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Diabetes among adults in Bangladesh: Changes in prevalence and risk factors from 2011 to 2018

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Complete List of Authors:	Chowdhury, Muhammad Abdul Baker; University of Florida, Emergency Medicine Islam, Mirajul; University of Dhaka, Statistics Rahman, Jakia; BRAC University, Mathematics and Natural Sciences Uddin, Md. Jamal; Shahjalal University of Science and Technology, Statistics Rabiul Haque, Md; University of Dhaka, Population Sciences
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Title

Diabetes among adults in Bangladesh: Changes in prevalence and risk factors from 2011 to 2018

Short title

Diabetes among adults in Bangladesh

Authors

Muhammad Abdul Baker Chowdhury, MPH, MPS, MS[1*]; Mirajul Islam, MS[2] Jakia Rahman, BS[3]; Md Jamal Uddin, PhD[4+]; Md Rabiul Haque, PhD[5+]

Affiliations

1. Department of Emergency Medicine, College of Medicine, University of Florida, Gainesville, FL
2. Department of Statistics, University of Dhaka, Dhaka, Bangladesh
3. Department of Mathematics and Natural Sciences, BRAC University, Dhaka, Bangladesh
4. Department of Statistics, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh
5. Department of Population Sciences, University of Dhaka, Dhaka, Bangladesh

[+]Senior authors

* Corresponding author

* Corresponding author email: mchow023@fiu.edu

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Abstract

Objective: To investigate the change in the prevalence and risk factors of diabetes among adults in Bangladesh between 2011 and 2018.

Design: The study was conducted using nationally representative two waves of the Bangladesh Demographic and Health Survey (BDHS) in 2011 and 2017-18.

Setting: Bangladesh

Participants: Adults age 18 years and older.

Primary outcome: Diabetes mellitus.

Results The prevalence of diabetes among 18-34 years old adults in 2018 was 5.35% (95% CI: 4.62, 6.20). From 2011 to 2018, the diabetes prevalence among adults aged ≥35 years increased from 10.95% to 13.75% ($p<0.001$), with the largest relative increase (90%) among obese individuals. The prevalence of diabetes remained high in 2018 for both rural (12.06%) and urban (18.95%) participants Regression analysis identified age and BMI were the key risk factors of diabetes. Overweight and obese adults experienced significantly higher diabetes risk in the overall analysis in both survey years. Other significant risk factors of diabetes were sex, marital status, education, geographic region, wealth index, and hypertension status in both survey years.

Conclusion A high prevalence of diabetes was observed and it is increasing significantly over time. We found a substantial portion of younger adults is living with diabetes. Population-level approaches are needed to improve the identification and prevention of diabetes among adults in Bangladesh.

Keywords: Diabetes, Hypertension, trends, prevalence, risk factors, Bangladesh.

Strengths and limitations of this study

- To our knowledge this is the first study to estimate the change in prevalence and risk factors among adult population in Bangladesh using nationally representative sample including the most recent one which is released in December 2020.
- Another unique aspect of this study is the investigation of correlates of diabetes among younger adults (ages 18-34 years)
- Data of these surveys relates to anthropometric and diabetes were not self-reported rather collected by the trained and experienced health workers such as nurses, midwives, health assistance using the WHO-recommended guidelines.
- The unavailability of data of some important correlates like the types of diet, intake of fast food, intake of calories, physical exercise including the nature of work, family history of diabetes, and cholesterol level of diabetes was the major limitation of these data sets.

Introduction

Diabetes mellitus or type 2 diabetes is one of the most common chronic and preventable diseases affecting 463 million individuals worldwide in 2019.(1, 2) Furthermore, according to International Diabetes Federation (IDF), about 700 million people will have diabetes by 2045, which is a 51% increase compared to 2019.(2) This preventable disease is associated with significantly higher morbidity, mortality, and a poor quality of life. It is also associated with numerous health complications such as heart disease, stroke, renal failure, and blindness.(3-5)Moreover, diabetes causes huge financial burden on the patient, healthcare system, as well as on the country which is expected to continue to grow. Global health expenditure on diabetes is estimated to reach $825 billion by 2030 and $845 billion by 2045 compared to $760 billion in 2019.(2, 6)

With more than two-thirds of people with diabetes, low- and middle-income countries have experienced a faster growth in diabetes prevalence than high-income countries.(1, 7) More specifically, the prevalence of diabetes has increased more rapidly in South East Asia than in any other regions in the world.(8) Available literature on diabetes suggests that approximately 90% to 95% of all diagnosed diabetes cases of this region are type 2 diabetes.(9, 10)Like many other countries, Bangladesh is also undergoing an epidemiological transformation, a shift from communicable to non-communicable diseases. The transition is happening due to improved socio-economic status and unplanned but rapid urban growth. From 1990 to 2014, the number of urban population increased about 2.5 times and projected to reach 112.4 million by 2050.(11) While healthy life style is less common among urban dwellers. Almost 33% of them lives in densely populated areas with poor living-environment and socio-economic conditions. They mostly have inadequate access to the basic requirements for urban life. They are subsequently

placing themselves at risk of contracting and suffering from both communicable and non-communicable diseases.(12)

Bangladesh is also experiencing a nutritional transition from a conventional food habit to a fast-food dietary practice and sedentary lifestyle which is also responsible for the emergence of non-communicable diseases including diabetes.(13) These reasons will lead Bangladesh to endure increased diabetes prevalence in the future. A systematic review of published studies between 1994 and 2013 reported that the prevalence of diabetes in Bangladesh ranged between 4.5% and 35.0%.(14) The number of diabetic patients in Bangladesh is estimated to be 13.7 million by 2045.(8)

Several studies on diabetes conducted in Bangladesh confirmed that diabetes prevalence among adults is rising steadily.(15, 16) However, most of those studies were confined to urban-rural communities or some other specific groups (e.g., slum residents), which did not consider a wide range of correlates of diabetes for the entire country. While an upward trend in the prevalence of diabetes is evident, a very few population-based studies also reported the prevalence of diabetes, which are outdated. Despite the rising literature of diabetes research in Bangladesh, no study has identified trends in the prevalence of diabetes and its related risk factors or made a comparison of its risk factors over the years.

In this study, we explored whether the overall prevalence of type 2 diabetes among adults in Bangladesh changed between 2011 and 2018 and to what extent it changed by individuals' socioeconomic and demographic characteristics. We also examined the factors that potentially contribute to the risk of diabetes among the studied population and make comparisons among

them. It is important to recognize changes in diabetes prevalence by population subgroups to ensure access to and use of available treatment required for the population living with diabetes.

Methods

Data source

We used two waves of BDHS's cross-sectional data, 2011 and 2017-18 (written as 2018 onward) to estimate the prevalence of diagnosed diabetes among the noninstitutionalized Bangladeshi population aged 18 years and older. Diabetes testing and related questionnaires were included only in the 2011 and 2018 surveys. The BDHS was designed to collect data to monitor and evaluate population health and nutritional status of the country using two-stage stratified cluster sampling from non-institutionalized households. The details of the sampling procedure and sample selection are published elsewhere.(17, 18)

The National Institute of Population Research and Training (NIPORT) Ethics Review Board approved the data collection of the Bangladesh Demographic and Health Survey (BDHS) with the requirement of documented consent from all study participants. Our study was exempt from the ethical review approval because we used publicly available de-identified data.

Outcome variable

The outcome variable for this study was the prevalence of diabetes for both survey years. Diabetes Mellitus (DM)/ type-2 status was measured by fasting blood glucose (FBG) values greater than or equal to 7.0 mmol/L or self-reported diabetes medication use during the interview.

Demographic and other covariates

Demographic, household, and community-level characteristics were included to assess the prevalence and risk factors of diabetes by survey years. Individual-level characteristics were participant's (grouped into 18-24, 25-29, 30-34, 35-44, 45-54, 55-64, 65-74, and 75+ years of age), sex, marital status (currently married, not currently married), educational level (no education, primary, secondary, higher), body mass index (BMI), and hypertension status. The BMI was calculated as weight in kilograms divided by height in meters squared. We used BMI classifications for Asian population: normal weight (18.5 to 23.0), moderate risk/ overweight (23.0 to < 27.5), high risk/obese (≥27.5).(19) Household and community characteristics were socio-economic status (wealth index), place of residence (urban, rural), and geographic region (division).

Statistical analysis

The full sample of each survey was used for descriptive analysis of individuals demographic and socioeconomic characteristics. Chi-square tests were performed to check the bivariate association between each characteristic and diabetes status. We also used independent proportion tests to know whether the prevalence of diabetes between the two surveys was changed significantly and calculated the relative changes between the survey periods. For the adjusted analysis, we performed multiple logistic regression models to identify the associated risk factors of diabetes in Bangladesh.

To make an appropriate comparison between the two homogeneous groups for study periods, adjusted odds ratios (AORs) were calculated for both 2011 and 2018 BDHS data of the study participants aged 35 years and older. Then we separately analyzed 18-34-year-old adults for the 2018 BDHS survey, to estimate the factors associated with diabetes among younger

adults. Moreover, we performed sensitivity analysis by splitting the datasets into rural and urban as well as males and females. We used $P < 0.05$ at 2-sided statistical significance for all analyses. Data management and statistical analyses were performed using Stata 15 (StataCorp, College Station, TX, USA). We considered the sample weights, primary sampling units, and Strata using the "SVY" command of Stata considering the complex nature of survey design. Comparisons by different groups were drawn using the "svysubpop" command.

Results

Sample characteristics

Biomarker measurements including blood pressure and blood glucose were collected only in 2011 and 2018 BDHS. The 2018 BDHS survey included adults ≥ 18 years representing one in four of the households selected for the survey for biomarker data whereas the 2011 BDHS collected biomarker measurements for adults aged ≥35 years only. A total of 23,541 adults were eligible for blood glucose measurements in both surveys. After exclusion of nonresponses and individuals with missing data, and pregnant women, 19,584 adults comprised the study population for both survey years. Of the total included study participants 14,376 (7,556 in 2011 and 6,820in 2018) were age 35 years or over, and the remaining 5,208 were 18-34 years representing 2018 BDHS survey. In our study, male participants were approximately 49%, and 84% of the participants were married.

Diabetes prevalence

Table 1 shows the socio-demographic characteristics of participants with age ≥35 years in Bangladesh and their diabetes prevalence in 2011 and 2018 with relative ratios. The overall prevalence of diabetes among adults ages ≥35 years increased from 10.95% in 2011 to 13.75% in

2018. The relative highest increase (38%) in diabetes prevalence was found among individuals with age 65-74 and the second-highest increase rate (36%) was found among the age group 45-54. The prevalence rate of diabetes among females increased significantly from 11.25% in 2011 to 13.81% in 2018 whereas this increment among males is not significant. The relative increase in diabetes prevalence overtime among married, currently not working individuals and rural areas were 30%, 42%, and 28%, respectively. A significant increase in diabetes prevalence was also observed among adults with no education and secondary education. The highest relative increase (54%) in diabetes prevalence was in the Dhaka region followed by 53% in the Khulna region. Diabetes prevalence among middle, richer, and the richest individuals increased significantly by 48%, 41%, and 33%, respectively. The prevalence of diabetes increased by 90% among obese individuals, this rate decreased by 9% among overweight adults. Hyperglycemia was positively and linearly associated with BMI in 2018 whereas this trend was not exactly linear in 2011 **[Figure 1].** The prevalence of diabetes among males and females increased as the BMI of those individuals increased in both periods 2011 and 2018 [**Figure 2**].

Risk factor analysis

The adjusted results from multivariable logistic regression analysis are reported in **Table 2.** The likelihood of diabetes was the highest [AOR: 2.11, 95% CI: 1.58, 2.83] among adults ages 55-64 in 2011 whereas this rate was highest [AOR: 1.67, 95% CI: 1.21, 2.30] in the age group 65-74 in 2018 compared to adults ages 35-44. There was no significant difference in the odds of having diabetes among males and females in both periods. Although marital status was highly insignificant (p-value=0.572) in 2011, this variable was found as marginally insignificant (p-value=0.057) in 2018.

The findings of the study also suggest that adults with primary, secondary, and higher education had 31%, 32%, and 87% higher odds of having diabetes, respectively than adults with no education in 2011. However, education was not a significant factor for diabetes among adults in 2018. Place of residence had no significant effect on diabetes in both periods. Compared to the Dhaka division, individuals living in Barisal and Chittagong divisions had a 43% and 44% higher likelihood of having diabetes, respectively in 2011. On the other hand, there exists no significant difference in having diabetes among adults in Barisal, Chittagong, Dhaka, Rajshahi, and Sylhet divisions in 2018. Regarding economic status, only the richest individuals had a significantly higher likelihood (96%) of diabetes in 2011 compared to the poorest individuals. However, both the richer and richest adults had more likelihood of diabetes [AOR: 1.84 and 3.09] than the poorest adults in 2018.

Higher BMI was a significant factor in both 2011 and 2018. For example, overweight and obese adults compared to normal-weight adults had 54% and 51% more likelihood of diabetes, respectively in 2011, and 22% and 44% higher likelihood of diabetes in 2018. Moreover, the odds of having diabetes among working adults in 2018 was lower [AOR: 0.80, 95% CI: (0.65, 0.99)] than non-working adults. Since there exists a strong relationship between diabetes and hypertension, individuals having hypertension had 51% and 57% more likelihoods of diabetes, respectively in 2011 and 2018 compared to individuals without hypertension.

The adjusted odds ratios of the factors with their corresponding 95% confidence intervals and p-value among adults' ages 18-34 years in 2018 are presented in **Table 3**. Individuals from age group 30-34 had 97% [AOR: 1.97, 95% CI: 1.31, 2.97] higher odds of having diabetes than individuals from age group 18-24. Adults living in Chittagong, Khulna, and Rangpur had 49%,

46%, and 62% fewer odds of diabetes, respectively compared to adults living in Dhaka. Moreover, obese individuals had a higher likelihood [AOR: 1.73, 95% CI: 1.12, 2.67] of diabetes than individuals with normal weight. Similar to the older adults (≥35 years), individuals having who were working at the time of survey had 35% lower odds of diabetes than individuals having no job, and hypertension was also found significant (p=0.002) factor for diabetes.

Subgroup analysis

Subgroup analysis of diabetes by sex and place of residence were also performed and the results of this analysis are presented in **Table S1** and **Table S2**. Male with higher education had 99% higher risk of diabetes compared to male with no education in 2011 whereas no significant difference in the risk of diabetes among them was observed in 2018. However, the odds of having diabetes between a male with primary education and no education was not significantly different [p=0.236] in 2011.The opposite scenario [AOR: 1.48 [(1.06, 2.06), p=0.022] was observed in 2018. Urban males had less likelihood [AOR: 0.71, 95% CI: 0.55, 0.93] of diabetes than rural males in 2018 whereas there was no difference in the likelihood of diabetes among them in 2011.

Marital status was found to be significant factor (p=0.043) of diabetes among rural adults in 2018 only. Richer individuals had no significant difference (p>0.05) in having diabetes compared to the poorest individuals except in rural areas in 2018 (p=0.019). Currently working individuals had 31% (AOR: 0.69, 95% CI: 0.49, 0.99) and 27% (AOR: 0.73, 95% CI: 0.57, 0.95) lower odds of having diabetes than non-working rural individuals, in 2011 and 2018, respectively. However, there was no significant difference in diabetes among working and non-working urban individuals for both periods.

