.98, 9.92)	45.07 (42.38, 47.79)	34.26 (32.21, 36.37)	29.2 (27.08, 31.41)	24.12 (22.65, 25.66)	17.81 (16.16, 19.6)
	28.42 (20.42, 38.06)	21.4 (18.58, 24.51)	14.18 (12.04, 16.63)	9.53 (7.94, 11.4)	9.37 (7.69, 11.38)	57.48 (52.25, 62.55)	35.4 (32.99, 37.89)	32.94 (30.5, 35.48)	24.75 (23.05, 26.53)	17.98 (16.13, 19.99)
	35.89 (8.84, 76.36)	30.27 (25.06, 36.03)	20.51 (16.36, 25.39)	12.56 (9.83, 15.92)	10.61 (7.61, 14.61)	60.97 (42.57, 76.7)	42.56 (38.75, 46.46)	37.24 (33.25, 41.42)	30.41 (27.56, 33.42)	23.58 (20.29, 27.22)
	29.73 (27.21, 32.39)	24.84 (23.32, 26.42)	19.54 (18.17, 20.99)	13.46 (12.45, 14.54)	12.2 (11.16, 13.34)	48.18 (46.47, 49.91)	36.89 (35.7, 38.11)	32.44 (31.2, 33.71)	27.82 (26.91, 28.76)	21.08 (20.06, 22.15)
Normal weight	60.28 (55.93, 64.48)	60.8 (57.48, 64.02)	62.4 (58.97, 65.72)	66.43 (63.53, 69.2)	59.81 (56.54, 62.98)	49.84 (47.3, 52.37)	58.05 (55.85, 60.21)	61.86 (59.48, 64.18)	59.97 (58.06, 61.85)	61.91 (59.64, 64.13)
	55.78 (51.59, 59.89)	57.51 (54.44, 60.52)	56.31 (53.15, 59.41)	57.53 (54.77, 60.23)	51.95 (49.19, 54.7)	51.45 (48.72, 54.17)	59.71 (57.54, 61.85)	60.19 (57.82, 62.51)	61.03 (59.3, 62.73)	60.12 (58.05, 62.16)
	53.39 (43.32, 63.19)	50.67 (47.04, 54.3)	52.6 (49.17, 56)	51.3 (48.14, 54.45)	44.95 (41.78, 48.16)	39.23 (34.25, 44.44)	56.17 (53.61, 58.7)	57.42 (54.77, 60.02)	61.14 (59.16, 63.07)	59.66 (57.26, 62.01)
	19.96 (4.12, 59.13)	43.23 (37.44, 49.21)	50.28 (44.61, 55.94)	52.82 (48.04, 57.55)	45.45 (40.36, 50.64)	35.62 (20.55, 54.2)	50.06 (46.14, 53.98)	54.54 (50.29, 58.72)	55.41 (52.25, 58.52)	56.51 (52.71, 60.24)
	57.4 (54.54, 60.21)	55.43 (53.6, 57.24)	56.33 (54.52, 58.14)	57.89 (56.29, 59.47)	51.49 (49.82, 53.16)	49.17 (47.44, 50.9)	57.33 (56.08, 58.57)	59.43 (58.09, 60.75)	60.14 (59.13, 61.15)	60.11 (58.89, 61.32)
Overweight	5.82 (4.11, 8.17)	6.59 (5.15, 8.41)	8.67 (6.88, 10.86)	11.08 (9.32, 13.12)	15.63 (13.42, 18.13)	1.28 (0.82, 2.01)	2.91 (2.25, 3.75)	3.82 (2.96, 4.91)	5.34 (4.55, 6.25)	9.52 (8.33, 10.87)
	14.07 (11.39, 17.26)	17.65 (15.41, 20.15)	21.33 (18.84, 24.05)	24.61 (22.29, 27.09)	31.22 (28.7, 33.85)	2.95 (2.14, 4.05)	5 (4.13, 6.05)	9.64 (8.32, 11.15)	13.06 (11.92, 14.29)	19.1 (17.61, 20.68)
	13.61 (7.8, 22.66)	22.23 (19.39, 25.35)	25.93 (23.03, 29.06)	30.21 (27.36, 33.23)	33.2 (30.3, 36.23)	3.28 (1.86, 5.7)	7.67 (6.37, 9.21)	8.91 (7.5, 10.55)	12.01 (10.77, 13.37)	18.54 (16.79, 20.42)
	44.14 (12.09, 81.39)	21.23 (16.77, 26.51)	21.68 (17.25, 26.88)	24.62 (20.76, 28.93)	30.73 (26.28, 35.57)	3.4 (0.47, 20.56)	6.38 (4.69, 8.62)	7.07 (5.22, 9.52)	11.55 (9.72, 13.67)	17.18 (14.72, 19.95)
	10.57 (8.92, 12.47)	15.87 (14.59, 17.23)	19.18 (17.78, 20.66)	22.25 (20.93, 23.63)	27.56 (26.11, 29.06)	2.19 (1.73, 2.77)	5.1 (4.57, 5.69)	7.39 (6.71, 8.13)	10.39 (9.79, 11.03)	16.14 (15.3, 17.02)
Obese	1.13 (0.49, 2.59)	1.78 (1.05, 2.99)	1.51 (0.85, 2.66)	2.33 (1.58, 3.43)	3.55 (2.47, 5.07)	0.48 (0.23, 0.99)	0.12 (0.03, 0.39)	0.36 (0.15, 0.81)	0.66 (0.4, 1.08)	1.1 (0.75, 1.6)
	2.97 (1.81, 4.84)	3.9 (2.85, 5.32)	4.99 (3.83, 6.49)	6.61 (5.34, 8.16)	8.48 (6.98, 10.25)	0.51 (0.22, 1.13)	1.01 (0.63, 1.59)	0.95 (0.55, 1.64)	1.77 (1.37, 2.29)	2.95 (2.37, 3.67)
	4.56 (1.61, 12.27)	5.68 (4.25, 7.54)	7.27 (5.66, 9.28)	8.94 (7.26, 10.96)	12.46 (10.37, 14.9)	.	0.74 (0.4, 1.37)	0.72 (0.4, 1.29)	2.08 (1.59, 2.72)	3.81 (3.04, 4.76)
	.	5.25 (3.2, 8.51)	7.51 (4.96, 11.21)	9.98 (7.38, 13.36)	13.18 (10.08, 17.06)	.	0.99 (0.43, 2.26)	1.13 (0.49, 2.58)	2.61 (1.78, 3.81)	2.71 (1.88, 3.9)
	2.28 (1.54, 3.38)	3.85 (3.21, 4.61)	4.93 (4.2, 5.78)	6.38 (5.63, 7.23)	8.72 (7.79, 9.76)	0.43 (0.25, 0.74)	0.65 (0.47, 0.9)	0.72 (0.52, 1.01)	1.62 (1.38, 1.9)	2.64 (2.31, 3.03)

