


# BMJ Open Association of overweight and obesity with hypertension, diabetes and comorbidity among adults in Bangladesh: evidence from nationwide Demographic and Health Survey 2017–2018 data

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## ABSTRACT

**Objectives** The study aimed to determine the association of overweight and obesity with hypertension, diabetes and comorbidity among the adults of Bangladesh.

**Study design** This study used cross-sectional data from the nationally representative Bangladesh Demographic and Health Survey conducted in 2017–2018. The main outcome variables were hypertension, diabetes and comorbidity. Comorbidity was defined as the coexistence of hypertension and diabetes. Overweight and obesity, as measured by body mass index, were the main explanatory variables. The strength of the association was determined using the adjusted multiple logistic regression models.

**Setting** Rural and urban areas in Bangladesh.

**Participants** The study included a total of 11 881 adults (5241 men and 6640 women) aged 18 years or older.

**Results** The prevalence of hypertension, diabetes and comorbidity among the sample population were 28.5%, 9.9% and 4.5%, respectively. Among the respondents, 20.1% were overweight and 4.1% were obese. The risk of hypertension was 2.47 times more likely in the overweight group (adjusted OR (AOR) 2.47; 95% CI 2.22 to 2.75) and 2.65 times more likely in the obese group (AOR 2.65; 95% CI 2.16 to 3.26) compared with the normal or underweight group. Adults who were overweight and obese had 59% (AOR 1.59; 95% CI 1.37 to 1.84) and 88% (AOR 1.88; 95% CI 1.46 to 2.42) higher odds of having diabetes, respectively, than normal or underweight adults. Moreover, the risk of comorbidity was 2.21 times higher in overweight adults (AOR 2.21; 95% CI 1.81 to 2.71) and 2.86 times higher in obese adults (AOR 2.86; 95% CI 2.09 to 3.91) compared with normal or underweight adults.

**Conclusions** Using large-scale nationally representative data, we found that overweight and obesity were significantly associated with hypertension, diabetes and comorbidity. So, nationally representative data can be used for programme planning to prevent and treat these chronic conditions.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The main strength of the study is that it used the most recent large nationally representative survey data from Bangladesh.
- ⇒ Another strength is that this is the first study to use biomarker measurements of general adults aged 18 years or over to investigate the specific association of overweight and obesity with hypertension, diabetes and comorbidity by adjusting for other risk factors.
- ⇒ The limitations of this study include the use of a cross-sectional blood pressure and fasting plasma glucose measurement, which does not indicate a clinical diagnosis of hypertension or diabetes.
- ⇒ Since this analysis used cross-sectional data, only associations were determined; causality could not be measured.
- ⇒ Due to data limitations, some important determinants of hypertension and diabetes, such as family history, lifestyle, physical activity, dietary practice, smoking habits and the impact of urbanisation, were not included in the study.

## INTRODUCTION

The prevalence of overweight and obesity is growing at an alarming rate and is a serious threat to public health worldwide.<sup>1–4</sup> The global obesity prevalence almost doubled from 6.4% in 1980 to 12.0% in 2008, and the overweight prevalence rose from 24.6% to 34.4% during the same period.<sup>5</sup> According to an estimate of the WHO, more than 1.9 billion adults aged 18 years and older (39% of adults) were overweight in 2016, among whom more than 650 million (13% of adults) were obese.<sup>3</sup> Globally, the number of overweight and obese adults is projected to be 1.35 billion and 573 million by 2030, respectively.<sup>6</sup> Overweight

and obesity are major risk factors for developing various non-communicable diseases (NCDs), such as cardiovascular diseases (CVDs), diabetes, hypertension, musculoskeletal disorders, cancer and dyslipidaemia.<sup>3–7,14</sup> Global deaths and disability-adjusted life-years (DALYs) for both males and females have more than doubled between 1990 and 2017, according to the global burden of disease due to high body mass index (BMI).<sup>15</sup> In 2017, high BMI caused 2.4 million deaths and 70.7 million DALYs in females, and 2.3 million deaths and 77.0 million DALYs in males.<sup>15</sup>

The consequences of overweight and obesity increase the risk of NCDs, which are the leading cause of death globally. The illness burden of NCDs diseases is extremely high among low-income and middle-income countries (LMICs) and populations. In 2016, a total of 71% (41 million) of the 57 million global deaths occurred due to NCDs, while 78% of all NCDs deaths and 85% of premature deaths occurred in LMICs.<sup>16</sup> Diabetes is one of the four major NCDs responsible for an estimated 1.6 million deaths worldwide, accounting for 4% of all NCDs deaths and 3% of all global deaths in 2016.<sup>16</sup> According to the International Diabetes Federation, 463 million adults worldwide had diabetes in 2019, with the figure projected to rise to 700 million by 2045.<sup>17</sup> Diabetes cases in South-east Asian countries are also projected to rise by 74% over the next two decades.<sup>18</sup> Furthermore, high blood pressure or hypertension is the leading risk factor of CVD, which is a major cause of premature deaths and DALYs worldwide.<sup>16</sup> It increases the risk of coronary heart attack, stroke, kidney failure and visual deficiency.<sup>19,20</sup> According to the WHO, the global prevalence of hypertension is 22%, with a 25% prevalence in Southeast Asia.<sup>21</sup> An estimated 1.13 billion people had hypertension worldwide in 2019, most of whom (two-thirds) living in LMICs,<sup>21</sup> and the number is projected to rise to 1.6 billion by 2025.<sup>22</sup> Due to the nature of the NCDs, often diabetes and hypertension coexist in the adult population, putting them at a higher risk of general disability and premature death.<sup>23,24</sup> Furthermore, diabetes itself is a risk factor for developing CVDs, while the coexistence of diabetes and hypertension enhances the risk of developing CVDs, and being overweight or obese increases the risk of developing both diabetes and hypertension.<sup>25–27</sup>