Discussion

For the first time, we systematically analyses the prevalence and risk factors of diabetes among the adult population (aged 18 years) in Bangladesh using two waves of nationally representative survey data. We found some remarkable findings linked to diabetes and its risk factors. One of the important findings was the identification of upward trends in the overall prevalence of diabetes and its distribution as per individual characteristics. In 2018 the prevalence of diabetes among 18-34 years adults was 5.35%. The prevalence among adults ≥35 years has significantly increased from 10.95% in 2011 to 13.75% in 2018; with a relative increase of 26%. During this period, the prevalence of diabetes increased significantly not only among the overall population but also among each age groups, both sexes, married individuals, uneducated and secondary completed, rural areas, middle to richest wealth index group, obese individuals, unemployed, and hypertensive patients. The prevalence of diabetes had increased rapidly among obese, middle to rich income group, and in Dhaka and Khulna regions. During this period, the proportion of people with hyperglycemia also increased significantly among male, obese, and 45-74 age groups. This finding is consistent with the reported prevalence of diabetes among the adult populations over the years. (20-22)

We found that the likelihood of diabetes increased with an increase of age. The odds of having diabetes was almost two times for adults aged 30-34 years compared to the 18-24 years adults. Similar to the previous studies in Bangladesh(23, 24) and other developing countries, (25, 26) the odds of having diabetes increased consistently for all age groups of older adults (≥ 35 years) in both data sets. In the future, the upward trend of having diabetes is likely to be a major public health concern in Bangladesh as its population age-structure changes with lower fertility rate, steady socioeconomic growth, and increased life expectancy. This process will sharply lead

to an increase in the number of middle and older age population and diabetes prevalence in Bangladesh. (27) The prevalence of diabetes among the working-age population may be a concern because of the complex effects of diabetes on co-morbidity and economic growth in Bangladesh, where about 12% of total households pay for diabetic care by selling household assets or borrowing money. (28-30)

We observed a substantially higher relative increase in the prevalence of diabetes in rural areas (28%) compared to urban areas (18%), which indicates that diabetes is no longer confined to urban areas in Bangladesh and is also a matter of concern in rural areas of Bangladesh. Tripathy et al.(31) found a similar trend in our neighboring country India. Our study also identified the greater prevalence of having diabetes among married people compared to unmarried people. This finding was significant in 2018, but was not found to be significant in 2011.(27) This result was broadly consistent with previous studies in which the presence of diabetes was also associated with greater marital stability and satisfaction (23, 31, 32). Moreover, male being married was also associated with a higher risk of hypertension and type-2 diabetes (33).

Although higher education and socio-economic status are negatively associated with diabetes in developed countries, we have found the opposite results in Bangladesh for both survey periods. Richest individuals aged ≥35 years are 3.09 times to have diabetes, followed by richer and middle-income groups compared to the poorest wealth group. These findings are in line with the previous studies conducted in Asian and other developing countries (23, 34, 35). The prevalence of diabetes varies also by region among individuals ≥35 years in Bangladesh. For example, people living in Rangpur and Khulna regions have experienced a significantly lower risk of

having diabetes than those from Dhaka and other regions. The relatively lower socioeconomic status of people in these two divisions compared to Dhaka is plausibly linked with their lower odds of living with diabetes (23, 35). The rapid increase in the prevalence of diabetes in all regions, particularly in Dhaka and Khulna regions, in which it has increased 54% and 53% respectively between 2011 and 2018, is plausibly associated with the rapid growth of urbanization and its consequences on healthy lifestyles (36).

High BMI and abdominal obesity are independent risk factors of diabetes reported in most of the previous studies. (23, 28, 30) Our study findings also pointed out that adults ages ≥35 years with higher BMI have a greater likelihood of having diabetes compared to normal weight adults in both 2011 and 2018. For instance, the odds of having diabetes among overweight and obese individuals were 1.22 and 1.44 times compared to the normal weight individuals in 2018.

Another unique aspect of this study is the investigation of correlates of diabetes among younger adults (ages 18-34 years). This study reports the prevalence of diabetes among younger adults for the first time in Bangladesh. We observed 5.35% younger adults had diabetes in Bangladesh in 2018. Although the prevalence of diabetes among < 35 years adults is low; in Bangladesh, the population age structure is predominantly young, this is an alarming rate with the total number of young adults with diabetes. While the annual cost of caring for older people with diabetes may be higher than caring for younger people with diabetes, since they have longer to live with the disease, the lifetime health burden and cost may also be greater for young people. Moreover, due to change in diet habits younger population are at greater risk of obesity than in older adults resulting them into higher risk group of diabetes. Similar to the older adults, the

increasing age, higher BMI and, having hypertension were found as significant risk factors of diabetes among younger adults.

One of the major strengths of our study is the use of nationally representative cross-sectional survey data of the last two waves, including the most recent one which is released in December 2020. Data of these surveys relates to anthropometric and diabetes were not self-reported rather collected by the trained and experienced health workers such as nurses, midwives, health assistance using the WHO-recommended guidelines. Compared to other context-specific cross-sectional survey data, the measurement error and bias are likely to be less for this data sets due to the use of globally standard and valid measures in Bangladesh. To our knowledge, this study for the first time estimated the national diabetes prevalence and its risk factors among general adults of Bangladesh. Another important strength is that we compared changes in estimates of diabetes predictors between 2011 and 2018 surveys along with subgroups analyses: such as 18-34 years, by sex, and by place of residence. Despite having some strength, our study is not beyond the limitations. The unavailability of data of some important correlates like the types of diet, intake of fast food, intake of calories, physical exercise including the nature of work, family history of diabetes, and cholesterol level of diabetes was the major limitation of these data sets. Moreover, as a cross-sectional survey, blood sugar level was measured for one day only and thus we do not have follow-up and or longitudinal data on diabetes and its correlates.

The study shows that among Bangladeshi adults, there is a high prevalence of diabetes and it is escalating over time. The study also reports a significant portion of younger adults with diabetes. Age and overweight/obesity are the two most important risk factors for diabetes for all adults, irrespective of sex, residence, educational attainment and wealth index. There is evidence

of an increase in the magnitude of diabetes over time and in the younger population; indeed, as age increases the chances of developing Diabetes mellitus significantly. These findings, together with an increase in the prevalence of type 2 diabetes among Bangladeshi general adults, underscore the need for primary and secondary prevention efforts tailored to age-specific populations.

List of Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Availability of data and material: All data presented here in the manuscript is freely available at dhsprogram.com.

Prior Publication: This data has not been published previously and is not under consideration elsewhere.

Author Contribution: M.A.B. Chowdhury conceptualized the study, designed the analytic approach, managed and performed the analysis, interpreted the results, and drafted the manuscript. M. Islam: helped with the analysis, interpreted the results, and drafted the manuscript. J. Rahman, M.J. Uddin reviewed, edited and updated the manuscript and M.R.Haque reviewed, edited, and supervised the study.

Disclosures/Conflict of Interest: There are no potential conflicts (financial, professional, or personal) to disclose by any of the authors.

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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.

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 were involved the study design and questionnaire development. The results will be used by the health researchers, policy makers of the country.

Description of tables and figures

FIGURE 1: Trends in diabetes class by age group and sex

FIGURE 2: Trends in diabetes class by BMI groups and sex

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

TABLE 2. Adjusted odds ratios for factors predicting diabetes among adults 35 years and older BDHS 2011-2018

TABLE 3. Adjusted odds Ratios for factors predicting diabetes among adults 18-34 years BDHS 2017-18.

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
All adults age 35 years and older	100%	10.95 (0.0048)	13.75 (0.0056)	<0.001	1.26
Age group					
35-44	35.99	8.82 (0.0065)	11.21 (0.0078)	0.081	1.27
45-54	27.43	10.86 (0.0079)	14.82 (0.01)	0.008	1.36
55-64	18.65	14.69 (0.012)	15.78 (0.0115)	0.6286	1.07
65-74	11.26	11.60 (0.0128)	15.97 (0.016)	0.1123	1.38
75+	6.68	12.11 (0.0174)	13.43 (0.0189)	0.793	1.11
Sex					
Male	48.98	10.65 (0.0061)	13.69 (0.0072)	0.091	1.29
Female	51.02	11.25 (0.006)	13.81 (0.0072)	0.003	1.23
Marital status					
Not married	15.88	12.13 (0.0112)	12.54 (0.0111)	0.953	1.03
Married	84.12	10.73 (0.0049)	13.98 (0.006)	<0.001	1.3
Educational level					
No education	44.8	8.39 (0.0058)	10.64 (0.0072)	0.021	1.27
Primary	29.07	11.10 (0.0078)	13.59 (0.009)	0.141	1.22
Secondary	18.15	13.03 (0.0108)	17.8 (0.0121)	0.015	1.37
Higher	7.98	21.79 (0.018)	20.27 (0.0185)	0.209	0.93
Place of residence					
Urban	23.91	16.08 (0.0106)	18.95 (0.0106)	0.129	1.18
Rural	76.09	9.39 (0.0051)	12.06 (0.0065)	0.003	1.28
Geographic region					
Barisal	5.79	12.54 (0.0117)	12.09 (0.0161)	0.975	0.96
Chittagong	16.45	14.28 (0.0125)	17.33 (0.0169)	0.087	1.21
Dhaka	38.99	11.26 (0.0107)	17.32 (0.0118)	0.002	1.54
Khulna	13.45	7.30 (0.007)	11.14 (0.0114)	0.002	1.53
Rajshahi	13.15	10.73 (0.01)	11.32 (0.0134)	0.664	1.05
Rangpur	9.26	8.59 (0.0111)	7.93 (0.0097)	0.667	0.92
Sylhet	2.91	11.85 (0.011)	12.71 (0.0169)	0.998	1.07
Wealth index					
Poorest	19.91	7.28 (0.0088)	7.26 (0.0091)	0.69	1.00
Poorer	19.74	7.35 (0.0084)	7.70 (0.0085)	0.891	1.05
Middle	20.19	7.56 (0.0075)	11.17 (0.01)	0.005	1.48
Richer	19.70	11.33 (0.0098)	16.01 (0.0128)	<0.001	1.41
Richest	20.46	20.49 (0.0122)	27.18 (0.0134)	0.006	1.33
Body Mass Index					
Underweight	19.87	7.27 (0.0081)	7.79 (0.0087)	0.437	1.07
Normal weight	36.10	9.59 (0.0071)	11.21 (0.0074)	0.343	1.17
Overweight	20.14	18.57 (0.0149)	16.95 (0.0095)	0.045	0.91
Obese	23.88	11.90 (0.0078)	22.56 (0.0156)	<0.001	1.9
Currently working					

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
No	43.63	12.11 (0.0064)	17.16 (0.0089)	<0.001	1.42
Yes	56.37	9.70 (0.0061)	12.00 (0.006)	0.10	1.24
Hypertension					
No	67.45	9.06 (0.0048)	10.55 (0.0063)	0.522	1.16
Yes	32.55	16.33 (0.0105)	18.57 (0.009)	0.178	1.14

TABLE 2. Adjusted odds ratios for factors predicting diabetes among adults 35 years and older BDHS 2011-2018.

	2011 BDHS		2017-18 BDHS	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups				
35-44	Ref		Ref	
45-54	1.36 (1.07, 1.72)	0.012	1.41 (1.13, 1.76)	0.002
55-64	2.11 (1.58, 2.83)	<0.001	1.58 (1.24, 2.03)	<0.001
65-74	1.60 (1.13, 2.27)	0.008	1.67 (1.21, 2.30)	0.002
75+	1.77 (1.14, 2.74)	0.011	1.32 (0.86, 2.01)	0.202
Sex				
Male	Ref		Ref	
Female	0.78 (0.58, 1.05)	0.104	0.92 (0.75, 1.13)	0.435
Marital status				
Not married	Ref			
Married	0.93 (0.72, 1.20)	0.572	1.28 (0.99, 1.64)	0.057
Educational level				
No education	Ref		Ref	
Primary	1.31 (1.05, 1.64)	0.017	1.23 (0.99, 1.53)	0.059
Secondary	1.32 (1.01, 1.73)	0.045	1.23 (0.96, 1.57)	0.108
Higher	1.87 (1.35, 2.60)	<0.001	1.15 (0.83, 1.60)	0.397
Place of residence				
Urban	1.08 (0.87, 1.33)	0.7	0.96 (0.79, 1.16)	0.678
Rural	Ref		Ref	
Geographic region				
Barisal	1.43 (1.04, 1.96)	0.027	0.75 (0.54, 1.06)	0.103
Chittagong	1.44 (1.09, 1.89)	0.010	0.88 (0.67, 1.16)	0.369
Dhaka	Ref		Ref	
Khulna	0.66 (0.50, 0.89)	0.007	0.60 (0.46, 0.79)	<0.001
Rajshahi	1.17 (0.87, 1.57)	0.309	0.74 (0.55, 1.00)	0.054
Rangpur	1.00 (0.69, 1.45)	0.986	0.56 (0.41, 0.76)	<0.001
Sylhet	1.22 (0.91, 1.63)	0.183	0.75 (0.53, 1.06)	0.101
Wealth index				
Poorest	Ref		Ref	
Poorer	0.89 (0.62, 1.27)	0.514	0.99 (0.70, 1.40)	0.957
Middle	0.86 (0.62, 1.19)	0.365	1.33 (0.94, 1.88)	0.103
Richer	1.18 (0.84, 1.65)	0.345	1.84 (1.29, 2.61)	0.001
Richest	1.96 (1.40, 2.76)	<0.001	3.09 (2.18, 4.38)	<0.001
Body Mass Index				
Underweight	0.82 (0.61, 1.10)	0.177	0.77 (0.58, 1.01)	0.055
Normal weight	Ref		Ref	
Overweight	1.54 (1.20, 1.97)	0.001	1.22 (1.00, 1.50)	0.052
Obese	1.51 (1.16, 1.97)	0.003	1.44 (1.13, 1.84)	0.003
Currently working				
No	Ref		Ref	
Yes	0.77 (0.59, 1.01)	0.056	0.80 (0.65, 0.99)	0.039
Hypertension				
No	Ref		Ref	
Yes	1.51 (1.26, 1.81)	<0.001	1.57 (1.32, 1.87)	<0.001

TABLE 3. Adjusted odds Ratios for factors predicting diabetes among adults 18-34 years BDHS 2017-18.

