# Prevalence of Diabetes Mellitus and its Associated Risk Indicators in a Rural Bangladeshi Population

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**Abstract:** *Background*: Substantial racial heterogeneity in diabetes leads to the necessity of conducting epidemiological studies in different communities. Such studies are still inadequate in Bangladeshi population, particularly in truly respective rural areas. The objectives of the study were to estimate the prevalence of diabetes and to identify its associated risk indicators in a rural population of Bangladesh.

*Methods*: This population based cross-sectional study was conducted in remote rural areas of Northern Bangladesh, which included a total of 836 participants aged at or above 25 years through screening in camp settings. Diabetes was diagnosed by WHO criteria after a 2-sample OGTT. BMI, waist-hip ratio, blood pressure, lipid profile and serum creatinine were also estimated.

*Results*: The prevalence of diabetes was found to be 7.2% (95% CI 5.4-9.0) and that of impaired glucose regulation [including both impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG)] was 6.5% (95% CI 4.8-8.2). The prevalence of diabetes and impaired glucose regulation differed between males and females, but, both increased with age in males as well as females. A good correlation was observed between fasting blood glucose and 2hr after glucose (Kappa value 0.86) among the study participants. After adjusting for potential confounders BMI and WHR were found as significant independent risk indicators for the occurrence of diabetes in this population.

*Conclusion*: A relatively high prevalence of diabetes was observed in this rural Bangladeshi population. Preventive programs, particularly targeted to body weight management through lifestyle modification should be strengthened even in rural areas.

**Keywords:** Bangladesh, diabetes, epidemiology, prevalence.

## INTRODUCTION

Diabetes mellitus (DM) is becoming a pandemic worldwide. The highest percentages of increases in disease prevalence are likely to be in developing nations, with major increases in the Middle-East, Sub-Saharan Africa, South Asia, and Latin America [1]. WHO listed 10 countries to have the highest numbers of people with diabetes in 2000 and 2030. According to this report, Bangladesh has 3.2 million of diabetic subjects in 2000 and the number is expected to increase to a staggering 11.1 million by 2030 placing her among the top 10 countries with diabetes [1].

Several small-scale population based studies conducted in Bangladesh at different time points have revealed an increasing trend of diabetes prevalence in rural and urban communities [2-9]. A recent population based study [3] showed a significant increase in the prevalence of DM in rural Bangladesh from 2.3% to 6.8% over 5 years. This prevalence was higher than found in the previous rural based studies on the same population [5, 7]. Most of these studies have been conducted near the capital city, Dhaka and the people of these areas are very much used to modern lifestyle and hence these studies might not reflect the real picture of rural Bangladesh where more than 75% people are living. No population based study on the burden of diabetes has so far been conducted in the rural areas of northern Bangladesh. The pattern of diabetes in Bangladeshi population differs from that in Europeans and Americans in several aspects: the onset is at a younger age and a large number of the diabetic people are non-obese. However, the association of obesity and diabetes in this population is not strong. Some studies showed that BMI and WHR were important predictors of diabetes in rural Bangladeshi population, although the population was considered as lean [3, 5], while the others did not [2, 4].

These clinical differences and the rising prevalence of diabetes in Bangladesh warrant well-conducted epidemiologic studies on diabetes in this population. The present study was conducted to observe the prevalence of

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diabetes and to identify its associated risk indicators in a rural Bangladeshi population at the northern part of the country.

## MATERIALS & METHODOLOGY

### Study Population

This was a population based cross-sectional study which was conducted in a district of north-western Bangladesh, called Thakurgaon, which is about 467 km from Dhaka, the capital city. Subjects were recruited from all 5 upazilas (sub-districts) of Thakurgaon. Ten villages were randomly selected from those 5 upazilas. To determine the required sample size, the formula: $n = PQ/d^2$ was used, where P stands for prevalence (of DM + Pre DM) from a previous study [3], i.e. 0.13 (13%); Q = 1 - P, i.e. 0.87 and $d$ = allowable error of known prevalence i.e. 0.085 × 0.13. Thus the calculated sample size was, n = 926. 1000 individuals (both male and female) aged ≥ 25 years of those 10 villages were invited to participate in this study by following simple random procedure from the record of national identification number; among them 836 agreed individuals were investigated. This epidemiological survey was conducted through screening in camp settings. Three camps were organized in 3 different places by Thakurgaon Swasthoseba Hospital within 6 months.