Bangladesh, an LMIC in South Asia, has experienced a substantial increase in overweight and obesity prevalence over the period.<sup>28–32</sup> According to the Bangladesh Demographic and Health Survey (BDHS) 2011 report, the prevalence of overweight and obesity among ever-married women aged 15–49 years was 13.6% and 2.9%, respectively, and 9.1% of men aged 35 years and older were overweight or obese. In addition, the prevalence of hypertension among women and men aged 35 years and older was 32% and 20%, respectively, and the prevalence of diabetes mellitus among women and men aged 35 years and older was 11.2% and 11.7%, respectively.<sup>33</sup> Similarly, in BDHS 2017–2018 report, approximately 18% of men aged 18 years and older were overweight or obese, and more than 32% ever-married women aged

15–49 years were overweight or obese. Furthermore, the prevalence of hypertension among women and men aged 18 years and older was 28.4% and 26.2%, respectively, and the prevalence of diabetes mellitus among women and men aged 18 years and older was 9.5% and 10.5%, respectively.<sup>32</sup> The proportion of ever-married women of reproductive age (15–49 years) suffering from overweight and obesity increased from 3% in 1996–1997 and 12% in 2007 to 32% in 2017–2018.<sup>32</sup> The increasing prevalence of overweight and obesity in both men and women clearly indicates that Bangladesh is now experiencing a double burden of malnutrition from both overnutrition and undernutrition,<sup>34–36</sup> and a recent study found that the prevalence of overweight women of reproductive age has exceeded that of underweight women.<sup>37</sup> In addition, several studies in Bangladesh found an increasing prevalence of hypertension, with more than 20% of adults suffering from this chronic condition.<sup>38–41</sup> In 2019, there were 8.4 million adults in Bangladesh living with diabetes, with the number projected to nearly double (15.0 million) by 2045.<sup>18</sup> The proportion of deaths in Bangladesh due to NCDs increased from 43.1% in 2000 to 70.2% in 2019, according to data from the Global Health Estimates 2020.<sup>42</sup>

Previous studies in Bangladesh mainly focused on infectious disease and undernutrition since these were traditionally the country's major public health problems,<sup>43–44</sup> with little attention given to the increasing burden of overweight and obesity, as well as the chronic diseases and comorbidities that come with it.<sup>27,45</sup> Given the rapid rise in overweight and obesity at the population level in Bangladesh, assessing the specific association of overweight and obesity with NCDs by considering and adjusting other mediating factors such as age, sex, urbanicity and socioeconomic status is very important for the successful implication of public health interventions among the targeted groups of the population. Earlier studies conducted in different geographical areas show that overweight and obesity are associated with various NCDs such as hypertension, diabetes and comorbidity.<sup>7,46–48</sup> However, in the context of Bangladesh, most of the studies in the literature identified overweight or obesity as an important significant factor, along with many other factors, in the development of common NCDs.<sup>8,38,45,49–54</sup> There is no study, to the best of our knowledge, which specifically looked at the association of overweight and obesity with hypertension, diabetes and comorbidity using large-scale nationally representative samples of the general adult population aged 18 years and older in Bangladesh. Therefore, the objectives of this study were to determine the prevalence of hypertension, diabetes and comorbidity across different subgroups of the study population, as well as to find out the specific association of overweight and obesity not only with hypertension and diabetes, but also with comorbidity (the coexistence of hypertension and diabetes) by adjusting for other risk factors for hypertension and diabetes using data from a large-scale nationally representative sample of Bangladesh. Moreover, unlike the previous BDHS 2011

survey, where biomarker measurements were only available for adults aged 35 years and over, this study analysed BDHS 2017–2018 survey data, where we used a large-scale nationally representative sample of general adults aged 18 years and over to investigate the specific association of overweight and obesity with hypertension, diabetes and comorbidity. The study findings can assist health policy-makers in Bangladesh and elsewhere with similar settings in developing successful health policies and prioritising action among the targeted groups to address overweight and obesity-induced NCDs.