Variables	OR (95% CI)	p-value
Age groups		
18-24	Ref	
25-19	1.36 (0.93, 2.00)	0.113
30-34	1.97 (1.31, 2.97)	0.001
Sex		
Male	Ref	
Female	0.88 (0.64, 1.22)	0.445
Marital status		
Not married		
Married	0.88 (0.61, 1.26)	0.473
Educational level		
No education	Ref	
Primary	1.48 (0.81, 2.69)	0.198
Secondary	1.27 (0.67, 2.41)	0.464
Higher	1.17 (0.59, 2.34)	0.654
Place of residence		
Urban	1.26 (0.9, 1.75)	0.179
Rural		
Geographic region		
Barisal	0.95 (0.58, 1.55)	0.840
Chittagong	0.51 (0.32, 0.81)	0.004
Dhaka	Ref	
Khulna	0.54 (0.35, 0.85)	0.007
Rajshahi	0.60 (0.35, 1.01)	0.053
Rangpur	0.38 (0.21, 0.68)	0.001
Sylhet	0.97 (0.57, 1.64)	0.896
Wealth index		
Poorest	Ref	
Poorer	1.02 (0.60, 1.72)	0.933
Middle	1.04 (0.63, 1.70)	0.902
Richer	1.53 (0.92, 2.53)	0.122
Richest	1.58 (0.94, 2.69)	0.088
Body Mass Index		
Underweight	1.07 (0.67, 1.70)	0.778
Normal weight	Ref	
Overweight	1.31 (0.93, 1.84)	0.128
Obese	1.73 (1.12, 2.67)	0.013
Currently working		
No	Ref	
Yes	0.65 (0.48, 0.89)	0.007
Hypertension		
No	Ref	
Yes	1.73 (1.23, 2.42)	0.002

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.56 (1.1, 2.21)	0.013	1.41 (0.98, 2.03)	0.065	1.18 (0.87, 1.62)	0.288	1.41 (1.06, 1.86)	0.018
55-64	2.36 (1.6, 3.47)	<0.001	1.58 (1.09, 2.29)	0.015	1.84 (1.15, 2.94)	0.012	1.53 (1.09, 2.14)	0.013
65-74	1.79 (1.14, 2.8)	0.011	1.80 (1.18, 2.75)	0.007	1.35 (0.76, 2.39)	0.304	1.44 (0.9, 2.33)	0.132
75+	1.52 (0.85, 2.72)	0.153	1.41 (0.79, 2.51)	0.24	1.92 (0.98, 3.76)	0.059	1.11 (0.62, 1.99)	0.727
Marital status								
Not married	Ref				Ref			
Married	0.66 (0.35, 1.26)	0.205	1.83 (0.96, 3.47)	0.064	1.00 (0.75, 1.34)	0.992	1.17 (0.89, 1.56)	0.263
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (0.88, 1.68)	0.236	1.48 (1.06, 2.06)	0.022	1.37 (1, 1.86)	0.047	1.12 (0.84, 1.48)	0.434
Secondary	1.14 (0.80, 1.63)	0.47	1.15 (0.78, 1.69)	0.482	1.53 (1.05, 2.23)	0.029	1.37 (0.97, 1.92)	0.071
Higher	1.99 (1.31, 3.01)	0.001	1.19 (0.76, 1.86)	0.449	1.85 (1.1, 3.11)	0.02	0.98 (0.59, 1.64)	0.941
Place of residence								
Urban	1.03 (0.76, 1.4)	0.838	0.71 (0.55, 0.93)	0.012	1.1 (0.83, 1.45)	0.497	1.24 (0.96, 1.61)	0.097
Rural	Ref		Ref		Ref		Ref	
Geographic region								
Barisal	1.42 (0.91, 2.22)	0.121	0.83 (0.53, 1.30)	0.415	1.44 (0.97, 2.14)	0.072	0.72 (0.46, 1.12)	0.148
Chittagong	1.55 (1.05, 2.27)	0.027	0.88 (0.62, 1.26)	0.484	1.36 (0.97, 1.91)	0.071	0.88 (0.61, 1.26)	0.48
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.75 (0.50, 1.12)	0.159	0.56 (0.39, 0.82)	0.003	0.61 (0.4, 0.92)	0.02	0.65 (0.46, 0.93)	0.019
Rajshahi	1.14 (0.73, 1.77)	0.569	0.78 (0.52, 1.2)	0.259	1.21 (0.82, 1.77)	0.338	0.71 (0.46, 1.09)	0.116
Rangpur	1.04 (0.64, 1.68)	0.885	0.60 (0.39, 0.92)	0.019	0.99 (0.63, 1.57)	0.975	0.53 (0.34, 0.82)	0.004
Sylhet	1.41 (0.92, 2.15)	0.112	0.66 (0.41, 1.07)	0.091	1.11 (0.77, 1.6)	0.58	0.82 (0.54, 1.22)	0.325
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	0.81 (0.51, 1.30)	0.389	1.20 (0.72, 2.00)	0.485	0.96 (0.58, 1.59)	0.88	0.87 (0.58, 1.32)	0.522
Middle	0.75 (0.46, 1.21)	0.239	1.90 (1.16, 3.12)	0.011	0.99 (0.63, 1.57)	0.981	1.02 (0.66, 1.57)	0.945

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Richer	0.95 (0.59, 1.51)	0.815	2.58 (1.53, 4.34)	<0.001	1.43 (0.9, 2.25)	0.129	1.44 (0.94, 2.21)	0.093
Richest	1.54 (0.94, 2.53)	0.088	5.47 (3.25, 9.19)	<0.001	2.38 (1.49, 3.79)	<0.001	2.03 (1.33, 3.09)	0.001
Body Mass Index								
Underweight	0.86 (0.6, 1.22)	0.382	0.76 (0.51, 1.13)	0.177	0.69 (0.44, 1.08)	0.101	0.78 (0.52, 1.18)	0.238
Normal weight	Ref		Ref		Ref		Ref	
Overweight	1.54 (1.13, 2.12)	0.007	1.25 (0.94, 1.66)	0.122	1.63 (1.09, 2.42)	0.016	1.15 (0.86, 1.52)	0.343
Obese	1.71 (1.1, 2.68)	0.018	1.82 (1.22, 2.69)	0.003	1.31 (0.86, 1.98)	0.207	1.29 (0.95, 1.76)	0.105
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.71 (0.48, 1.06)	0.09	0.80 (0.54, 1.17)	0.249	0.84 (0.55, 1.26)	0.394	0.79 (0.61, 1.03)	0.076
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.17 (0.88, 1.56)	0.269	1.42 (1.1, 1.83)	0.007	1.77 (1.4, 2.24)	<0.001	1.70 (1.33, 2.18)	<0.001

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.58 (1.07, 2.36)	0.023	1.19 (0.85, 1.65)	0.312	1.22 (1.66, 0.9)	0.194	1.59 (1.18, 2.13)	0.002
55-64	3.57 (2.16, 5.9)	<0.001	1.50 (0.98, 2.29)	0.059	1.60 (2.3, 1.11)	0.011	1.67 (1.24, 2.27)	0.001
65-74	2.25 (1.24, 4.1)	0.008	1.50 (0.84, 2.66)	0.168	1.32 (2.04, 0.86)	0.200	1.75 (1.19, 2.57)	0.004
75+	2.54 (1.17, 5.5)	0.018	1.89 (1.01, 3.51)	0.045	1.45 (2.45, 0.85)	0.171	1.14 (0.65, 2.01)	0.645
Sex								
Female	0.82 (0.49, 1.38)	0.461	1.29 (0.9, 1.85)	0.173	0.76 (1.11, 0.52)	0.15	0.8 (0.63, 1.03)	0.087
Male	Ref		Ref		Ref		Ref	
Marital status								
Not married	Ref				Ref			
Married	0.8 (0.52, 1.24)	0.322	1.07 (0.7, 1.62)	0.759	1.01 (1.38, 0.74)	0.962	1.39 (1.01, 1.92)	0.043
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.44 (0.96, 2.14)	0.076	1 (0.69, 1.45)	0.992	1.26 (1.64, 0.97)	0.086	1.30 (1.00, 1.69)	0.048
Secondary	1.46 (0.94, 2.27)	0.089	1.35 (0.89, 2.03)	0.155	1.22 (1.72, 0.86)	0.272	1.15 (0.83, 1.59)	0.394
Higher	1.9 (1.13, 3.19)	0.015	1.19 (0.74, 1.93)	0.465	1.85 (2.94, 1.16)	0.009	1.15 (0.74, 1.81)	0.532
Geographic region								
Barisal	0.93 (0.58, 1.49)	0.76	0.99 (0.54, 1.83)	0.982	1.63 (2.45, 1.09)	0.018	0.70 (0.46, 1.06)	0.088
Chittagong	1.04 (0.69, 1.58)	0.845	0.58 (0.4, 0.84)	0.004	1.66 (2.41, 1.15)	0.007	1.04 (0.72, 1.5)	0.841
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.82 (0.52, 1.28)	0.381	0.70 (0.5, 1.00)	0.05	0.61 (0.91, 0.4)	0.017	0.57 (0.4, 0.81)	0.002
Rajshahi	0.94 (0.60, 1.48)	0.802	0.74 (0.51, 1.06)	0.095	1.28 (1.9, 0.86)	0.228	0.75 (0.51, 1.12)	0.165
Rangpur	0.77 (0.46, 1.29)	0.318	0.5 (0.33, 0.78)	0.002	1.07 (1.71, 0.67)	0.775	0.58 (0.4, 0.84)	0.005
Sylhet	1.43 (0.89, 2.31)	0.143	0.71 (0.47, 1.09)	0.115	1.22 (1.79, 0.83)	0.318	0.77 (0.5, 1.18)	0.226
Wealth index								
Poorest	Ref		Ref		Ref		Ref	

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Poorer	1.23 (0.49, 3.07)	0.653	0.87 (0.36, 2.08)	0.754	0.87 (1.27, 0.6)	0.468	0.98 (0.67, 1.42)	0.896
Middle	1.05 (0.49, 2.24)	0.900	0.67 (0.3, 1.51)	0.335	0.84 (1.2, 0.58)	0.327	1.42 (0.97, 2.08)	0.07
Richer	0.92 (0.49, 1.72)	0.787	1.74 (0.81, 3.76)	0.155	1.27 (1.85, 0.87)	0.218	1.64 (1.08, 2.47)	0.019
Richest	1.67 (0.89, 3.11)	0.108	2.54 (1.21, 5.34)	0.014	2.05 (3.05, 1.38)	<0.001	3.05 (2.03, 4.60)	<0.001
Body Mass Index								
Underweight	0.96 (0.55, 1.68)	0.884	1.24 (0.73, 2.1)	0.422	0.77 (1.07, 0.55)	0.119	0.68 (0.49, 0.94)	0.02
Normal weight	Ref		Ref		Ref		Ref	
Overweight	2.27 (1.47, 3.5)	<0.001	0.99 (0.7, 1.41)	0.971	1.32 (1.8, 0.97)	0.077	1.36 (1.06, 1.73)	0.015
Obese	2.86 (1.88, 4.34)	<0.001	1.5 (1.04, 2.16)	0.029	1.1 (1.55, 0.78)	0.581	1.36 (0.98, 1.89)	0.068
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.91 (0.6, 1.38)	0.664	1.04 (0.73, 1.48)	0.828	0.69 (0.49, 0.99)	0.044	0.73 (0.57, 0.95)	0.02
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.52 (1.15, 2.02)	0.004	1.58 (1.18, 2.11)	0.002	1.50 (1.91, 1.18)	0.001	1.6 (1.29, 1.99)	<0.001

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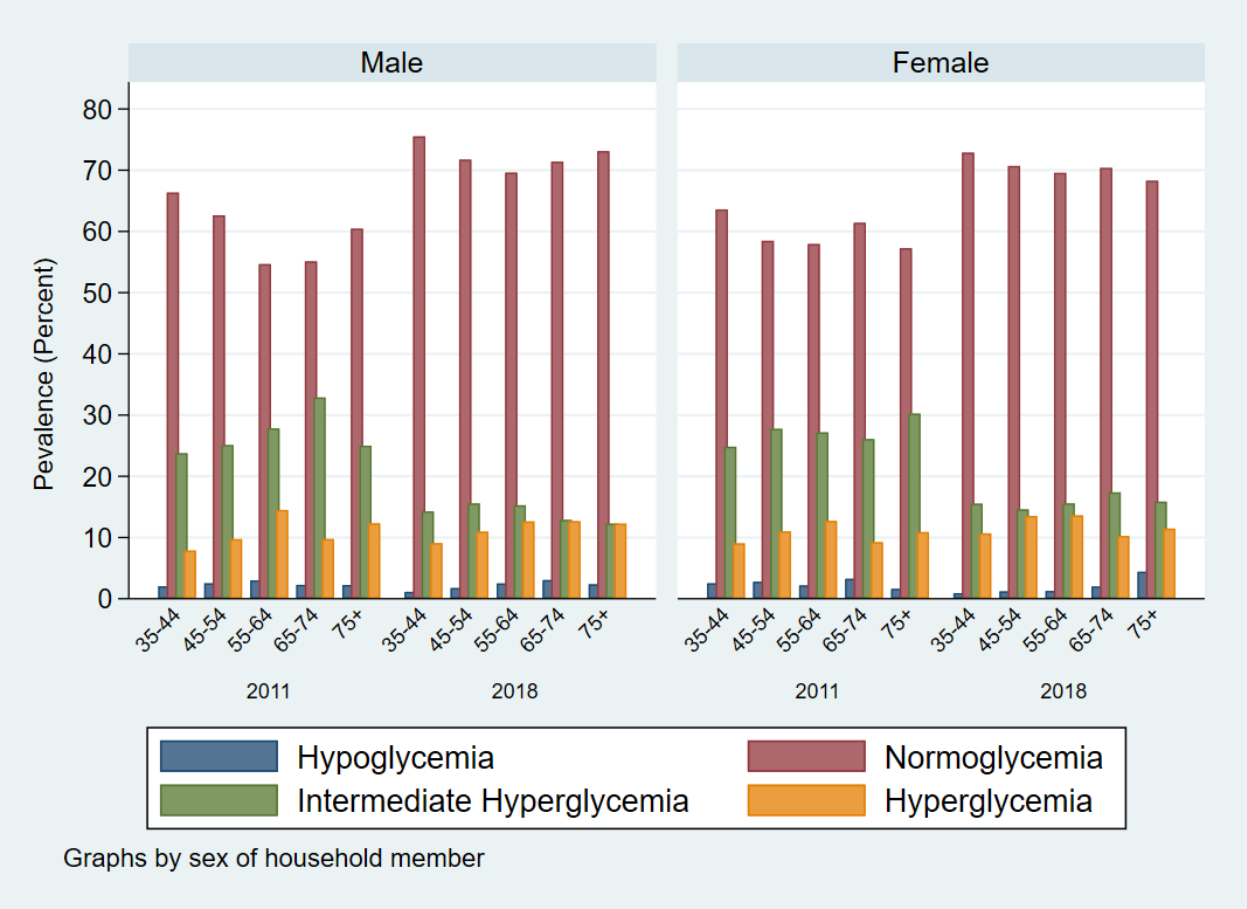

Figure 1: Trends in diabetes class by age group and sex

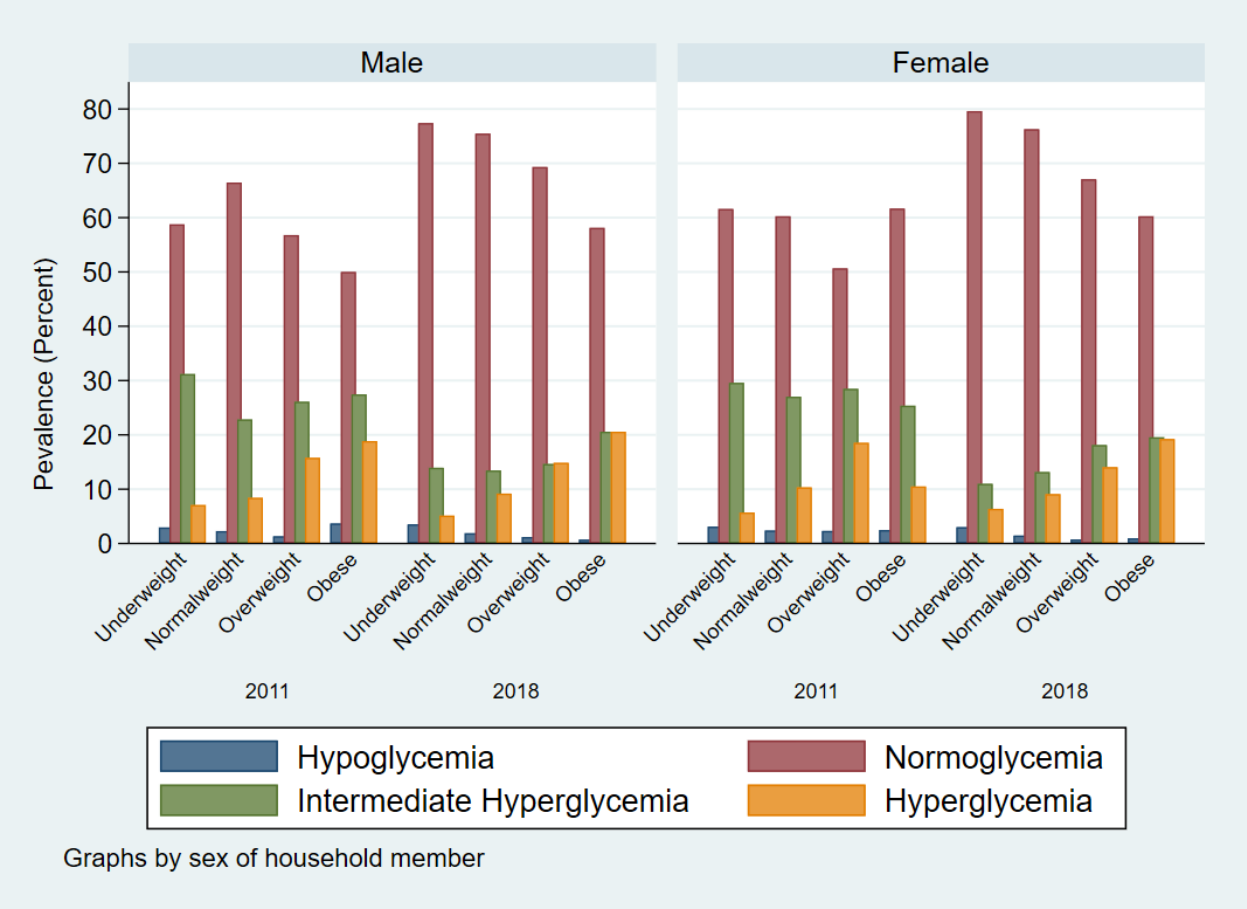

Figure 2: Trends in diabetes class by BMI groups and sex

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

		(*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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Diabetes among adults in Bangladesh: changes in prevalence and risk factors from 2011 to 2018