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Figure S1. Prevalence of BMI categories International cutoff

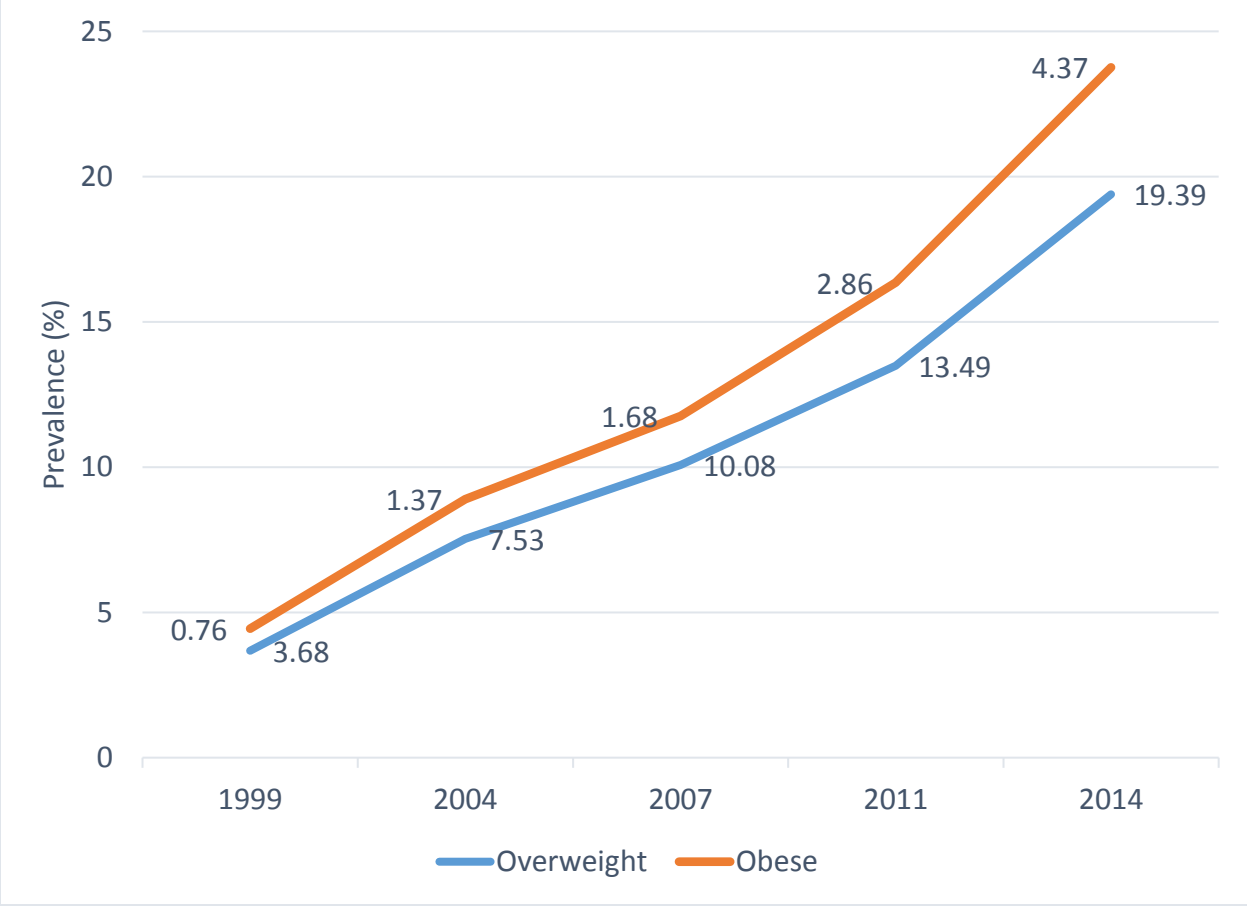

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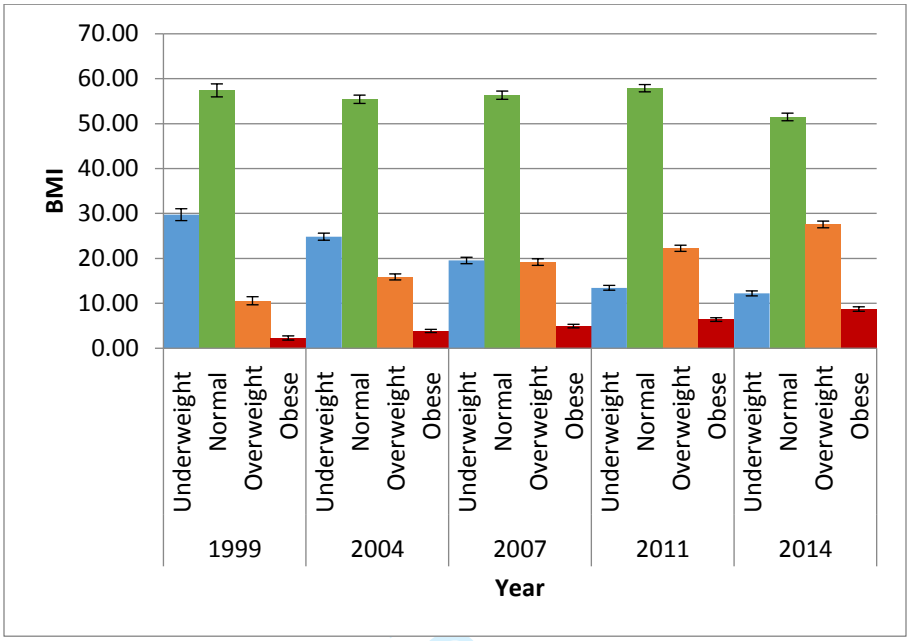
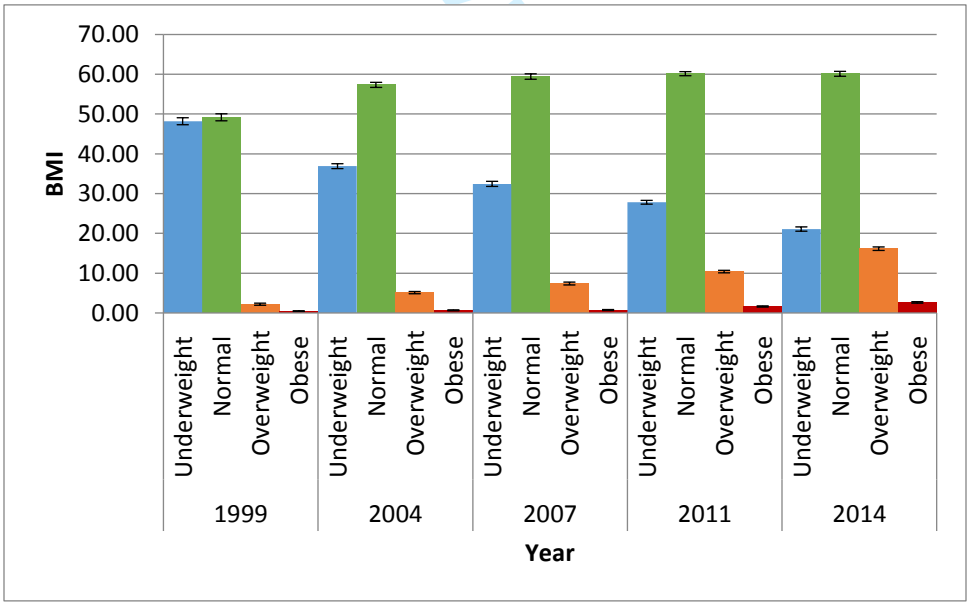
Figure S2. Prevalence of underweight, normal, overweight, and obesity by year and place of residence BDHS 1999-2014 (International cutoff).

(a) Urban



(b) Rural



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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	5 - 6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Not applicable
Bias	9	Describe any efforts to address potential sources of bias	Not applicable
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	6-8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8

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		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6- 9
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3, 14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	14-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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