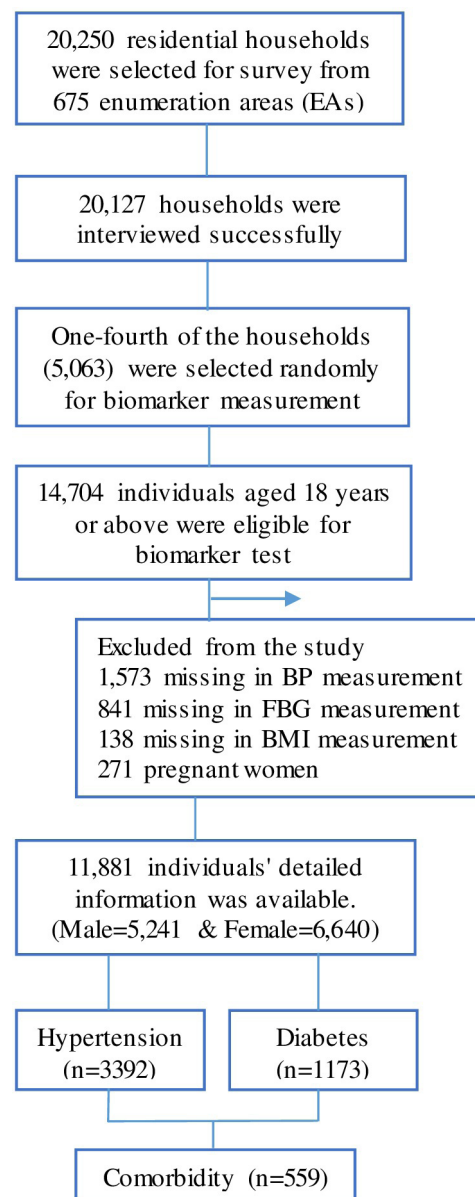
## METHODS

### Study population and data source

This study used secondary data from the most recent nationally representative BDHS 2017–2018. We obtained data from the MEASURE DHS Archive ([https://dhsprogram.com/data/dataset/Bangladesh\\_Standard-DHS\\_2017.cfm?flag=1](https://dhsprogram.com/data/dataset/Bangladesh_Standard-DHS_2017.cfm?flag=1)).<sup>55</sup> The survey was conducted between October 2017 and March 2018 under the authority of the National Institute of Population Science and Training, Medical Education and Family Welfare Division, Ministry of Health and Family Welfare.<sup>32</sup> The main objective of the survey was to analyse the health indicators and provide a comprehensive summary of population, maternal and child health problems, along with the status of several NCDs such as hypertension and diabetes among adults. This was the second nationally representative survey in Bangladesh that incorporated the measurement of biomarker information, including blood pressure and blood glucose levels. In this research, the study population was adult men and women aged 18 years and over in Bangladesh.

### Study design and sample size

The 2017–2018 BDHS used a two-stage stratified cluster sample of households.<sup>32</sup> The survey is nationally representative and includes the entire population of non-institutional residents of Bangladesh. As a sampling frame, the survey had used a database of enumeration areas (EAs) from the Population and Housing Census of the People's Republic of Bangladesh in 2011, issued by the Bangladesh Bureau of Statistics.<sup>56</sup> The survey's primary sampling unit was an EA, which contains an average of about 120 households. In the primary stage, 675 EAs (250 in urban areas and 425 in rural areas) were chosen with a probability proportional to their number. In the second stage of sampling, a systematic sample of an average of 30 households per EA was chosen to provide statistically reliable estimates of key demographic and health variables for the country as a whole, urban and rural areas separately, and for every one of the eight divisions. The survey selected 20 250 residential households according to this design. Of the selected households, 20 127 households were effectively interviewed.<sup>32</sup> To measure biomarker information, one-fourth of the 20 250 eligible households was selected as a subsample. In



**Figure 1** Study flow chart of the respondents selected from the Bangladesh Demographic and Health Survey 2017–2018 data. BMI, body mass index; BP, blood pressure; FBG, fasting blood glucose.

this subsample, both women and men aged 18 years and older were entitled to participate in the biomarker test, which involved blood pressure tests and fasting blood glucose (FBG) testing. The subsample included a total of 14 704 (6691 men and 8013 women) individuals aged 18 years and over who were eligible for the biomarker test. After excluding missing data and non-responses, the final analytic sample consists of a total of 11 881 individuals, with 5241 men and 6640 women providing detailed information. The analytic sample selection procedure is presented in figure 1. The detailed survey method, data collection process, measurement procedures and questionnaires are available in the final report of the 2017–2018 BDHS.<sup>32</sup>



### Biomarker measurements

The 2017–2018 BDHS incorporated biomarkers, including blood pressure measurement and blood glucose testing. According to the BDHS 2017–2018 report, the LIFE SOURCE UA-767 Plus BP monitor model was used to measure blood pressure.<sup>32</sup> This automated gadget had different cuffs for monitoring blood pressure in people with small, medium and large arm circumferences. Blood pressure was measured and reported during the survey by two qualified health technicians trained under the recommended protocol. During the survey, three systolic and diastolic blood pressure (SBP/DBP) readings were taken at approximately 10 min intervals. The blood pressure levels of the respondents were recorded using the average of the second and third readings.<sup>32</sup> For the measurement of blood glucose, the HemoCue 201 RT analyzer was used. After respondents had fasted overnight, capillary blood was obtained from the middle or ring finger. The first two drops were wiped away, and for measurement, the third drop was taken. Blood glucose was measured in millimoles per litre (mmol/L). In the final report of the 2017–2018 BDHS, a complete description of biomarker measurements is available.<sup>32</sup>