### Ethical Consideration

The Helsinki Declaration on medical ethics was respected in the surveys. The protocol was approved by the Norwegian Ethical Committee for Medical Research and the Ethical Committee of Diabetic Association of Bangladesh.

### Survey Procedures

Sixteen Field Assistants were recruited from the local community and trained for the field work which included subject selections, organizing the screening camps, collection of data by reviewing the questionnaire, and delivering the results to the participants. They listed all the adults aged ≥ 25 years from each area using the record of national identification number and identified the required number of subjects randomly. Pregnant women and physically or mentally disabled persons, unable to follow simple questions; were excluded from the study.

All the individuals selected for the study were given an identification number. The Field Assistants approached the potential participants by an information letter and a response document. Participants were informed regarding the purpose and the procedure of the study and were requested to attend the screening camps in the morning on a pre-arranged date after an overnight fast of at least 8-10 hours. On arrival at the pre scheduled time (7.30 am to 8.30 am) on the appointed day, confirmation of the fasting state was verified once again from each participant. After receiving the consent general registration of the participant was initiated. With proper aseptic precaution, 8 ml of venous blood sample was collected from each participant. Fasting blood glucose (FBG), lipid profile, serum creatinine and glycosylated hemoglobin ($HbA_1c$) were determined from fasting blood sample. All subjects other than those with known diabetes (n=12) were then given a 75-g oral glucose solution (75-g oral glucose in 500 ml of water) to drink. Another 3 ml of venous blood was collected after 2 hours to determine 2 hr post oral glucose tolerance test (OGTT). After collecting blood, samples were centrifuged on site within 3 hours and plasma samples were then refrigerated and stored at $-20^0C$ until laboratory assays was done. Serum glucose (fasting and 2 hr after glucose) was measured by glucose oxidase method, Glycosylated hemoglobin (HbA1c) by high performance liquid chromatography (HPLC), total cholesterol (TC), triglyceride (TG) and high-density lipoprotein (HDL) were analyzed by enzymatic-colorimetric method, low-density lipoprotein (LDL) was estimated by Friedewald's formula and serum creatinine was measured by alkaline picrate method.

The pretested questionnaire was used for collecting some general information; like the demographic and socioeconomic information from each participant, which included sex, age, education, occupation, marital status, monthly income, monthly expenditure and family assets. In addition, anthropometric measures (height, weight, waist circumference and hip circumference) and blood pressure were recorded. The written results of laboratory examinations were distributed and explained to the participants through Thakurgaon Swasthoseba Hospital, the Health Care Center of the Diabetic Association of Bangladesh. The identified cases for diabetes were referred to the hospital for follow up and further treatment.

### Anthropometrical Measurement

Anthropometric measurements included height, weight, waist circumference and hip circumference. The measurements were taken with light clothes without shoes. Height was measured by using a portable, locally manufactured, stadiometer, standing upright on a flat surface without shoes. Body weight was measured while wearing light clothes by an adjusted scale. Body mass index (BMI) was calculated by the formula: weight in kilograms divided by height in meters squared [weight (kg)/height ($m^2$)]. Waist circumference was measured at 1 cm above the level of navel at minimal respiration and hip circumference was measured at the level of maximum posterior extension of the buttocks by placing a flexible plastic tape horizontally with light clothes. Both circumferences were recorded to the nearest 0.1 cm. Two readings of height, weight, waist circumference and hip circumference were recorded and the mean of the two was taken as the final reading. Asian BMI criteria were used to identify overweight and obese in this population [10]. Abdominal obesity was evaluated by waist/hip ratio, with android and gynaecoid cut off points taken at 0.8 and 0.9 for females and males respectively [11].