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Title

Diabetes among adults in Bangladesh: changes in prevalence and risk factors from 2011 to 2018

Short title

Diabetes among adults in Bangladesh

Authors

Muhammad Abdul Baker Chowdhury, MPH, MPS, MS[1*]; Mirajul Islam, MS[2,3] Jakia Rahman, BS[4]; Md Jamal Uddin, PhD[5+]; Md Rabiul Haque, PhD[6+]

Affiliations

1. Department of Neurosurgery, College of Medicine, University of Florida, Gainesville, FL
2. Statistics Department, University of Florida, Gainesville FL
3. Department of Statistics, University of Dhaka, Dhaka, Bangladesh
4. Department of Mathematics and Natural Sciences, BRAC University, Dhaka, Bangladesh
5. Department of Statistics, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh
6. Department of Population Sciences, University of Dhaka, Dhaka, Bangladesh

[+]Senior authors

* Corresponding author

* Corresponding author email: mchow023@fiu.edu

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Abstract

Objective/ Research Question: To investigate the change in the prevalence and risk factors of diabetes among adults in Bangladesh between 2011 and 2018.

Design: The study was conducted using nationally representative two waves of cross-sectional data extracted from 2011 and 2017-18 Bangladesh Demographic and Health Survey.

Setting: Bangladesh

Participants: Adults age 35 years and older.

Primary outcome: Diabetes mellitus.

Results: From 2011 to 2018, the diabetes prevalence among adults aged ≥35 years increased from 10.95% to 13.75% ($p<0.001$), with the largest relative increase (90%) among obese individuals. Multivariable logistic regression analysis identified age and BMI were the key risk factors of diabetes. Overweight and obese adults experienced significantly higher diabetes risk in the overall analysis in both survey years. Other significant risk factors of diabetes were marital status, education, geographic region, wealth index, and hypertension status in both survey years.

Conclusion A high prevalence of diabetes was observed and it is increasing significantly over time. Population-level approaches are needed to improve the identification and prevention of diabetes among adults in Bangladesh.

Keywords: *Diabetes, Hypertension, trends, prevalence, risk factors, Bangladesh.*

Strengths and limitations of this study

- We estimated the change in prevalence and risk factors of diabetes among Bangladeshi adults between 2011 and 2018.
- Data were obtained from nationally representative two cross-sectional surveys including the most recent one.
- Our study uniquely investigates the correlates of diabetes among adults
- Anthropometric and diabetes data collected using the WHO-recommended guidelines.
- Unavailability of information of some important correlates was the major data limitation.

Introduction

Diabetes mellitus or type 2 diabetes is one of the most common chronic and preventable diseases affecting 463 million individuals worldwide in 2019.[1 2] By 2045, the International Diabetes Federation (IDF) predicts 700 million people will have diabetes worldwide, a 51% increase from 2019. [2] Morbidity, mortality, and poor quality of life are associated with this preventable disease and it is also linked to heart disease, stroke, renal failure, and blindness.[3-5] Moreover, diabetes causes huge financial burden on the patient and healthcare system of the country which is expected to continue to grow. Global health expenditure on diabetes is estimated to reach $825 billion by 2030 and $845 billion by 2045 compared to $760 billion in 2019.[2 6]

With more than two-thirds of people with diabetes, low- and middle-income countries have experienced a faster growth in diabetes prevalence than high-income countries.[1 7-10] Bangladesh, like many other countries, is transitioning from communicable to non-communicable diseases due to improved socio-economic status and unplanned but rapid urbanization.[11] Bangladesh is also going through a nutritional transition from traditional eating habits to a fast-food diet and sedentary lifestyle, which is contributing to the rise of non-communicable diseases like diabetes.[12] These reasons may lead Bangladesh to endure increased diabetes prevalence in the future. A systematic review of published studies between 1994 and 2013 found that diabetes prevalence in Bangladesh ranged from 4.5 to 35.0 percent.[13] Furthermore, the number of diabetic patients in Bangladesh is estimated to be 13.7 million by 2045. [14]

Several studies on diabetes conducted in Bangladesh confirmed that diabetes prevalence among adults is rising steadily.[15 16] In Bangladesh, people being living in urban areas, being member of higher income households, higher age groups, having higher education and hypertension experienced greater prevalence of diabetes. [11 17-24] Systematic review study on

prevalence of diabetes and pre-diabetes in Bangladesh mentioned that the prevalence of diabetes was significantly higher in urban areas compared with rural areas, while there was no significant gender difference. [19]Another cross-sectional study found that longer duration of diabetes, use of insulin, and presence of diabetes complications were significantly related to the average annual cost per patient in Bangladesh. [18]People with lower socioeconomic status are less aware as well as spend less for care of diabetes. However, most of those studies were confined to urban-rural communities or some other specific groups (e.g., slum residents), which did not consider a wide range of correlates of diabetes for the entire country. While an upward trend in the prevalence of diabetes is evident, a very few population-based studies also reported the prevalence of diabetes, which are outdated. Despite the rising literature of diabetes research in Bangladesh, no study has identified trends in the prevalence of diabetes and its related risk factors or made a comparison of its risk factors over the years.

In this study, we explored whether the overall prevalence of type 2 diabetes among adults in Bangladesh changed between 2011 and 2018 and to what extent it changed by individuals' socioeconomic and demographic characteristics. We also examined the factors that potentially contribute to the risk of diabetes among the studied population and make comparisons among them. It is important to recognize changes in diabetes prevalence by population subgroups to ensure access to and use of available treatment required for the population living with diabetes.

Methods

Data source

We used two waves of Bangladesh Demographic and Health Survey (BDHS) cross-sectional data from 2011 and 2017-18 (written as 2018 onward) to estimate the prevalence of diagnosed diabetes among the noninstitutionalized Bangladeshi population aged 35 years and

older. Diabetes testing and related questionnaires were included only in the 2011 and 2018 surveys. The BDHS was designed to collect data to monitor and evaluate population health and nutritional status of the country using two-stage stratified cluster sampling from non-institutionalized households. The details of the sampling procedure and sample selection are published elsewhere.[25 26]

The National Institute of Population Research and Training (NIPORT) Ethics Review Board approved the data collection of the BDHS with the requirement of documented consent from all study participants. Our study was exempt from the ethical review approval because we used freely available de-identified data.

Biomarker measurements including blood pressure and blood glucose were collected only in 2011 and 2018 BDHS. A total of 23,541 adults were eligible for blood glucose measurements in both surveys. After exclusion of nonresponses and individuals with missing data, and pregnant women, 19,584 adults comprised the study population for both survey years. Of the total included study participants 14,376 (7,556 in 2011 and 6,820 in 2018) were age 35 years or over.

Outcome variable

The outcome variable for this study was the prevalence of diabetes for both survey years. Diabetes status was measured by fasting blood glucose (FBG) values greater than or equal to 7.0 mmol/L or self-reported use of blood glucose lowering medication during the interview.[27]

Demographic and other covariates

Demographic, household, and community-level characteristics were included to assess the prevalence and risk factors of diabetes by survey years. Individual-level characteristics were participant's (grouped into 35-44, 45-54, 55-64, 65-74, and 75+ years of age), sex, marital status (currently married, not currently married), educational level (no education, primary, secondary,

higher), body mass index (BMI), and hypertension status. The BMI was calculated as weight in kilograms divided by height in meters squared. We used BMI classifications for Asian population: underweight (<18.5) normal weight (18.5 to 23.0), moderate risk/ overweight (23.0 to < 27.5), high risk/obese (≥27.5).[28] Household and community characteristics were socio-economic status (wealth index), place of residence (urban, rural), and geographic region (division).

Statistical analysis

The full sample of each survey was used for descriptive analysis of individuals demographic and socioeconomic characteristics. Chi-square tests were performed to check the bivariate association between each characteristic and diabetes status. We also used independent proportion tests to know whether the prevalence of diabetes between the two surveys was changed significantly and calculated the relative changes between the survey periods. For the adjusted analysis in each survey years, we performed multivariable logistic regression models using the to identify the associated risk factors of diabetes in Bangladesh by entering the variables that were significantly associated with the outcome in the univariate logistic regression analysis. Before entering the models, tests for multi-collinearity between explanatory variables were performed. To select the best model, we checked the values of -2LogLikelihood ratio test, AIC, and the area under the receiver operating characteristic (ROC) curve. The best model had lower values of -2Log Likelihood ratio test and lower AIC value.

To make an appropriate comparison between the two homogeneous groups for study periods, adjusted odds ratios (AORs) were calculated for both 2011 and 2018 BDHS data of the study participants aged 35 years and older. Moreover, we performed sensitivity analysis by

splitting the datasets into rural and urban as well as males and females. We used $P < 0.05$ at 2-sided statistical significance for all analyses. Data management and statistical analyses were performed using Stata 15 (StataCorp, College Station, TX, USA). We considered the sample weights, primary sampling units, and Strata using the "SVY" command of Stata considering the complex nature of survey design. Comparisons by different groups were drawn using the "svysubpop" command.

Results

Diabetes prevalence

Table 1 shows the socio-demographic characteristics of participants with age ≥35 years in Bangladesh and their diabetes prevalence in 2011 and 2018 with relative ratios. The overall prevalence of diabetes among adults ages ≥35 years increased from 10.95% in 2011 to 13.75% in 2018. The relative highest increase (38%) in diabetes prevalence was found among individuals with age 65-74 and the second-highest increase rate (36%) was found among the age group 45-54. The prevalence rate of diabetes among females increased significantly from 11.25% in 2011 to 13.81% in 2018 whereas this increment among males is not significant. The relative increase in diabetes prevalence overtime among married, currently not working individuals and rural areas were 30%, 42%, and 28%, respectively. A significant increase in diabetes prevalence was also observed among adults with no education and secondary education. The highest relative increase (54%) in diabetes prevalence was in the Dhaka region followed by 53% in the Khulna region. Diabetes prevalence among middle, richer, and the richest individuals increased significantly by 48%, 41%, and 33%, respectively. The prevalence of diabetes increased by 90% among obese individuals, this rate decreased by 9% among overweight adults.

Risk factor analysis

The adjusted results from multivariable logistic regression analysis are reported in **Table 2.** The likelihood of diabetes was the highest [AOR: 2.11, 95% CI: 1.58, 2.83] among adults ages 55-64 in 2011 whereas this rate was highest [AOR: 1.67, 95% CI: 1.21, 2.30] in the age group 65-74 in 2018 compared to adults ages 35-44. There was no significant difference in the odds of having diabetes among males and females in both periods. Although marital status was highly insignificant (p-value=0.572) in 2011, this variable was found as marginally insignificant (p-value=0.057) in 2018.

The findings of the study also suggest that adults with primary, secondary, and higher education had 31%, 32%, and 87% higher odds of having diabetes, respectively than adults with no education in 2011. However, education was not a significant factor for diabetes among adults in 2018. Place of residence had no significant effect on diabetes in both periods. Compared to the Dhaka division, individuals living in Barisal and Chittagong divisions had a 43% and 44% higher likelihood of having diabetes, respectively in 2011. On the other hand, there exists no significant difference in having diabetes among adults in Barisal, Chittagong, Dhaka, Rajshahi, and Sylhet divisions in 2018. Regarding economic status, only the richest individuals had a significantly higher likelihood (96%) of diabetes in 2011 compared to the poorest individuals. However, both the richer and richest adults had more likelihood of diabetes [AOR: 1.84 and 3.09] than the poorest adults in 2018.

Higher BMI was a significant factor in both 2011 and 2018. For example, overweight and obese adults compared to normal-weight adults had 54% and 51% more likelihood of diabetes, respectively in 2011, and 22% and 44% higher likelihood of diabetes in 2018. Moreover, the

odds of having diabetes among working adults in 2018 was lower [AOR: 0.80, 95% CI: (0.65, 0.99)] than non-working adults. Since there exists a strong relationship between diabetes and hypertension, individuals having hypertension had 51% and 57% more likelihoods of diabetes, respectively in 2011 and 2018 compared to individuals without hypertension.

Subgroup analysis

Subgroup analysis of diabetes by sex and place of residence were also performed and the results of this analysis are presented in **Table S1** and **Table S2**. Male with higher education had 99% higher risk of diabetes compared to male with no education in 2011 whereas no significant difference in the risk of diabetes among them was observed in 2018. However, the odds of having diabetes between a male with primary education and no education was not significantly different [p=0.236] in 2011.The opposite scenario [AOR: 1.48 [(1.06, 2.06), p=0.022] was observed in 2018. Urban males had less likelihood [AOR: 0.71, 95% CI: 0.55, 0.93] of diabetes than rural males in 2018 whereas there was no difference in the likelihood of diabetes among them in 2011.

Marital status was found to be significant factor (p=0.043) of diabetes among rural adults in 2018 only. Richer individuals had no significant difference (p>0.05) in having diabetes compared to the poorest individuals except in rural areas in 2018 (p=0.019). Currently working individuals had 31% (AOR: 0.69, 95% CI: 0.49, 0.99) and 27% (AOR: 0.73, 95% CI: 0.57, 0.95) lower odds of having diabetes than non-working rural individuals, in 2011 and 2018, respectively. However, there was no significant difference in diabetes among working and non-working urban individuals for both periods.

Discussion

We systematically analyze the prevalence and risk factors of diabetes among the adult population (aged ≥35 years) in Bangladesh using two waves of nationally representative survey data (2011 and 2018). The purpose of this study was to compare the prevalence of diabetes among people aged >35 years in 2018 with 2011 in Bangladesh. To fulfill the purpose, we analyzed two nationally representative survey data and found several remarkable findings linked to diabetes and its risk factors. One of the important findings was the identification of upward trends in the overall prevalence of diabetes and its distribution as per individual characteristics. The prevalence of diabetes among adults ≥35 years has significantly increased from 2011 to 2018; with a relative increase of 26%. During this period, the prevalence increased significantly not only among the overall population but also among different age groups, both sexes, married individuals, uneducated and secondary completed, rural areas, middle to richest wealth index group, obese individuals, unemployed, and hypertensive patients. This finding is consistent with the reported prevalence of diabetes among the adult populations over the years. [29-31]

We found that the likelihood of diabetes increased with an increase of age. The odds of having diabetes was higher for older age individuals compared to the younger adults. Similar to the previous studies in Bangladesh [32 33] and other developing countries, [34 35] the odds of having diabetes increased consistently for all age groups of older adults (≥ 35 years) in both data sets. In the future, the upward trend of having diabetes is likely to be a major public health concern in Bangladesh owing to changes in population age-structure with lower fertility rate, steady socioeconomic growth, and increased life expectancy. This process will sharply lead to an increase in the number of middle and older age population and diabetes prevalence in Bangladesh. [36] The prevalence of diabetes among the working-age population may be a concern because of the complex effects of diabetes on co-morbidity and economic growth in Bangladesh,

where about 12% of total households pay for diabetic care by selling household assets or borrowing money. [37-39]

We found a significantly higher relative increase in diabetes prevalence in rural areas compared to urban areas, indicating that diabetes is no longer confined to urban areas in Bangladesh because, in recent years, rural residents have adopted an unhealthy lifestyle, consuming fast food with more carbs. Moreover, they are also less aware of the disease and seek medical attention at a later stage. Hira et al found a similar results in a study conducted in Bangladesh [40] and Tripathy et al.[41] found a similar trend in our neighboring country India.