### Outcome variables

The outcome or dependent variables for this study were having hypertension, diabetes and comorbidity. An individual was classified as having hypertension if they had average SBP  $\geq 140$  mm Hg (millimetres of mercury) and/or DBP  $\geq 90$  mm Hg and/or currently taking antihypertensive medication during the survey. Blood pressure measurements were classified using the Seventh Report of the United States National Institutes of Health's Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7).<sup>57</sup> An individual was considered as having raised blood glucose or diabetes if they had a FBG value greater than or equal to 7.0 mmol/L at the time of the survey, or currently taking prescribed medication due to diabetes.<sup>58</sup> Comorbidity was defined as the coexistence of hypertension and diabetes.<sup>59</sup>

### Explanatory variables

The explanatory variable of main interest was overweight and obesity measured by BMI, which was defined as weight in kilograms divided by height in metre square ( $\text{kg}/\text{m}^2$ ). The 2017–2018 BDHS carries out anthropometric measurements such as height and weight for adults aged 18 years and older (one-fourth of the total households) as an indicator of nutritional status. As per the WHO guidelines adults were classified as neither overweight nor obese if BMI was  $< 25 \text{ kg}/\text{m}^2$ , overweight if BMI was  $25\text{--}29.9 \text{ kg}/\text{m}^2$  and obese if BMI was  $\geq 30 \text{ kg}/\text{m}^2$ .<sup>3</sup> Data were excluded from the study if women were currently pregnant and details of the height and/or weight of the respondents were not available.

Based on the risk factors associated with hypertension and diabetes, the following important variables

were also included in this study as explanatory variables: respondent's age, sex, marital status, education, working status, wealth index, place of residence and division of residence. Respondent's age was categorised into three groups (18–34, 35–64 and 65 and above). Sex was classified as male and female. Marital status was classified into two groups as unmarried and ever married (currently married, widowed and divorced). Respondent's education level was categorised as 'no education', 'primary education', 'secondary education' and 'higher education'. No education refers to not experiencing any formal education, primary education was defined as completing grade 5, secondary education as completing grade 10, and higher education was defined as attaining more than grade 10 or had preuniversity/university-level education. The variable working status was classified as 'yes' and 'no', 'yes' means the respondent currently working and 'no' means not currently working. The household socio-economic status was measured by the wealth index and the wealth index was calculated by the BDHS using the principal component analysis ranging from poorest to richest levels.<sup>32</sup> Place of residence was divided into urban and rural categories. In addition, the region or division of residence was classified as the eight administrative divisions of Bangladesh, namely Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur and Sylhet.

### Statistical analysis

Data were analysed using statistical software Statistical Package for the Social Sciences (SPSS) V.20. At first, the descriptive characteristics of the selected variables were calculated and presented by frequency distribution. Then, cross-tabulations (ie, bivariate) were performed to compare hypertension, diabetes and comorbidity status across covariate categories. A  $\chi^2$  test was conducted to measure the proportional differences in hypertension, diabetes and comorbidity status across all selected categorical variables. Both bivariate and multivariable logistic regression models were used to identify the significant risk factors for hypertension, diabetes and comorbidity. At the first stage, in order to determine significant risk factors, we selected potential predictor variables with higher correlations with the dependent variable (s) and then performed a bivariate logistic regression analysis. In the bivariate logistic regression analysis, an arbitrary  $p \leq 0.25$  was used as a selection criterion to include the variable in the multivariate logistic regression model to control for confounding effects of all selected variables, and the results were statistically significant at a  $p \leq 0.01$ . All variables were checked for multicollinearity and no significant multicollinearity between any variables was observed. The association of overweight and obesity with hypertension, diabetes and comorbidity was measured separately through multiple logistic regression analysis. In the multiple logistic regression analysis, we used the normal or underweight category (BMI  $< 25.0 \text{ kg}/\text{m}^2$ ) as the reference group of BMI status. The references for using the normal or underweight category (BMI  $< 25.0 \text{ kg}/\text{m}^2$ ) as

the reference group in earlier studies can be found elsewhere.<sup>60–62</sup> The results of the multivariate logistic regression analysis were presented as crude ORs and adjusted ORs (AOR) for multifactorial effects in the model with corresponding 95% CIs. To ensure actual representation of the nationwide data, appropriate sampling weights provided by the 2017–2018 BDHS were used for analysis.

### Patient involvement

No patient was involved in this study.