### Blood Pressure Measurement

Blood pressure was taken after completion of the questionnaire. To reduce the variation, subjects rested for at least 10 minutes before the BP was recorded. The pressure was measured in sitting position on the right arm using normal cuffs for adults fitted with a standard mercury sphygmomanometer, placing the stethoscope bell lightly over the brachial artery. BP was usually recorded to the nearest 2 mm Hg from the top of the mercury meniscus. Two readings were taken 5 minutes apart, and the mean of the two was taken as the final blood pressure reading of the individual. Hypertension was defined as a systolic blood pressure (SBP) of ≥ 140 mm Hg and/or diastolic blood pressure (DBP) of ≥ 90 mm Hg [12].

### Diagnosis Criteria for Diabetes and Other Variables

After estimation of fasting blood glucose (FBG) and oral glucose tolerance test (OGTT), the participants were classified into non diabetes, diabetes mellitus, IFG (impaired fasting glucose) and IGT (impaired glucose tolerance), according to the recommendation of the World Health Organization Expert Committee [12]. According to the ADA recommendation [13] the cut of value of other variables like, total cholesterol (<200 mg/dl), triglyceride (<150 mg/dl), LDL (<100 mg/dl), HDL (for male >50 mg/dl and for female >40 mg/dl) and serum creatinine (for male <1.4 mg/dl and for female <1.2 mg/dl) was used for data analysis.

### Data Analysis

The prevalence rates of diabetes were determined by simple percentages. The odds ratio (OR) with 95% confidence interval (CI) for risk indicators was calculated assuming the least prevalence of clinically relevant criteria as a reference value. Multiple logistic regression were performed to quantify the individual effect of predictor variables and to adjust for potential confounding factors. All P-values presented are two-tailed. The statistical tests were considered significant at a level ≤5% (≤0.05). All the statistical analysis was performed using SPSS 16 software.

## RESULTS

Socio-demographic characteristics of the study subjects were presented in Table **1**. The mean age of the participants was 46 years. All participants were divided into 3 age groups with 15 years age interval; in which 39% were between 25 to 40 years, 36% participants were between 41 to 55 years and 25% were above 55 years of age. Among the 836 participants 56% (n=468) were male and 44% (n=368) were female participants. Male subjects were older compared to the female participants (Table **1**). About 34% of the adult population (≥25 years) was illiterate and 33% was found to have primary education. Occupationally, 35% were housewives, 34% farmers and day laborers and 13% were businessmen. In regard to socio-economic status, 23% were poorest of the poor, 43% poor and rest of the participants

**Table 1. Socio-Demographic Characteristics of the Study Subjects**

| Variables | | Frequency | Mean±SD/Percentage |
|---|---|---|---|
| Mean Age | Total Participants | 836 | 46.0(±12) |
| | Male Participants | 468 | 46.0(±12) |
| | Female Participants | 368 | 45.0(±11) |
| Age | 25-40yrs | 326 | 39 |
| | 41-55yrs | 300 | 36 |
| | > 55 yrs | 210 | 25 |
| Gender | Male | 468 | 56 |
| | Female | 368 | 44 |
| Education | Illiterate | 284 | 34 |
| | Primary | 276 | 33 |
| | Secondary School | 184 | 22 |
| | Higher Secondary | 59 | 7 |
| | Graduate & above | 33 | 4 |
| Occupation | Farmer and day labor | 284 | 34 |
| | Service holder | 84 | 10 |
| | Businessmen | 108 | 13 |
| | Housewives | 293 | 35 |
| | Retirement | 67 | 8 |
| Socio-Economic Status | Poorest of the poor | 192 | 23 |
| | Poor | 359 | 43 |
| | Lower middle class | 235 | 28 |
| | Middle class | 50 | 6 |
| Marital status | Single | 123 | 15 |
| | Married | 631 | 75 |
| | Others | 82 | 10 |