Our study also identified the greater prevalence of having diabetes among married people compared to unmarried people. This finding was significant in 2018, but was not found to be significant in 2011.[36] This result was broadly consistent with previous studies in which the presence of diabetes was also associated with greater marital stability and satisfaction [32 41 42]. Furthermore, this could be a proxy for age because married people are older than unmarried people, and married women who have children sometimes develop diabetes at a younger age [43] Moreover, male being married was also associated with a higher risk of hypertension and type-2 diabetes. [44]

Although higher education and socio-economic status are negatively associated with diabetes in developed countries, we have found the opposite results in Bangladesh for both survey periods. Richest individuals aged ≥35 years are three times to have diabetes, followed by richer and middle-income groups compared to the poorest wealth group. These findings are in line with the previous studies conducted in Asian and other developing countries. [32 45 46] The greater likelihoods of diabetes among people with no education and secondary education are likely to be associated with their less awareness about lifestyle. The prevalence of diabetes varies also by region among individuals in Bangladesh. For example, people living in Rangpur and Khulna regions

have experienced a significantly lower risk of having diabetes than those from Dhaka and other regions. The relatively lower socioeconomic status of people in these two divisions compared to Dhaka is plausibly linked with their lower odds of living with diabetes. [32 46] The rapid increase in the prevalence of diabetes in all regions, particularly in Dhaka and Khulna regions, in which it has increased 54% and 53% respectively between 2011 and 2018, is plausibly associated with the rapid growth of urbanization and its consequences on healthy lifestyles. [47] High BMI and hypertension are important factors of diabetes reported in most of the previous studies. [11 32 37 39] Our study findings also pointed out that with higher BMI have a greater likelihood of having diabetes compared to normal weight adults in both 2011 and 2018. [48-52]

One of the major strengths of our study is the use of nationally representative cross-sectional survey data of the two waves, including the most recent one which is released in December 2020. Data of these surveys relates to anthropometric and diabetes were not self-reported rather collected by the trained and experienced health workers such as nurses, midwives, health assistance using the WHO-recommended guidelines. To our knowledge, this study for the first time estimated the national diabetes prevalence and its risk factors among adults of Bangladesh. Another important strength is that we compared changes in estimates of diabetes predictors between 2011 and 2018 surveys along with subgroups analyses, by sex, and by place of residence. Despite having some strength, our study is not beyond the limitations. Due to lack of diabetes data for younger adults (<35 years) in previous surveys, we could not compare their current diabetes prevalence. Moreover, the unavailability of data of some important correlates like the types of diet, intake of fast food, intake of calories, physical exercise including the nature of work, family history of diabetes, and cholesterol level of diabetes was the major limitation of these data sets. As a cross-sectional survey, blood sugar level was measured for one day only and thus we do not have follow-up and or longitudinal data on diabetes and its

correlates. Due to the nature of survey data, this study identified the risk factors of diabetes only rather than causality.

The study shows that among Bangladeshi adults, there is a high prevalence of diabetes and it is escalating over time. The study also reports a significant portion of younger adults with diabetes. Age and overweight/obesity are the two most important risk factors for diabetes for all adults, irrespective of sex, residence, educational attainment and wealth index. There is evidence of an increase in the magnitude of diabetes over time and in the younger population; indeed, as age increases the chances of developing Diabetes mellitus significantly. These findings, together with an increase in the prevalence of type 2 diabetes among Bangladeshi adults, underscore the need for primary (awareness campaign about the adversity of fast food habit and impotence of physical mobility/work/exercise) and secondary (incorporate the issue text on the causes and consequences of diabetes and NCDs in school level curriculum) prevention efforts tailored to age-specific populations.

List of Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Availability of data and material: All data presented here in the manuscript is freely available at dhsprogram.com.

Prior Publication: This data has not been published previously and is not under consideration elsewhere.

Author Contribution: M.A.B. Chowdhury conceptualized the study, designed the analytic approach, managed and performed the analysis, interpreted the results, and drafted the

manuscript. M. Islam: helped with the analysis, interpreted the results, and drafted the manuscript. J. Rahman, M.J. Uddin reviewed, edited and updated the manuscript and M.R.Haque reviewed, edited, and supervised the study.

Disclosures/Conflict of Interest: There are no potential conflicts (financial, professional, or personal) to disclose by any of the authors.

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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.

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 were involved the study design and questionnaire development. The results will be used by the health researchers, policy makers of the country.

Description of tables

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

TABLE 2. Adjusted odds ratios for factors predicting diabetes among adults 35 years and older BDHS 2011-2018

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
All adults age 35 years and older	100%	10.95 (0.0048)	13.75 (0.0056)	<0.001	1.26
Age group					
35-44	35.99	8.82 (0.0065)	11.21 (0.0078)	0.081	1.27
45-54	27.43	10.86 (0.0079)	14.82 (0.01)	0.008	1.36
55-64	18.65	14.69 (0.012)	15.78 (0.0115)	0.6286	1.07
65-74	11.26	11.60 (0.0128)	15.97 (0.016)	0.1123	1.38
75+	6.68	12.11 (0.0174)	13.43 (0.0189)	0.793	1.11
Sex					
Male	48.98	10.65 (0.0061)	13.69 (0.0072)	0.091	1.29
Female	51.02	11.25 (0.006)	13.81 (0.0072)	0.003	1.23
Marital status					
Not married	15.88	12.13 (0.0112)	12.54 (0.0111)	0.953	1.03
Married	84.12	10.73 (0.0049)	13.98 (0.006)	<0.001	1.3
Educational level					
No education	44.8	8.39 (0.0058)	10.64 (0.0072)	0.021	1.27
Primary	29.07	11.10 (0.0078)	13.59 (0.009)	0.141	1.22
Secondary	18.15	13.03 (0.0108)	17.8 (0.0121)	0.015	1.37
Higher	7.98	21.79 (0.018)	20.27 (0.0185)	0.209	0.93
Place of residence					
Urban	23.91	16.08 (0.0106)	18.95 (0.0106)	0.129	1.18
Rural	76.09	9.39 (0.0051)	12.06 (0.0065)	0.003	1.28
Geographic region					
Barisal	5.79	12.54 (0.0117)	12.09 (0.0161)	0.975	0.96
Chittagong	16.45	14.28 (0.0125)	17.33 (0.0169)	0.087	1.21
Dhaka	38.99	11.26 (0.0107)	17.32 (0.0118)	0.002	1.54
Khulna	13.45	7.30 (0.007)	11.14 (0.0114)	0.002	1.53
Rajshahi	13.15	10.73 (0.01)	11.32 (0.0134)	0.664	1.05
Rangpur	9.26	8.59 (0.0111)	7.93 (0.0097)	0.667	0.92
Sylhet	2.91	11.85 (0.011)	12.71 (0.0169)	0.998	1.07
Wealth index					
Poorest	19.91	7.28 (0.0088)	7.26 (0.0091)	0.69	1.00
Poorer	19.74	7.35 (0.0084)	7.70 (0.0085)	0.891	1.05
Middle	20.19	7.56 (0.0075)	11.17 (0.01)	0.005	1.48
Richer	19.70	11.33 (0.0098)	16.01 (0.0128)	<0.001	1.41
Richest	20.46	20.49 (0.0122)	27.18 (0.0134)	0.006	1.33
Body Mass Index					
Underweight	19.87	7.27 (0.0081)	7.79 (0.0087)	0.437	1.07
Normal weight	36.10	9.59 (0.0071)	11.21 (0.0074)	0.343	1.17
Overweight	20.14	18.57 (0.0149)	16.95 (0.0095)	0.045	0.91
Obese	23.88	11.90 (0.0078)	22.56 (0.0156)	<0.001	1.9
Currently working					

TABLE 1. Sociodemographic characteristics of adults age 35 years and older and diabetes rate in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
No	43.63	12.11 (0.0064)	17.16 (0.0089)	<0.001	1.42
Yes	56.37	9.70 (0.0061)	12.00 (0.006)	0.10	1.24
Hypertension					
No	67.45	9.06 (0.0048)	10.55 (0.0063)	0.522	1.16
Yes	32.55	16.33 (0.0105)	18.57 (0.009)	0.178	1.14

TABLE 2. Adjusted odds ratios for factors predicting diabetes among adults 35 years and older BDHS 2011-2018.

	2011 BDHS		2017-18 BDHS	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups				
35-44	Ref		Ref	
45-54	1.36 (1.07, 1.72)	0.012	1.41 (1.13, 1.76)	0.002
55-64	2.11 (1.58, 2.83)	<0.001	1.58 (1.24, 2.03)	<0.001
65-74	1.60 (1.13, 2.27)	0.008	1.67 (1.21, 2.30)	0.002
75+	1.77 (1.14, 2.74)	0.011	1.32 (0.86, 2.01)	0.202
Sex				
Male	Ref		Ref	
Female	0.78 (0.58, 1.05)	0.104	0.92 (0.75, 1.13)	0.435
Marital status				
Not married	Ref			
Married	0.93 (0.72, 1.20)	0.572	1.28 (0.99, 1.64)	0.057
Educational level				
No education	Ref		Ref	
Primary	1.31 (1.05, 1.64)	0.017	1.23 (0.99, 1.53)	0.059
Secondary	1.32 (1.01, 1.73)	0.045	1.23 (0.96, 1.57)	0.108
Higher	1.87 (1.35, 2.60)	<0.001	1.15 (0.83, 1.60)	0.397
Place of residence				
Urban	1.08 (0.87, 1.33)	0.7	0.96 (0.79, 1.16)	0.678
Rural	Ref		Ref	
Geographic region				
Barisal	1.43 (1.04, 1.96)	0.027	0.75 (0.54, 1.06)	0.103
Chittagong	1.44 (1.09, 1.89)	0.010	0.88 (0.67, 1.16)	0.369
Dhaka	Ref		Ref	
Khulna	0.66 (0.50, 0.89)	0.007	0.60 (0.46, 0.79)	<0.001
Rajshahi	1.17 (0.87, 1.57)	0.309	0.74 (0.55, 1.00)	0.054
Rangpur	1.00 (0.69, 1.45)	0.986	0.56 (0.41, 0.76)	<0.001
Sylhet	1.22 (0.91, 1.63)	0.183	0.75 (0.53, 1.06)	0.101
Wealth index				
Poorest	Ref		Ref	
Poorer	0.89 (0.62, 1.27)	0.514	0.99 (0.70, 1.40)	0.957
Middle	0.86 (0.62, 1.19)	0.365	1.33 (0.94, 1.88)	0.103
Richer	1.18 (0.84, 1.65)	0.345	1.84 (1.29, 2.61)	0.001
Richest	1.96 (1.40, 2.76)	<0.001	3.09 (2.18, 4.38)	<0.001
Body Mass Index				
Underweight	0.82 (0.61, 1.10)	0.177	0.77 (0.58, 1.01)	0.055
Normal weight	Ref		Ref	
Overweight	1.54 (1.20, 1.97)	0.001	1.22 (1.00, 1.50)	0.052
Obese	1.51 (1.16, 1.97)	0.003	1.44 (1.13, 1.84)	0.003
Currently working				
No	Ref		Ref	
Yes	0.77 (0.59, 1.01)	0.056	0.80 (0.65, 0.99)	0.039
Hypertension				
No	Ref		Ref	
Yes	1.51 (1.26, 1.81)	<0.001	1.57 (1.32, 1.87)	<0.001

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TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.56 (1.1, 2.21)	0.013	1.41 (0.98, 2.03)	0.065	1.18 (0.87, 1.62)	0.288	1.41 (1.06, 1.86)	0.018
55-64	2.36 (1.6, 3.47)	<0.001	1.58 (1.09, 2.29)	0.015	1.84 (1.15, 2.94)	0.012	1.53 (1.09, 2.14)	0.013
65-74	1.79 (1.14, 2.8)	0.011	1.80 (1.18, 2.75)	0.007	1.35 (0.76, 2.39)	0.304	1.44 (0.9, 2.33)	0.132
75+	1.52 (0.85, 2.72)	0.153	1.41 (0.79, 2.51)	0.24	1.92 (0.98, 3.76)	0.059	1.11 (0.62, 1.99)	0.727
Marital status								
Not married	Ref				Ref			
Married	0.66 (0.35, 1.26)	0.205	1.83 (0.96, 3.47)	0.064	1.00 (0.75, 1.34)	0.992	1.17 (0.89, 1.56)	0.263
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (0.88, 1.68)	0.236	1.48 (1.06, 2.06)	0.022	1.37 (1, 1.86)	0.047	1.12 (0.84, 1.48)	0.434
Secondary	1.14 (0.80, 1.63)	0.47	1.15 (0.78, 1.69)	0.482	1.53 (1.05, 2.23)	0.029	1.37 (0.97, 1.92)	0.071
Higher	1.99 (1.31, 3.01)	0.001	1.19 (0.76, 1.86)	0.449	1.85 (1.1, 3.11)	0.02	0.98 (0.59, 1.64)	0.941
Place of residence								
Urban	1.03 (0.76, 1.4)	0.838	0.71 (0.55, 0.93)	0.012	1.1 (0.83, 1.45)	0.497	1.24 (0.96, 1.61)	0.097
Rural	Ref		Ref		Ref		Ref	
Geographic region								
Barisal	1.42 (0.91, 2.22)	0.121	0.83 (0.53, 1.30)	0.415	1.44 (0.97, 2.14)	0.072	0.72 (0.46, 1.12)	0.148
Chittagong	1.55 (1.05, 2.27)	0.027	0.88 (0.62, 1.26)	0.484	1.36 (0.97, 1.91)	0.071	0.88 (0.61, 1.26)	0.48
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.75 (0.50, 1.12)	0.159	0.56 (0.39, 0.82)	0.003	0.61 (0.4, 0.92)	0.02	0.65 (0.46, 0.93)	0.019
Rajshahi	1.14 (0.73, 1.77)	0.569	0.78 (0.52, 1.2)	0.259	1.21 (0.82, 1.77)	0.338	0.71 (0.46, 1.09)	0.116
Rangpur	1.04 (0.64, 1.68)	0.885	0.60 (0.39, 0.92)	0.019	0.99 (0.63, 1.57)	0.975	0.53 (0.34, 0.82)	0.004
Sylhet	1.41 (0.92, 2.15)	0.112	0.66 (0.41, 1.07)	0.091	1.11 (0.77, 1.6)	0.58	0.82 (0.54, 1.22)	0.325
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	0.81 (0.51, 1.30)	0.389	1.20 (0.72, 2.00)	0.485	0.96 (0.58, 1.59)	0.88	0.87 (0.58, 1.32)	0.522
Middle	0.75 (0.46, 1.21)	0.239	1.90 (1.16, 3.12)	0.011	0.99 (0.63, 1.57)	0.981	1.02 (0.66, 1.57)	0.945