## RESULTS

### Background characteristics of the respondents

The frequency distribution of the basic characteristics of the study participants is presented in table 1. The study analysed data from 11 881 respondents including men and women aged 18 years and above. Among the 11 881 respondents, 44.1% were male and 55.9% were female. The majority of the respondents (46.6%) were in the 35–64 years age group, followed by 18–34 years (43.7%) age group, and nearly 10% of the respondent's age were 65 years and older. Among all participants, only 10.6% were unmarried, more than one-third (37%) were unemployed, and more than a quarter (25.5%) of the respondents had no formal education. Nearly two-thirds (64.2%) of the respondents were from rural areas, and the highest proportion (approximately 14%) of the respondents came from the Khulna division and the lowest proportion (10.4%) of data came from the Barisal division. Regarding household wealth status, the majority of the respondents (22.2%) came from the richest wealth index households. According to the BMI measurement, approximately one-fourth of the respondents (24.2%) were overweight or obese, of whom more than 20% were overweight and more than 4% were obese (table 1).

### Prevalence and distribution of hypertension, diabetes and comorbidity

Overall, the prevalence of hypertension, diabetes and comorbidity among adults was 28.5%, 9.9% and 4.7%, respectively (table 1). The prevalence of hypertension, diabetes and comorbidity across the explanatory variables and the results of the  $\chi^2$  test of association are presented in table 2. The study found that hypertension, diabetes and comorbidity vary across covariates. The findings show that the prevalence of hypertension, diabetes and comorbidity increased with age, and that age was identified as a significant factor in all the three groups. Hypertension varies significantly between males and females (26.9% vs 29.8%), but sex-specific differences in diabetes and comorbidity were not significant. Moreover, the prevalence of hypertension was significantly higher among respondents with no education compared with those with primary, secondary or higher education, even though education was not found to be significantly associated with diabetes and comorbidity. Respondents who had ever married, were currently unemployed and belonged

**Table 1** Background characteristics of the study population aged 18 and older from BDHS 2017–2018 data (N=11 881)

| Variables             | Frequency (%) |
|-----------------------|---------------|
| Age group (in years)  |               |
| 18–34                 | 5188 (43.7)   |
| 35–64                 | 5535 (46.6)   |
| 65+                   | 1158 (9.7)    |
| Sex                   |               |
| Male                  | 5241 (44.1)   |
| Female                | 6640 (55.9)   |
| Marital status        |               |
| Unmarried             | 1264 (10.6)   |
| Ever married          | 10 617 (89.4) |
| Education             |               |
| No education          | 3032 (25.5)   |
| Primary education     | 3592 (30.2)   |
| Secondary education   | 3392 (28.5)   |
| Higher education      | 1865 (15.7)   |
| Working status        |               |
| No                    | 4401 (37.0)   |
| Yes                   | 7480 (63.0)   |
| Wealth index          |               |
| Poorest               | 2314 (19.5)   |
| Poorer                | 2250 (18.9)   |
| Middle                | 2353 (19.8)   |
| Richer                | 2325 (19.6)   |
| Richest               | 2639 (22.2)   |
| Place of residence    |               |
| Urban                 | 4248 (35.8)   |
| Rural                 | 7633 (64.2)   |
| Division of residence |               |
| Barisal               | 1234 (10.4)   |
| Chittagong            | 1602 (13.5)   |
| Dhaka                 | 1540 (13.0)   |
| Khulna                | 1650 (13.9)   |
| Mymensingh            | 1347 (11.3)   |
| Rajshahi              | 1565 (13.2)   |
| Rangpur               | 1539 (13.0)   |
| Sylhet                | 1404 (11.8)   |
| Body mass index       |               |
| Normal or underweight | 9005 (75.8)   |
| Overweight            | 2386 (20.1)   |
| Obesity               | 490 (4.1)     |
| Hypertension status*  |               |
| No                    | 8489 (71.5)   |
| Yes                   | 3392 (28.5)   |

Continued

**Table 1** Continued

| Variables        | Frequency (%) |
|------------------|---------------|
| Diabetes status† |               |
| No               | 10 708 (90.1) |
| Yes              | 1173 (9.9)    |
| Comorbidity‡     |               |
| No               | 11 322 (95.3) |
| Yes              | 559 (4.7)     |

\*An individual is classified as having hypertension if s/he has an average blood pressure level of  $\geq 140$  mm Hg SBP or  $\geq 90$  mm Hg DBP, or she/he is currently taking antihypertensive medication to lower blood pressure.

†An individual is classified as having diabetes if she/he reports taking medication for diabetes or has a fasting blood glucose of  $\geq 7.0$  mmol/L.

‡Comorbidity is defined as the presence of both hypertension and diabetes.

BDHS, Bangladesh Demographic and Health Survey; DBP, diastolic blood pressure; SBP, systolic blood pressure.

to the richest wealth quintile had a higher prevalence of hypertension, diabetes and comorbidity. Respondents living in urban areas had significantly higher prevalence in all three groups, namely hypertension, diabetes and comorbidity, than those living in rural areas (hypertension: urban 30.0% vs rural 27.8%; diabetes: urban 12.2% vs rural 8.6%; comorbidity: urban 6.1% vs rural 3.9%). The highest and lowest prevalence of hypertension was found in the Barisal (32.6%) and Mymensingh (24.0%) divisions, respectively. Furthermore, the prevalence of diabetes was highest in the Dhaka division (15.3%) and lowest in the Rangpur division (6.2%), with similar results were found for comorbidity status. According to the BMI status of the participants, the prevalence of hypertension, diabetes and comorbidity was higher in the overweight group compared with the normal or underweight group, with the highest prevalence in all groups was among those who were obese (table 2). All the associated factors were statistically significant by the  $\chi^2$  test of association at a significance level of  $p < 0.01$ .

#### Association of overweight and obesity with hypertension, diabetes and comorbidity

The association of overweight and obesity with hypertension, diabetes and comorbidity among the sample population was identified using the multivariate logistic regression technique, with normal or underweight considered as the reference group. In the final analysis, the model was adjusted by the respective significant explanatory variables of hypertension, diabetes and comorbidity in the bivariate analysis. The crude and aORs for hypertension, diabetes and comorbidity are shown in table 3 and table 4, respectively. In both crude and adjusted analyses, it was found that overweight and obesity were significantly associated with hypertension, diabetes and comorbidity. According to the adjusted model (table 4),

overweight and obese adults were 2.47 (AOR 2.47; 95% CI 2.22 to 2.75) and 2.65 (AOR 2.65; 95% CI 2.16 to 3.26) times more likely to develop hypertension than normal or underweight adults, respectively. Individuals who were overweight and obese had 59% (AOR 1.59; 95% CI 1.37 to 1.84) and 88% (AOR 1.88; 95% CI 1.46 to 2.42) higher odds of having diabetes, respectively than those who were normal or underweight. The risk of comorbidity was 2.21 times higher among the individuals who were overweight (AOR 2.21; 95% CI 1.81 to 2.71) and 2.86 times more likely among the individuals who were obese (AOR 2.86; 95% CI 2.09 to 3.91) than the reference normal or underweight adults (table 4). All the associations in the crude and adjusted model were statistically significant at a level of  $p < 0.001$ .

#### DISCUSSION

This study attempted to show the current prevalence of overweight, obesity, hypertension, diabetes mellitus and comorbidity among the adult population aged 18 years and over in Bangladesh, as well as the association of overweight and obesity with hypertension, diabetes and comorbidity, using the most recent nationally representative cross-sectional BDHS 2017–2018 survey data. The BDHS 2017–2018 is the second nationally representative survey that provides biomarker measurements of individuals with high blood pressure and high FBG. Unlike the previous BDHS 2011 survey, which measured biomarkers in only a subset of adults aged 35 years and over, the BDHS 2017–2018 survey measures biomarkers in all adults aged 18 years and higher. To the best of our knowledge, this is the first study to examine the specific association of overweight and obesity with hypertension, diabetes and comorbidity using broad-scale nationally representative data from the general adult population aged 18 years and older. After analysing the data, this study found that the likelihood of having hypertension, diabetes and comorbidity significantly increased with the increased BMI of the respondents, which is consistent with other similar studies in different geographical areas.<sup>7 46–48</sup> As compared with normal or underweight people, the risk of diabetes is nearly twofold in overweight and obese adults, and the risk of hypertension and comorbidity is more than twofold in overweight and obese adults, respectively.

In this study, the prevalence of overweight and obesity among adults aged 18 years and older in Bangladesh was 20.1% and 4.1%, respectively, whereas in the BDHS 2011 survey, the prevalence of overweight and obesity among ever-married women aged 15–49 years was 13.6% and 2.9%, respectively, and 9.1% of men aged 35 years and older were overweight or obese.<sup>33</sup> The increasing prevalence of overweight and obesity among adults in Bangladesh contributes to the alarming burden of NCDs such as hypertension, diabetes and comorbidity.<sup>27 28 49 63</sup> This study also revealed that more than one in every four adults aged 18 years and older had high blood pressure or hypertension (28.5%). In comparison to this study, in

**Table 2** Prevalence of hypertension, diabetes and comorbidity by the characteristics of the study participants, BDHS 2017–2018 (N=11 881)