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Richer	0.95 (0.59, 1.51)	0.815	2.58 (1.53, 4.34)	<0.001	1.43 (0.9, 2.25)	0.129	1.44 (0.94, 2.21)	0.093
Richest	1.54 (0.94, 2.53)	0.088	5.47 (3.25, 9.19)	<0.001	2.38 (1.49, 3.79)	<0.001	2.03 (1.33, 3.09)	0.001
Body Mass Index								
Underweight	0.86 (0.6, 1.22)	0.382	0.76 (0.51, 1.13)	0.177	0.69 (0.44, 1.08)	0.101	0.78 (0.52, 1.18)	0.238
Normal weight	Ref		Ref		Ref		Ref	
Overweight	1.54 (1.13, 2.12)	0.007	1.25 (0.94, 1.66)	0.122	1.63 (1.09, 2.42)	0.016	1.15 (0.86, 1.52)	0.343
Obese	1.71 (1.1, 2.68)	0.018	1.82 (1.22, 2.69)	0.003	1.31 (0.86, 1.98)	0.207	1.29 (0.95, 1.76)	0.105
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.71 (0.48, 1.06)	0.09	0.80 (0.54, 1.17)	0.249	0.84 (0.55, 1.26)	0.394	0.79 (0.61, 1.03)	0.076
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.17 (0.88, 1.56)	0.269	1.42 (1.1, 1.83)	0.007	1.77 (1.4, 2.24)	<0.001	1.70 (1.33, 2.18)	<0.001

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.58 (1.07, 2.36)	0.023	1.19 (0.85, 1.65)	0.312	1.22 (1.66, 0.9)	0.194	1.59 (1.18, 2.13)	0.002
55-64	3.57 (2.16, 5.9)	<0.001	1.50 (0.98, 2.29)	0.059	1.60 (2.3, 1.11)	0.011	1.67 (1.24, 2.27)	0.001
65-74	2.25 (1.24, 4.1)	0.008	1.50 (0.84, 2.66)	0.168	1.32 (2.04, 0.86)	0.200	1.75 (1.19, 2.57)	0.004
75+	2.54 (1.17, 5.5)	0.018	1.89 (1.01, 3.51)	0.045	1.45 (2.45, 0.85)	0.171	1.14 (0.65, 2.01)	0.645
Sex								
Female	0.82 (0.49, 1.38)	0.461	1.29 (0.9, 1.85)	0.173	0.76 (1.11, 0.52)	0.15	0.8 (0.63, 1.03)	0.087
Male	Ref		Ref		Ref		Ref	
Marital status								
Not married	Ref				Ref			
Married	0.8 (0.52, 1.24)	0.322	1.07 (0.7, 1.62)	0.759	1.01 (1.38, 0.74)	0.962	1.39 (1.01, 1.92)	0.043
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.44 (0.96, 2.14)	0.076	1 (0.69, 1.45)	0.992	1.26 (1.64, 0.97)	0.086	1.30 (1.00, 1.69)	0.048
Secondary	1.46 (0.94, 2.27)	0.089	1.35 (0.89, 2.03)	0.155	1.22 (1.72, 0.86)	0.272	1.15 (0.83, 1.59)	0.394
Higher	1.9 (1.13, 3.19)	0.015	1.19 (0.74, 1.93)	0.465	1.85 (2.94, 1.16)	0.009	1.15 (0.74, 1.81)	0.532
Geographic region								
Barisal	0.93 (0.58, 1.49)	0.76	0.99 (0.54, 1.83)	0.982	1.63 (2.45, 1.09)	0.018	0.70 (0.46, 1.06)	0.088
Chittagong	1.04 (0.69, 1.58)	0.845	0.58 (0.4, 0.84)	0.004	1.66 (2.41, 1.15)	0.007	1.04 (0.72, 1.5)	0.841
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.82 (0.52, 1.28)	0.381	0.70 (0.5, 1.00)	0.05	0.61 (0.91, 0.4)	0.017	0.57 (0.4, 0.81)	0.002
Rajshahi	0.94 (0.60, 1.48)	0.802	0.74 (0.51, 1.06)	0.095	1.28 (1.9, 0.86)	0.228	0.75 (0.51, 1.12)	0.165
Rangpur	0.77 (0.46, 1.29)	0.318	0.5 (0.33, 0.78)	0.002	1.07 (1.71, 0.67)	0.775	0.58 (0.4, 0.84)	0.005
Sylhet	1.43 (0.89, 2.31)	0.143	0.71 (0.47, 1.09)	0.115	1.22 (1.79, 0.83)	0.318	0.77 (0.5, 1.18)	0.226
Wealth index								
Poorest	Ref		Ref		Ref		Ref	

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Poorer	1.23 (0.49, 3.07)	0.653	0.87 (0.36, 2.08)	0.754	0.87 (1.27, 0.6)	0.468	0.98 (0.67, 1.42)	0.896
Middle	1.05 (0.49, 2.24)	0.900	0.67 (0.3, 1.51)	0.335	0.84 (1.2, 0.58)	0.327	1.42 (0.97, 2.08)	0.07
Richer	0.92 (0.49, 1.72)	0.787	1.74 (0.81, 3.76)	0.155	1.27 (1.85, 0.87)	0.218	1.64 (1.08, 2.47)	0.019
Richest	1.67 (0.89, 3.11)	0.108	2.54 (1.21, 5.34)	0.014	2.05 (3.05, 1.38)	<0.001	3.05 (2.03, 4.60)	<0.001
Body Mass Index								
Underweight	0.96 (0.55, 1.68)	0.884	1.24 (0.73, 2.1)	0.422	0.77 (1.07, 0.55)	0.119	0.68 (0.49, 0.94)	0.02
Normal weight	Ref		Ref		Ref		Ref	
Overweight	2.27 (1.47, 3.5)	<0.001	0.99 (0.7, 1.41)	0.971	1.32 (1.8, 0.97)	0.077	1.36 (1.06, 1.73)	0.015
Obese	2.86 (1.88, 4.34)	<0.001	1.5 (1.04, 2.16)	0.029	1.1 (1.55, 0.78)	0.581	1.36 (0.98, 1.89)	0.068
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.91 (0.6, 1.38)	0.664	1.04 (0.73, 1.48)	0.828	0.69 (0.49, 0.99)	0.044	0.73 (0.57, 0.95)	0.02
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.52 (1.15, 2.02)	0.004	1.58 (1.18, 2.11)	0.002	1.50 (1.91, 1.18)	0.001	1.6 (1.29, 1.99)	<0.001

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

		(*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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Diabetes among adults in Bangladesh: Changes in prevalence and risk factors between two cross sectional surveys

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Title

Diabetes among adults in Bangladesh: Changes in prevalence and risk factors between two cross sectional surveys

Short title

Diabetes among adults in Bangladesh

Authors

Muhammad Abdul Baker Chowdhury, MPH, MPS, MS[1*]; Mirajul Islam, MS[2,3] Jakia Rahman, BS[4]; Md Jamal Uddin, PhD[5,7+]**;** Md Rabiul Haque, PhD[6+]

Affiliations

1. Department of Neurosurgery, College of Medicine, University of Florida, Gainesville, FL
2. Statistics Department, University of Florida, Gainesville FL
3. Department of Statistics, University of Dhaka, Dhaka, Bangladesh
4. Department of Mathematics and Natural Sciences, BRAC University, Dhaka, Bangladesh
5. Department of Statistics, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh
6. Department of Population Sciences, University of Dhaka, Dhaka, Bangladesh
7. Department of General Educational and Development, Daffodil International University, Dhaka, Bangladesh

[+]Senior authors

* Corresponding author

* Corresponding author email: mchow023@fiu.edu

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Abstract

Objective/ Research Question: To investigate the change in the prevalence and risk factors of diabetes among adults in Bangladesh between 2011 and 2018.

Design: The study used two waves of nationally representative cross-sectional data extracted from the Bangladesh Demographic and Health Surveys in 2011 and 2017-18.

Setting: Bangladesh

Participants: 14,376 adults aged ≥35 years.

Primary outcome: Diabetes mellitus (Type-II diabetes).

Results: From 2011 to 2018, the diabetes prevalence among adults aged ≥35 years increased from 10.95% (880) to 13.75% (922) ($p<0.001$), with the largest relative increase (90%) among obese individuals. Multivariable logistic regression analysis identified age and body mass index (BMI) were the key risk factors for diabetes. Adults who were overweight or obese were 1.54 times (AOR: 1.54, 95% CI: 1.20, 1.97) more likely to develop diabetes than normal-weight individuals in 2011, and 1.22 times (AOR: 1.22, 95% CI: 1.00, 1.50) and 1.44 times (AOR: 1.44, 95% CI: 1.13, 1.84) more prone to develop diabetes in 2018. Other significant risk factors for diabetes were marital status, education, geographic region, wealth index, and hypertension status in both survey years.

Conclusion A high prevalence of diabetes was observed and it has been steadily increasing over timeTo enhance diabetes detection and prevention among adults in Bangladesh, population-level interventions focusing on health education, including a healthy diet and lifestyle, are required.

Keywords: *Diabetes, Hypertension, trends, prevalence, risk factors, Bangladesh.*

Strengths and limitations of this study

- We estimated the change in prevalence and risk factors of diabetes among Bangladeshi adults between 2011 and 2018.
- Data were obtained from nationally representative two cross-sectional surveys including the most recent one.
- Our study uniquely investigates the risk factors of diabetes among adults
- Anthropometric and diabetes data were collected using the WHO-recommended guidelines.
- Unavailability of information on some important risk factors was the major data limitation.

Introduction

Diabetes mellitus or type 2 diabetes is one of the most common chronic and preventable diseases affecting 463 million individuals worldwide in 2019.[1 2] By 2045, the International Diabetes Federation (IDF) predicts 700 million people will have diabetes worldwide, a 51% increase from 2019.[2] This preventable disease is linked to heart disease, stroke, renal failure, and blindness, as well as morbidity, mortality, and poor quality of life. [3-5] Moreover, diabetes causes a huge financial burden on the patient and the healthcare system of the country which is expected to continue to grow. Global health expenditure on diabetes is estimated to reach $825 billion by 2030 and $845 billion by 2045 compared to $760 billion in 2019.[2 6]

Low- and middle-income countries have seen a faster increase in diabetes prevalence than high-income countries, with more than two-thirds of the population suffering from the disease.[7-10] Bangladesh, like many other countries, is transitioning from communicable to non-communicable diseases due to improved socio-economic status and unplanned but rapid urbanization.[11] Bangladesh is also going through a nutritional transition from traditional eating habits to a fast-food diet and sedentary lifestyle, which is contributing to the rise of non-communicable diseases like diabetes.[12] These reasons may lead Bangladesh to endure increased diabetes prevalence in the future. A systematic review of published studies between 1994 and 2013 found that diabetes prevalence in Bangladesh ranged from 4.5 to 35.0 percent.[13] Furthermore, the number of diabetic patients in Bangladesh is estimated to be 13.7 million by 2045. [14]

Several studies on diabetes conducted in Bangladesh confirmed that diabetes prevalence among adults is rising steadily.[15 16] People in Bangladesh who live in urban areas, belong to higher-income households, are older, have more education, and have hypertension get a higher prevalence of diabetes. [17-24] Systematic review study on the prevalence of diabetes and pre-diabetes in Bangladesh mentioned that the prevalence of diabetes was significantly higher in urban areas compared with rural areas, while there was no significant gender difference. [19]Another cross-sectional study found that longer duration of

diabetes, use of insulin, and presence of diabetes complications were significantly related to the average annual cost per patient in Bangladesh. [18] People with lower socioeconomic status are less aware as well as spend less on the care of diabetes. However, most of those studies were confined to urban-rural communities or some other specific groups (e.g., slum residents), which did not consider a wide range of correlates of diabetes for the entire country. While an upward trend in the prevalence of diabetes is evident, very few population-based studies also reported the prevalence of diabetes, which are outdated. Despite the rising literature on diabetes research in Bangladesh, no study has identified trends in the prevalence of diabetes and its related risk factors or made a comparison of its risk factors over the years.

In this study, we explored whether the overall prevalence of type 2 diabetes among adults in Bangladesh changed between 2011 and 2018 and to what extent it changed by socioeconomic and demographic characteristics of individuals. We also examined the factors that potentially contribute to the risk of diabetes among the studied population and make comparisons among them. It is important to recognize changes in diabetes prevalence by population subgroups to ensure access to and use of available treatment required for the population living with diabetes.

Methods

Data source

We used two waves of cross-sectional data from the Bangladesh Demographic and Health Survey (BDHS) from 2011 and 2017-18 to estimate the prevalence of diagnosed diabetes among the noninstitutionalized Bangladeshi population aged 35 and older. Diabetes testing and related questionnaires were included only in the 2011 and 2018 surveys. The BDHS was designed to collect data to monitor and evaluate the population health and nutritional status of the country using two-stage stratified cluster sampling from non-institutionalized households. The details of the sampling procedure and sample selection are published elsewhere.[25 26]

The National Institute of Population Research and Training (NIPORT) Ethics Review Board approved the data collection of the BDHS with the requirement of documented consent from all study participants. Our study was exempt from the ethical review approval because we used freely available de-identified data.

Biomarker measurements including blood pressure and blood glucose were collected only in 2011 and 2018 BDHS. A total of 23,541 adults were eligible for blood glucose measurements in both surveys. After exclusion of nonresponses and individuals with missing data and pregnant women, 19,584 adults comprised the study population for both survey years. Of the total included study participants 14,376 (7,556 in 2011 and 6,820 in 2018) were aged 35 years or over.

Outcome variable

The outcome variable for this study was the prevalence of diabetes for both survey years. Diabetes status was measured by fasting blood glucose (FBG) values greater than or equal to 7.0 mmol/L or self-reported use of blood glucose-lowering medication during the interview.[27]

Demographic and other covariates

Demographic, household and community-level characteristics were included to assess the prevalence and risk factors of diabetes by survey years. Individual-level characteristics were participant's age (grouped into 35-44, 45-54, 55-64, 65-74, and 75+ years of age), sex, marital status (currently married, not currently married), educational level (no education, primary, secondary, higher), body mass index (BMI), and hypertension status. The BMI was calculated as weight in kilograms divided by height in meters squared. We used BMI classifications for Asian population: underweight (<18.5) normal weight (18.5 to 23.0), moderate risk/ overweight (23.0 to < 27.5), high risk/obese (≥27.5).[28] Household and community characteristics were socio-economic status (wealth index), place of residence (urban, rural), and geographic region (division).

Statistical analysis

The full sample of each survey was used for descriptive analysis of individuals' demographic and socioeconomic characteristics. Chi-square tests were performed to check the bivariate association between each characteristic and diabetes status. We also used independent proportion tests to know whether the prevalence of diabetes between the two surveys was changed significantly and calculated the relative changes between the survey periods. For the adjusted analysis in each survey year, we performed multivariable logistic regression models to identify the associated risk factors of diabetes in Bangladesh by entering the variables that were significantly associated with the outcome in the univariate logistic regression analysis. Before entering the models, tests for multi-collinearity between explanatory variables were performed. To select the best model, we checked the values of -2Log Likelihood ratio test, AIC, and the area under the receiver operating characteristic (ROC) curve. The best model had lower values of -2Log Likelihood ratio test and lower AIC value.

To make an appropriate comparison between the two homogeneous groups for study periods, adjusted odds ratios (AORs) were calculated for both 2011 and 2018 BDHS data of the study participants aged 35 years and older. Moreover, we performed sensitivity analysis by splitting the datasets into rural and urban as well as males and females. We used $P < 0.05$ at 2-sided statistical significance for all analyses. Data management and statistical analyses were performed using Stata 15 (StataCorp, College Station, TX, USA). We considered the sample weights, primary sampling units, and Strata using the "SVY" command of Stata considering the complex nature of the survey design. Comparisons by different groups were drawn using the "svysubpop" command.