| Characteristics       | Hypertension (n=3392) |         | Diabetes (n=1173) |         | Comorbidity (n=559) |         |
|-----------------------|-----------------------|---------|-------------------|---------|---------------------|---------|
|                       | n (%)                 | P value | n (%)             | P value | n (%)               | P value |
| Age group             |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| 18–34                 | 686 (13.2)            |         | 277 (5.3)         |         | 66 (1.3)            |         |
| 35–64                 | 2051 (37.1)           |         | 724 (13.1)        |         | 376 (6.8)           |         |
| 65+                   | 655 (56.6)            |         | 172 (14.9)        |         | 117 (10.1)          |         |
| Sex                   |                       | 0.001   |                   | 0.95    |                     | 0.061   |
| Male                  | 1411 (26.9)           |         | 516 (9.8)         |         | 225 (4.3)           |         |
| Female                | 1981 (29.8)           |         | 657 (9.9)         |         | 334 (5.0)           |         |
| Marital status        |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| Unmarried             | 153 (12.1)            |         | 56 (4.4)          |         | 8 (0.6)             |         |
| Ever married          | 3239 (30.5)           |         | 1117 (10.5)       |         | 551 (5.2)           |         |
| Education             |                       | <0.001  |                   | 0.788   |                     | 0.862   |
| No education          | 1082 (35.7)           |         | 288 (9.5)         |         | 146 (4.8)           |         |
| Primary education     | 1022 (28.5)           |         | 354 (9.9)         |         | 162 (4.5)           |         |
| Secondary education   | 824 (24.3)            |         | 348 (10.3)        |         | 166 (4.9)           |         |
| Higher education      | 464 (24.9)            |         | 183 (9.8)         |         | 85 (4.6)            |         |
| Working status        |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| No                    | 1440 (32.7)           |         | 522 (11.9)        |         | 267 (6.1)           |         |
| Yes                   | 1952 (26.1)           |         | 651 (8.7)         |         | 292 (3.9)           |         |
| Wealth index          |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| Poorest               | 545 (23.6)            |         | 131 (5.7)         |         | 45 (1.9)            |         |
| Poorer                | 575 (25.6)            |         | 134 (6.0)         |         | 48 (2.1)            |         |
| Middle                | 654 (27.8)            |         | 189 (8.0)         |         | 87 (3.7)            |         |
| Richer                | 697 (30.0)            |         | 252 (10.8)        |         | 119 (5.1)           |         |
| Richest               | 921 (34.9)            |         | 467 (17.7)        |         | 260 (9.9)           |         |
| Place of residence    |                       | 0.011   |                   | <0.001  |                     | <0.001  |
| Urban                 | 1273 (30.0)           |         | 520 (12.2)        |         | 258 (6.1)           |         |
| Rural                 | 2119 (27.8)           |         | 653 (8.6)         |         | 301 (3.9)           |         |
| Division of residence |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| Barisal               | 402 (32.6)            |         | 126 (10.2)        |         | 58 (4.7)            |         |
| Chittagong            | 490 (30.6)            |         | 182 (11.4)        |         | 98 (6.1)            |         |
| Dhaka                 | 377 (24.5)            |         | 236 (15.3)        |         | 93 (6.0)            |         |
| Khulna                | 507 (30.7)            |         | 149 (9.0)         |         | 87 (5.3)            |         |
| Mymensingh            | 323 (24.0)            |         | 111 (8.2)         |         | 45 (3.3)            |         |
| Rajshahi              | 436 (27.9)            |         | 135 (8.6)         |         | 62 (4.0)            |         |
| Rangpur               | 487 (31.6)            |         | 95 (6.2)          |         | 50 (3.2)            |         |
| Sylhet                | 370 (26.4)            |         | 139 (9.9)         |         | 66 (4.7)            |         |
| Body mass index       |                       | <0.001  |                   | <0.001  |                     | <0.001  |
| Normal or underweight | 2138 (23.7)           |         | 709 (7.9)         |         | 281 (3.1)           |         |
| Overweight            | 1023 (42.9)           |         | 364 (15.3)        |         | 212 (8.9)           |         |
| Obesity               | 231 (47.1)            |         | 100 (20.4)        |         | 66 (13.5)           |         |

$\chi^2$  test was applied to assess the proportional significant differences within groups. Statistical significance at  $p < 0.01$ . BDHS, Bangladesh Demographic and Health Survey.



**Table 3** Association (crude) of overweight and obesity with hypertension, diabetes and comorbidity among adults in Bangladesh, BDHS 2017–2018

| BMI status               | Hypertension         | Diabetes             | Comorbidity          |
|--------------------------|----------------------|----------------------|----------------------|
|                          | COR (95% CI)         | COR (95% CI)         | COR (95% CI)         |
| Normal/underweight (ref) | 1                    | 1                    | 1                    |
| Overweight               | 2.41* (2.19 to 2.65) | 2.11* (1.84 to 2.41) | 3.02* (2.52 to 3.64) |
| Obesity                  | 2.86* (2.38 to 3.44) | 3.00* (2.38 to 3.79) | 4.83* (3.63 to 6.43) |

\*P<0.05.  
BDHS, Bangladesh Demographic and Health Survey; BMI, body mass index; COR, crude OR.

the BDHS 2011 survey, the prevalence of hypertension among women and men aged 35 years and older was 32% and 20%, respectively.<sup>33</sup> According to this study, the prevalence of hypertension was higher among overweight and obese individuals (42.9% and 47.1%, respectively) than the normal or underweight individuals, which is consistent with the previous studies in Bangladesh.<sup>27 50–52 64</sup> The prevalence of hypertension was higher among adults from the older age group (65 years and over), who were female, ever married, had no educational attainment, not employed, those residing in urban areas and those in the richer to richest wealth index, which is consistent with the findings of previous studies in Bangladesh<sup>38 51 64</sup> and reveals some similarities and differences with the studies from other developing countries.<sup>65–73</sup> In our study, we found that nearly 10% (1 in every 10) of adults aged 18 years and older had diabetes mellitus. Similar results were found in the BDHS 2011 survey, where the prevalence of diabetes mellitus among women and men aged 35 and older was 11.2% and 10.7%, respectively.<sup>33</sup> The prevalence of diabetes was higher in urban areas, among adults who were not working and among adults who had ever married, and it increased sharply as an individual's BMI, age and wealth index increased. These results are consistent with previous researches undertaken in Bangladesh<sup>53 54 74 75</sup> as well as researches from other LMICs.<sup>76–80</sup>

Although, to the best of our knowledge, this is the first study that explores the specific association of overweight and obesity with common NCDs such as hypertension, diabetes and comorbidity in Bangladesh using a nationally representative sample of general adults aged 18 years and older, previous

studies have identified overweight and obesity as significant correlates of hypertension and type 2 diabetes mellitus.<sup>45 50 51 53</sup> Moreover, this study found that approximately 5% of adults in Bangladesh had both hypertension and diabetes comorbidity, which is consistent with the results of previous studies in Bangladesh.<sup>27 45</sup> A systematic review of the published paper on hypertension and diabetes in Southeast Asian and African regions, including Bangladesh, reported that diabetes and hypertension coexist in type 2 diabetic individuals.<sup>81</sup> According to other studies, hypertension is a widespread comorbid condition in people with diabetes mellitus and vice versa, and there is significant evidence that diabetics persons have a higher prevalence of hypertension.<sup>59 82 83</sup> We found, as in previous research, that the risk of having comorbidity (coexistence of hypertension and diabetes) was greatly increased in overweight and obese adults compared with normal or underweight adults.<sup>27 45</sup>

The findings in this study indicate an increasing prevalence of adult's overweight and obesity, as well as the subsequent risk of NCDs, which is becoming a serious issue for Bangladesh's inadequate public health system. Given the increasing prevalence of overweight and obesity in the country, as well as the associated disease burden, health policy-makers must establish effective recommendations for healthy lifestyles and implement interventions among those who are already overweight and obese in order to tackle chronic diseases. In this regard, clinical diagnosis of NCD such as hypertension and diabetes is required, followed by research into the association between these diseases and overweight and obesity of the

**Table 4** Association (adjusted) of overweight and obesity with hypertension, diabetes and comorbidity among adults in Bangladesh, BDHS 2017–2018

| BMI status               | Hypertension         | Diabetes             | Comorbidity          |
|--------------------------|----------------------|----------------------|----------------------|
|                          | AOR (95% CI)         | AOR (95% CI)         | AOR (95% CI)         |
| Normal/underweight (ref) | 1                    | 1                    | 1                    |
| Overweight               | 2.47* (2.22 to 2.75) | 1.59* (1.37 to 1.84) | 2.21* (1.81 to 2.71) |
| Obesity                  | 2.65* (2.16 to 3.26) | 1.86* (1.46 to 2.42) | 2.86* (2.09 to 3.91) |

Adjusted by respective significant explanatory variables in bivariate analysis.  
\*P<0.05.  
AOR, adjusted OR; BDHS, Bangladesh Demographic and Health Survey; BMI, body mass index.



adult population in Bangladesh. Furthermore, although several studies indicate an increasing prevalence of overweight and obesity in children and adolescents,<sup>84–87</sup> more research is required to determine the association between childhood overweight and obesity and NCDs.

There are some significant strengths and shortcomings of this study. The main strengths of the study are the use of large nationally representative sample data with detailed biomarker information on hypertension and diabetes for adults aged 18 years and older. Unlike the previous study, which used partial data from women and men aged 35 years and older, this study uses full data from general adults aged 18 years and older in Bangladesh for the first time, which provides more reliable estimates of the prevalence of hypertension, diabetes and comorbidity. Furthermore, respondents' height, body weight, blood pressure and blood glucose levels were assessed using standard methods by qualified and experienced health technicians. In comparison to other cross-sectional studies in Bangladesh, the BDHS used a validated questionnaire and calibrated measuring instruments, which reduces the risk of measurement error and bias. The main limitation of the study is that, due to the use of cross-sectional data, a causal relationship between the outcome and the predictor variable of interest cannot be determined. The survey data provide a cross-sectional measure of blood pressure and fasting plasma glucose, although it does not indicate a clinical diagnosis of hypertension or diabetes. Moreover, some important factors of hypertension and diabetes, such as stress, family history, lifestyle, physical exercise, dietary practice, smoking status, salt intake and impact of urbanisation were not included in the study due to the lack of availability in the BDHS data.

## CONCLUSIONS

The findings of this study revealed that a large number of adults aged 18 years or over in Bangladesh are overweight and obese. Overweight and obesity is now a global public health issue that causes many health complications among people of all ages and, as a result, puts huge health and economic burden on a country. In Bangladesh, more than one out of every four individuals aged 18 years or older is hypertensive, and nearly 1 out of every 10 individuals has diabetes. This study also finds a significant association between overweight and obesity with hypertension, diabetes and comorbidity. This study suggests that public health initiatives aiming to reduce overweight and obesity at the population level are urgently needed for effective prevention and control of the disease burden of hypertension, diabetes and comorbidity.

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