Results

Diabetes prevalence

Table 1 shows the socio-demographic characteristics of participants with age ≥35 years in Bangladesh. The highest percentage of individuals came from the age group 35-44 in 2011 (35.77%) and

2018 (36.03%). In both years' male and female percentages are approximately 50%, and a similar decreasing trend in education level was observed. Urban individuals were higher than rural in both years. We observe that the lowest percentages of individuals came from overweight (12.97%) in 2011 but from obese (13.36%) in 2018.

The diabetes prevalence in 2011 and 2018 with relative ratios are presented in Table 2. The overall prevalence of diabetes among adults ages ≥35 years increased from 10.95% in 2011 to 13.75% in 2018. The relative highest increase (38%) in diabetes prevalence was found among individuals with age 65-74 and the second-highest increase rate (36%) was found among the age group 45-54. The prevalence rate of diabetes among females increased significantly from 11.25% in 2011 to 13.81% in 2018 whereas this increment among males is not significant. The relative increase in diabetes prevalence over time among married, currently not working individuals and rural areas were 30%, 42%, and 28%, respectively. A significant increase in diabetes prevalence was also observed among adults with no education and secondary education. The highest relative increase (54%) in diabetes prevalence was in the Dhaka region followed by 53% in the Khulna region. Diabetes prevalence among middle, richer, and the richest individuals increased significantly by 48%, 41%, and 33%, respectively. The prevalence of diabetes increased by 90% among obese individuals, this rate decreased by 9% among overweight adults.

Risk factor analysis

The adjusted results from multivariable logistic regression analysis are reported in **Table 3.** The likelihood of diabetes was the highest [AOR: 2.11, 95% CI: 1.58, 2.83] among adults ages 55-64 in 2011 whereas this rate was highest [AOR: 1.67, 95% CI: 1.21, 2.30] in the age group 65-74 in 2018 compared to adults ages 35-44. There was no significant difference in the odds of having diabetes among males and females in both periods. Although marital status was highly insignificant (p-value=0.572) in 2011, this variable was found as marginally insignificant (p-value=0.057) in 2018.

The findings of the study also suggest that adults with primary, secondary, and higher education had 31%, 32%, and 87% higher odds of having diabetes, respectively than adults with no education in 2011. However, education was not a significant factor for diabetes among adults in 2018. Place of residence had no significant effect on diabetes in both periods. Compared to the Dhaka division, individuals living in Barisal and Chittagong divisions had a 43% and 44% higher likelihood of having diabetes, respectively in 2011. On the other hand, there exists no significant difference in having diabetes among adults in Barisal, Chittagong, Dhaka, Rajshahi, and Sylhet divisions in 2018. Regarding economic status, only the richest individuals had a significantly higher likelihood (96%) of diabetes in 2011 compared to the poorest individuals. However, both the richer and richest adults had more likelihood of diabetes [AOR: 1.84 and 3.09] than the poorest adults in 2018.

Higher BMI was a significant factor in both 2011 and 2018. For example, overweight and obese adults compared to normal-weight adults had 54% and 51% more likelihood of diabetes, respectively in 2011, and 22% and 44% higher likelihood of diabetes in 2018. Moreover, the odds of having diabetes among working adults in 2018 was lower [AOR: 0.80, 95% CI: (0.65, 0.99)] than in non-working adults. Since there exists a strong relationship between diabetes and hypertension, individuals having hypertension had 51% and 57% more likelihood of diabetes, respectively in 2011 and 2018 compared to individuals without hypertension.

Subgroup analysis

Subgroup analysis of diabetes by sex and place of residence were also performed and the results of this analysis are presented in **Table S1** and **Table S2**. Male with higher education had 99% higher risk of diabetes compared to male with no education in 2011 whereas no significant difference in the risk of diabetes among them was observed in 2018. However, the odds of having diabetes between a male with primary education and no education was not significantly different [p=0.236] in 2011.The opposite scenario [AOR: 1.48 [(1.06, 2.06), p=0.022] was observed in 2018. Urban males had less likelihood

[AOR: 0.71, 95% CI: 0.55, 0.93] of diabetes than rural males in 2018 whereas there was no difference in the likelihood of diabetes among them in 2011.

Marital status was found to be a significant factor (p=0.043) of diabetes among rural adults in 2018 only. Richer individuals had no significant difference (p>0.05) in having diabetes compared to the poorest individuals except in rural areas in 2018 (p=0.019). Currently working individuals had 31% (AOR: 0.69, 95% CI: 0.49, 0.99) and 27% (AOR: 0.73, 95% CI: 0.57, 0.95) lower odds of having diabetes than non-working rural individuals, in 2011 and 2018, respectively. However, there was no significant difference in diabetes among working and non-working urban individuals for both periods.

Discussion

We systematically analyze the prevalence and risk factors of diabetes among the adult population (aged ≥35 years) in Bangladesh using two waves of nationally representative survey data (2011 and 2018). The purpose of this study was to compare the prevalence of diabetes among people aged >35 years in 2018 with 2011 in Bangladesh. We found several remarkable findings linked to diabetes and its risk factors. One of the important findings was the identification of upward trends in the overall prevalence of diabetes and its distribution as per individual characteristics. The prevalence of diabetes increased by 26% between 2011 and 2018.. During this period, the prevalence increased significantly not only among the overall population but also among different age groups, both sexes, married individuals, uneducated and secondary completed, rural areas, middle to richest wealth index group, obese individuals, unemployed, and hypertensive patients. This finding is consistent with the reported prevalence of diabetes among the adult populations over the years. [29-31]

We found that the likelihood of diabetes increased with an increase of age. The odds of having diabetes was higher for older age individuals compared to younger adults. Similar to the previous studies in Bangladesh [32 33] and other developing countries, [34 35] the odds of having diabetes increased consistently for all age groups of older adults (≥ 35 years) in both data sets. In the future, the upward trend of having

diabetes is likely to be a major public health concern in Bangladesh owing to changes in population age structure with lower fertility rate, steady socioeconomic growth, and increased life expectancy. This process will sharply lead to an increase in the number of middle and older age population and diabetes prevalence in Bangladesh. [36] The prevalence of diabetes among the working-age population may be a concern because of the complex effects of diabetes on co-morbidity and economic growth in Bangladesh, where about 12% of total households pay for diabetic care by selling household assets or borrowing money. [37-39]

We found a significantly higher relative increase in diabetes prevalence in rural areas compared to urban areas, indicating that diabetes is no longer confined to urban areas in Bangladesh because, in recent years, rural residents have adopted an unhealthy lifestyle, consuming fast food with more carbs. Moreover, they are also less aware of the disease and seek medical attention at a later stage. Hira et al [40] found similar results in a study conducted in Bangladesh and Tripathy et al.[41] found a similar trend in our neighboring country India.

Our study also identified the greater prevalence of having diabetes among married people compared to unmarried people. This finding was significant in 2018 but was not found to be significant in 2011.[36] This result was broadly consistent with previous studies in which the presence of diabetes was also associated with greater marital stability and satisfaction. [32 41 42] Furthermore, this could be a proxy for age because married people are older than unmarried people, and married women who have children sometimes develop diabetes at a younger age. [43] Moreover, male being married was also associated with a higher risk of hypertension and type-2 diabetes. [44]

Although higher education and socio-economic status are negatively associated with diabetes in developed countries, we have found the opposite results in Bangladesh for both survey periods. The richest 35-year-olds are three times more likely to have diabetes than the poorest wealth group . These findings are in line with the previous studies conducted in Asian and other developing countries. [32 45 46] The greater likelihoods of diabetes among people with no education and secondary education are likely to

be associated with their less awareness about lifestyle, and may not consider it as a threat to their health.[47-50] The prevalence of diabetes varies also by region among individuals in Bangladesh. For example, people living in Rangpur and Khulna regions have experienced a significantly lower risk of having diabetes than those from Dhaka and other regions. People in these two divisions have a lower socioeconomic status than those in Dhaka, which may be linked to a lower risk of diabetes. [32 46] The rapid increase in the prevalence of diabetes in all regions, particularly in Dhaka and Khulna regions, in which it has increased by 54% and 53% respectively between 2011 and 2018, is plausibly associated with the rapid growth of urbanization and its consequences on healthy lifestyles. [9 51] High BMI and hypertension are important factors of diabetes reported in most of the previous studies. [8 11 32 37 39 52 53] Our study findings also pointed out that with higher BMI have a greater likelihood of having diabetes compared to normal-weight adults in both 2011 and 2018. [54-57]

One of the major strengths of our study is the use of nationally representative cross-sectional survey data of the two waves, including the most recent one which is released in December 2020. Data of these surveys related to anthropometrics and diabetes were not self-reported but rather collected by trained and experienced health workers such as nurses, midwives, and health assistants using the WHO-recommended guidelines. To our knowledge, this study for the first time estimated the national diabetes prevalence and its risk factors among adults in Bangladesh. Another important strength is that we compared changes in estimates of diabetes predictors between 2011 and 2018 surveys along with subgroups analyses, by sex, and by place of residence. Despite having some strengths, our study is not beyond the limitations. Due to the lack of diabetes data for younger adults (<35 years) in previous surveys, we could not compare their current diabetes prevalence. Moreover, the unavailability of data on some important correlates like the types of diet, intake of fast food, intake of calories, physical exercise including the nature of work, family history of diabetes, and cholesterol level of diabetes was the major limitation of these data sets. As a cross-sectional survey, blood sugar level was measured for one day only

and thus we do not have follow-up and or longitudinal data on diabetes and its correlates. Due to the nature of survey data, this study identified the risk factors of diabetes only rather than causality.

The study shows that among Bangladeshi adults, there is a high prevalence of diabetes and it is escalating over time. The study also reports a significant portion of younger adults with diabetes. Age and overweight/obesity are the two most important risk factors for diabetes for all adults, irrespective of sex, residence, educational attainment, and wealth index. There is evidence of an increase in the magnitude of diabetes over time and in the younger population; indeed, age increases the chances of developing diabetes mellitus significantly. These findings, together with an increase in the prevalence of type 2 diabetes among Bangladeshi adults, underscore the need for primary (awareness campaign about the adversity of fast food habit and impotence of physical mobility/work/exercise) and secondary (incorporate the issue text on the causes and consequences of diabetes and NCDs in school level curriculum) prevention efforts tailored to age-specific populations.

List of Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular diseases
WHO	World Health Organization
BDHS	Bangladesh Demographic and Health Survey

Availability of data and material: All data presented here in the manuscript is freely available at dhsprogram.com.

Prior Publication: This data has not been published previously and is not under consideration elsewhere.

Author Contribution: M.A.B. Chowdhury conceptualized the study, designed the analytic approach, managed and performed the analysis, interpreted the results, and drafted the manuscript. M. Islam: helped with the analysis, interpreted the results, and drafted the manuscript. J. Rahman, M.J. Uddin reviewed, edited, and updated the manuscript, and M.R.Haque reviewed, edited, and supervised the study.

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Ethical approval and consent

All BDHS surveys received ethical approval from ICF Macro Institutional Review Board, Maryland, USA, and the 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.

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 were involved in the study design and questionnaire development. The results will be used by the health researchers and policymakers of the country.

TABLE 1. Socio-demographic characteristics of the study sample by survey year, Bangladesh Demographic and Health Surveys.

Variables	2011, n (%)	2017-18, n (%)
Age group		
35-44	2703 (35.77)	2457 (36.03)
45-54	2236 (29.59)	1721 (25.23)
55-64	1292 (17.1)	1394 (20.44)
65-74	809 (10.71)	809 (11.86)
75+	516 (6.83)	439 (6.44)
Sex		
Female	3823 (50.6)	3510 (51.47)
Male	3733 (49.4)	3310 (48.53)
Marital status		
Not married	1214 (16.07)	1140 (16.72)
Married	6342 (83.93)	5680 (83.28)
Wealth index		
Poorest	1346 (17.81)	1380 (20.23)
Poorer	1351 (17.88)	1328 (19.47)
Middle	1463 (19.36)	1353 (19.84)
Richer	1584 (20.96)	1278 (18.74)
Richest	1812 (23.98)	1481 (21.72)
Educational level		
No education	3424 (45.31)	2663 (39.07)
Primary	2082 (27.55)	2175 (31.91)
Secondary	1403 (18.57)	1314 (19.28)
Higher	647 (8.56)	664 (9.74)
Place of residence		
Urban	5071 (67.11)	4514 (66.19)
Rural	2485 (32.89)	2306 (33.81)

TABLE 1. Socio-demographic characteristics of the study sample by survey year, Bangladesh Demographic and Health Surveys.

Variables	2011, n (%)	2017-18, n (%)
Geographic region		
Dhaka	1316 (17.42)	1608 (23.58)
Barisal	866 (11.46)	748 (10.97)
Chittagong	1116 (14.77)	865 (12.68)
Khulna	1205 (15.95)	1034 (15.16)
Rajshahi	1067 (14.12)	890 (13.05)
Rangpur	1066 (14.11)	924 (13.55)
Sylhet	920 (12.18)	751 (11.01)
Body Mass Index		
Underweight	1594 (21.1)	1188 (17.42)
Normal weight	2424 (32.08)	2711 (39.75)
Overweight	980 (12.97)	2010 (29.47)
Obese	2558 (33.85)	911 (13.36)
Currently working		
No	3901 (51.64)	2367 (34.71)
Yes	3653 (48.36)	4453 (65.29)
Hypertension		
No	5534 (73.24)	4036 (59.18)
Yes	2022 (26.76)	2784 (40.82)

TABLE 2. Prevalence of diabetes among adults age 35 years and older in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
All adults age 35 years and older	100%	10.95 (0.0048)	13.75 (0.0056)	<0.001	1.26
Age group					
35-44	35.99	8.82 (0.0065)	11.21 (0.0078)	0.081	1.27
45-54	27.43	10.86 (0.0079)	14.82 (0.01)	0.008	1.36
55-64	18.65	14.69 (0.012)	15.78 (0.0115)	0.6286	1.07
65-74	11.26	11.60 (0.0128)	15.97 (0.016)	0.1123	1.38
75+	6.68	12.11 (0.0174)	13.43 (0.0189)	0.793	1.11
Sex					
Male	48.98	10.65 (0.0061)	13.69 (0.0072)	0.091	1.29
Female	51.02	11.25 (0.006)	13.81 (0.0072)	0.003	1.23
Marital status					
Not married	15.88	12.13 (0.0112)	12.54 (0.0111)	0.953	1.03
Married	84.12	10.73 (0.0049)	13.98 (0.006)	<0.001	1.3
Educational level					
No education	44.8	8.39 (0.0058)	10.64 (0.0072)	0.021	1.27
Primary	29.07	11.10 (0.0078)	13.59 (0.009)	0.141	1.22
Secondary	18.15	13.03 (0.0108)	17.8 (0.0121)	0.015	1.37
Higher	7.98	21.79 (0.018)	20.27 (0.0185)	0.209	0.93
Place of residence					
Urban	23.91	16.08 (0.0106)	18.95 (0.0106)	0.129	1.18
Rural	76.09	9.39 (0.0051)	12.06 (0.0065)	0.003	1.28
Geographic region					
Barisal	5.79	12.54 (0.0117)	12.09 (0.0161)	0.975	0.96
Chittagong	16.45	14.28 (0.0125)	17.33 (0.0169)	0.087	1.21
Dhaka	38.99	11.26 (0.0107)	17.32 (0.0118)	0.002	1.54

TABLE 2. Prevalence of diabetes among adults age 35 years and older in Bangladesh, 2011-2018

Variables	Distribution 2011-2018, %	Diabetes 2011 BDHS, % (SE)	Diabetes 2018 BDHS, % (SE)	p-value 2011 vs. 2018	Ratio
Khulna	13.45	7.30 (0.007)	11.14 (0.0114)	0.002	1.53
Rajshahi	13.15	10.73 (0.01)	11.32 (0.0134)	0.664	1.05
Rangpur	9.26	8.59 (0.0111)	7.93 (0.0097)	0.667	0.92
Sylhet	2.91	11.85 (0.011)	12.71 (0.0169)	0.998	1.07
Wealth index					
Poorest	19.91	7.28 (0.0088)	7.26 (0.0091)	0.69	1.00
Poorer	19.74	7.35 (0.0084)	7.70 (0.0085)	0.891	1.05
Middle	20.19	7.56 (0.0075)	11.17 (0.01)	0.005	1.48
Richer	19.70	11.33 (0.0098)	16.01 (0.0128)	<0.001	1.41
Richest	20.46	20.49 (0.0122)	27.18 (0.0134)	0.006	1.33
Body Mass Index					
Underweight	19.87	7.27 (0.0081)	7.79 (0.0087)	0.437	1.07
Normal weight	36.10	9.59 (0.0071)	11.21 (0.0074)	0.343	1.17
Overweight	20.14	18.57 (0.0149)	16.95 (0.0095)	0.045	0.91
Obese	23.88	11.90 (0.0078)	22.56 (0.0156)	<0.001	1.9
Currently working					
No	43.63	12.11 (0.0064)	17.16 (0.0089)	<0.001	1.42
Yes	56.37	9.70 (0.0061)	12.00 (0.006)	0.10	1.24
Hypertension					
No	67.45	9.06 (0.0048)	10.55 (0.0063)	0.522	1.16
Yes	32.55	16.33 (0.0105)	18.57 (0.009)	0.178	1.14

TABLE 3. Adjusted odds ratios for factors predicting diabetes among adults 35 years and older BDHS 2011-2018.

	2011 BDHS		2017-18 BDHS	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups				
35-44	Ref		Ref	
45-54	1.36 (1.07, 1.72)	0.012	1.41 (1.13, 1.76)	0.002
55-64	2.11 (1.58, 2.83)	<0.001	1.58 (1.24, 2.03)	<0.001
65-74	1.60 (1.13, 2.27)	0.008	1.67 (1.21, 2.30)	0.002
75+	1.77 (1.14, 2.74)	0.011	1.32 (0.86, 2.01)	0.202
Sex				
Male	Ref		Ref	
Female	0.78 (0.58, 1.05)	0.104	0.92 (0.75, 1.13)	0.435
Marital status				
Not married	Ref			
Married	0.93 (0.72, 1.20)	0.572	1.28 (0.99, 1.64)	0.057
Educational level				
No education	Ref		Ref	
Primary	1.31 (1.05, 1.64)	0.017	1.23 (0.99, 1.53)	0.059
Secondary	1.32 (1.01, 1.73)	0.045	1.23 (0.96, 1.57)	0.108
Higher	1.87 (1.35, 2.60)	<0.001	1.15 (0.83, 1.60)	0.397
Place of residence				
Urban	1.08 (0.87, 1.33)	0.7	0.96 (0.79, 1.16)	0.678
Rural	Ref		Ref	
Geographic region				
Barisal	1.43 (1.04, 1.96)	0.027	0.75 (0.54, 1.06)	0.103
Chittagong	1.44 (1.09, 1.89)	0.010	0.88 (0.67, 1.16)	0.369
Dhaka	Ref		Ref	
Khulna	0.66 (0.50, 0.89)	0.007	0.60 (0.46, 0.79)	<0.001

Rajshahi	1.17 (0.87, 1.57)	0.309	0.74 (0.55, 1.00)	0.054
Rangpur	1.00 (0.69, 1.45)	0.986	0.56 (0.41, 0.76)	<0.001
Sylhet	1.22 (0.91, 1.63)	0.183	0.75 (0.53, 1.06)	0.101
Wealth index				
Poorest	Ref		Ref	
Poorer	0.89 (0.62, 1.27)	0.514	0.99 (0.70, 1.40)	0.957
Middle	0.86 (0.62, 1.19)	0.365	1.33 (0.94, 1.88)	0.103
Richer	1.18 (0.84, 1.65)	0.345	1.84 (1.29, 2.61)	0.001
Richest	1.96 (1.40, 2.76)	<0.001	3.09 (2.18, 4.38)	<0.001
Body Mass Index				
Underweight	0.82 (0.61, 1.10)	0.177	0.77 (0.58, 1.01)	0.055
Normal weight	Ref		Ref	
Overweight	1.54 (1.20, 1.97)	0.001	1.22 (1.00, 1.50)	0.052
Obese	1.51 (1.16, 1.97)	0.003	1.44 (1.13, 1.84)	0.003
Currently working				
No	Ref		Ref	
Yes	0.77 (0.59, 1.01)	0.056	0.80 (0.65, 0.99)	0.039
Hypertension				
No	Ref		Ref	
Yes	1.51 (1.26, 1.81)	<0.001	1.57 (1.32, 1.87)	<0.001

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TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.56 (1.1, 2.21)	0.013	1.41 (0.98, 2.03)	0.065	1.18 (0.87, 1.62)	0.288	1.41 (1.06, 1.86)	0.018
55-64	2.36 (1.6, 3.47)	<0.001	1.58 (1.09, 2.29)	0.015	1.84 (1.15, 2.94)	0.012	1.53 (1.09, 2.14)	0.013
65-74	1.79 (1.14, 2.8)	0.011	1.80 (1.18, 2.75)	0.007	1.35 (0.76, 2.39)	0.304	1.44 (0.9, 2.33)	0.132
75+	1.52 (0.85, 2.72)	0.153	1.41 (0.79, 2.51)	0.24	1.92 (0.98, 3.76)	0.059	1.11 (0.62, 1.99)	0.727
Marital status								
Not married	Ref				Ref			
Married	0.66 (0.35, 1.26)	0.205	1.83 (0.96, 3.47)	0.064	1.00 (0.75, 1.34)	0.992	1.17 (0.89, 1.56)	0.263
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.22 (0.88, 1.68)	0.236	1.48 (1.06, 2.06)	0.022	1.37 (1, 1.86)	0.047	1.12 (0.84, 1.48)	0.434
Secondary	1.14 (0.80, 1.63)	0.47	1.15 (0.78, 1.69)	0.482	1.53 (1.05, 2.23)	0.029	1.37 (0.97, 1.92)	0.071
Higher	1.99 (1.31, 3.01)	0.001	1.19 (0.76, 1.86)	0.449	1.85 (1.1, 3.11)	0.02	0.98 (0.59, 1.64)	0.941
Place of residence								
Urban	1.03 (0.76, 1.4)	0.838	0.71 (0.55, 0.93)	0.012	1.1 (0.83, 1.45)	0.497	1.24 (0.96, 1.61)	0.097
Rural	Ref		Ref		Ref		Ref	
Geographic region								
Barisal	1.42 (0.91, 2.22)	0.121	0.83 (0.53, 1.30)	0.415	1.44 (0.97, 2.14)	0.072	0.72 (0.46, 1.12)	0.148
Chittagong	1.55 (1.05, 2.27)	0.027	0.88 (0.62, 1.26)	0.484	1.36 (0.97, 1.91)	0.071	0.88 (0.61, 1.26)	0.48
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.75 (0.50, 1.12)	0.159	0.56 (0.39, 0.82)	0.003	0.61 (0.4, 0.92)	0.02	0.65 (0.46, 0.93)	0.019
Rajshahi	1.14 (0.73, 1.77)	0.569	0.78 (0.52, 1.2)	0.259	1.21 (0.82, 1.77)	0.338	0.71 (0.46, 1.09)	0.116
Rangpur	1.04 (0.64, 1.68)	0.885	0.60 (0.39, 0.92)	0.019	0.99 (0.63, 1.57)	0.975	0.53 (0.34, 0.82)	0.004
Sylhet	1.41 (0.92, 2.15)	0.112	0.66 (0.41, 1.07)	0.091	1.11 (0.77, 1.6)	0.58	0.82 (0.54, 1.22)	0.325
Wealth index								
Poorest	Ref		Ref		Ref		Ref	
Poorer	0.81 (0.51, 1.30)	0.389	1.20 (0.72, 2.00)	0.485	0.96 (0.58, 1.59)	0.88	0.87 (0.58, 1.32)	0.522
Middle	0.75 (0.46, 1.21)	0.239	1.90 (1.16, 3.12)	0.011	0.99 (0.63, 1.57)	0.981	1.02 (0.66, 1.57)	0.945

TABLE S1. Adjusted odds ratios predicting diabetes and adults age 35 and older by gender and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Male		2018 BDHS-Male		2011 BDHS-Female		2018 BDHS-Female	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Richer	0.95 (0.59, 1.51)	0.815	2.58 (1.53, 4.34)	<0.001	1.43 (0.9, 2.25)	0.129	1.44 (0.94, 2.21)	0.093
Richest	1.54 (0.94, 2.53)	0.088	5.47 (3.25, 9.19)	<0.001	2.38 (1.49, 3.79)	<0.001	2.03 (1.33, 3.09)	0.001
Body Mass Index								
Underweight	0.86 (0.6, 1.22)	0.382	0.76 (0.51, 1.13)	0.177	0.69 (0.44, 1.08)	0.101	0.78 (0.52, 1.18)	0.238
Normal weight	Ref		Ref		Ref		Ref	
Overweight	1.54 (1.13, 2.12)	0.007	1.25 (0.94, 1.66)	0.122	1.63 (1.09, 2.42)	0.016	1.15 (0.86, 1.52)	0.343
Obese	1.71 (1.1, 2.68)	0.018	1.82 (1.22, 2.69)	0.003	1.31 (0.86, 1.98)	0.207	1.29 (0.95, 1.76)	0.105
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.71 (0.48, 1.06)	0.09	0.80 (0.54, 1.17)	0.249	0.84 (0.55, 1.26)	0.394	0.79 (0.61, 1.03)	0.076
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.17 (0.88, 1.56)	0.269	1.42 (1.1, 1.83)	0.007	1.77 (1.4, 2.24)	<0.001	1.70 (1.33, 2.18)	<0.001

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age groups								
35-44	Ref		Ref		Ref		Ref	
45-54	1.58 (1.07, 2.36)	0.023	1.19 (0.85, 1.65)	0.312	1.22 (1.66, 0.9)	0.194	1.59 (1.18, 2.13)	0.002
55-64	3.57 (2.16, 5.9)	<0.001	1.50 (0.98, 2.29)	0.059	1.60 (2.3, 1.11)	0.011	1.67 (1.24, 2.27)	0.001
65-74	2.25 (1.24, 4.1)	0.008	1.50 (0.84, 2.66)	0.168	1.32 (2.04, 0.86)	0.200	1.75 (1.19, 2.57)	0.004
75+	2.54 (1.17, 5.5)	0.018	1.89 (1.01, 3.51)	0.045	1.45 (2.45, 0.85)	0.171	1.14 (0.65, 2.01)	0.645
Sex								
Female	0.82 (0.49, 1.38)	0.461	1.29 (0.9, 1.85)	0.173	0.76 (1.11, 0.52)	0.15	0.8 (0.63, 1.03)	0.087
Male	Ref		Ref		Ref		Ref	
Marital status								
Not married	Ref				Ref			
Married	0.8 (0.52, 1.24)	0.322	1.07 (0.7, 1.62)	0.759	1.01 (1.38, 0.74)	0.962	1.39 (1.01, 1.92)	0.043
Educational level								
No education	Ref		Ref		Ref		Ref	
Primary	1.44 (0.96, 2.14)	0.076	1 (0.69, 1.45)	0.992	1.26 (1.64, 0.97)	0.086	1.30 (1.00, 1.69)	0.048
Secondary	1.46 (0.94, 2.27)	0.089	1.35 (0.89, 2.03)	0.155	1.22 (1.72, 0.86)	0.272	1.15 (0.83, 1.59)	0.394
Higher	1.9 (1.13, 3.19)	0.015	1.19 (0.74, 1.93)	0.465	1.85 (2.94, 1.16)	0.009	1.15 (0.74, 1.81)	0.532
Geographic region								
Barisal	0.93 (0.58, 1.49)	0.76	0.99 (0.54, 1.83)	0.982	1.63 (2.45, 1.09)	0.018	0.70 (0.46, 1.06)	0.088
Chittagong	1.04 (0.69, 1.58)	0.845	0.58 (0.4, 0.84)	0.004	1.66 (2.41, 1.15)	0.007	1.04 (0.72, 1.5)	0.841
Dhaka	Ref		Ref		Ref		Ref	
Khulna	0.82 (0.52, 1.28)	0.381	0.70 (0.5, 1.00)	0.05	0.61 (0.91, 0.4)	0.017	0.57 (0.4, 0.81)	0.002
Rajshahi	0.94 (0.60, 1.48)	0.802	0.74 (0.51, 1.06)	0.095	1.28 (1.9, 0.86)	0.228	0.75 (0.51, 1.12)	0.165
Rangpur	0.77 (0.46, 1.29)	0.318	0.5 (0.33, 0.78)	0.002	1.07 (1.71, 0.67)	0.775	0.58 (0.4, 0.84)	0.005
Sylhet	1.43 (0.89, 2.31)	0.143	0.71 (0.47, 1.09)	0.115	1.22 (1.79, 0.83)	0.318	0.77 (0.5, 1.18)	0.226
Wealth index								
Poorest	Ref		Ref		Ref		Ref	

TABLE S2. Adjusted odds ratios predicting diabetes and adults age 35 and older by rural-urban and survey year in Bangladesh, BDHS 2011-2018.

	2011 BDHS-Urban		2018 BDHS-Urban		2011 BDHS-Rural		2018 BDHS-Rural	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Poorer	1.23 (0.49, 3.07)	0.653	0.87 (0.36, 2.08)	0.754	0.87 (1.27, 0.6)	0.468	0.98 (0.67, 1.42)	0.896
Middle	1.05 (0.49, 2.24)	0.900	0.67 (0.3, 1.51)	0.335	0.84 (1.2, 0.58)	0.327	1.42 (0.97, 2.08)	0.07
Richer	0.92 (0.49, 1.72)	0.787	1.74 (0.81, 3.76)	0.155	1.27 (1.85, 0.87)	0.218	1.64 (1.08, 2.47)	0.019
Richest	1.67 (0.89, 3.11)	0.108	2.54 (1.21, 5.34)	0.014	2.05 (3.05, 1.38)	<0.001	3.05 (2.03, 4.60)	<0.001
Body Mass Index								
Underweight	0.96 (0.55, 1.68)	0.884	1.24 (0.73, 2.1)	0.422	0.77 (1.07, 0.55)	0.119	0.68 (0.49, 0.94)	0.02
Normal weight	Ref		Ref		Ref		Ref	
Overweight	2.27 (1.47, 3.5)	<0.001	0.99 (0.7, 1.41)	0.971	1.32 (1.8, 0.97)	0.077	1.36 (1.06, 1.73)	0.015
Obese	2.86 (1.88, 4.34)	<0.001	1.5 (1.04, 2.16)	0.029	1.1 (1.55, 0.78)	0.581	1.36 (0.98, 1.89)	0.068
Currently working								
No	Ref		Ref		Ref		Ref	
Yes	0.91 (0.6, 1.38)	0.664	1.04 (0.73, 1.48)	0.828	0.69 (0.49, 0.99)	0.044	0.73 (0.57, 0.95)	0.02
Hypertension								
No	Ref		Ref		Ref		Ref	
Yes	1.52 (1.15, 2.02)	0.004	1.58 (1.18, 2.11)	0.002	1.50 (1.91, 1.18)	0.001	1.6 (1.29, 1.99)	<0.001

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

		(*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.