**Table 2. Distribution of Participants for Different Variables by Age and Gender**

| Variables | 25-40 yrs | | | 41-55 yrs | | | above 55 yrs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Male (n=162) | Female (n=164) | P for Difference | Male (n=172) | Female (n=128) | P for Difference | Male (n=134) | Female (n=76) | P for Difference |
| BMI (kg/m$^2$) | 21.4±3.2 | 21.6±3.5 | 0.650 | 22.3±3.6 | 21.8±3.7 | 0.141 | 22.9±4.2 | 22.5±4.6 | 0.585 |
| WHR* | 0.89±0.06 | 0.87±0.07 | 0.018 | 0.92±0.07 | 0.88±0.07 | 0.001 | 0.93±0.07 | 0.92±0.08 | 0.122 |
| SBP (mmHg) | 117±15.4 | 113±15.8 | 0.014 | 120±16.8 | 121±22.6 | 0.490 | 124±19.1 | 125±20.1 | 0.418 |
| DBP (mmHg) | 77.5±10.8 | 74.6±11.6 | 0.029 | 78.2±11.4 | 80.3±15.5 | 0.253 | 78.7±12.9 | 81.2±15.0 | 0.196 |
| FBG (mmol/l) | 5.03±1.7 | 5.05±1.8 | 0.913 | 5.1±1.5 | 5.3±2.1 | 0.277 | 5.2±1.4 | 5.7±2.3 | 0.142 |
| AG (mmol/l) | 5.9±2.3 | 6.2±2.6 | 0.209 | 6.1±2.7 | 6.4±3.1 | 0.325 | 6.4±3.0 | 7.3±4.5 | 0.146 |
| HbA1c (%) | 4.9±1.2 | 5.01±1.1 | 0.480 | 5.1±1.3 | 5.1±1.2 | 0.996 | 5.4±1.4 | 5.8±1.9 | 0.172 |
| Triglyceride (mg/dl) | 156±65.3 | 136±54.7 | 0.002 | 157±62.1 | 156±56.9 | 0.936 | 162±65.3 | 163±71.9 | 0.912 |
| Cholesterol (mg/dl) | 187±32.4 | 178±32.9 | 0.013 | 189±40.6 | 193±35.2 | 0.642 | 191±40.3 | 198±40.5 | 0.068 |
| HDL (mg/dl)* | 36.8±8.4 | 34.1±8.3 | 0.010 | 37.8±11.1 | 34.8±7.4 | 0.002 | 38.0±11.2 | 37.3±8.6 | 0.615 |
| LDL (mg/dl) | 119±29.6 | 116±30 | 0.332 | 127±37.6 | 126±33.6 | 0.702 | 118±37.1 | 124±39.4 | 0.310 |
| S Creatinine (mg/dl)* | 1.12±0.23 | 1.03±0.21 | 0.001 | 1.24±0.33 | 1.16±0.26 | 0.050 | 1.40±0.40 | 1.31±0.43 | 0.062 |

Data are presented as mean±SD; independent t- test was done as a test of significance.
Abbreviations: BMI, Body mass index; WHR, Waist hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; FBG, Fasting blood glucose; AG, After 2 hr glucose load; $HbA1_c$, Glycosylated hemoglobin; HDL, High density lipoprotein; LDL, Low density lipoprotein;
*Data were coded with reference value separately for male and female and then analyzed together.

were from middle class family. Anthropometric, clinical and biochemical parameters of the participants were presented by gender in Table **2**. The mean BMI was 22.2 kg/m$^2$ and 21.9 kg/m$^2$ for the male and female participants, respectively. Mean BMI increased with increasing age for both males and females. This picture was also reflected in the assessment of other parameters except for LDL. In younger age group there were significant differences in systolic and diastolic blood pressure, triglyceride and total cholesterol between male and female participants. But it is not reflected in other age groups. A superior agreement was observed between FBG and 2hAG (Kappa value 0.86) among the study participants (data has not been shown).

The overall prevalence of diabetes was 7.2% (95% CI 5.4-9.0) and that of impaired glucose regulation [including both impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG)] was 6.5% (95% CI 4.8-8.2). Prevalence of diabetes and impaired glucose regulation increased with increasing age both for males and females (Table **3**). Though non-significant, overall females had higher prevalence of both diabetes and impaired glucose regulation compared with males. The difference in prevalence of diabetes by sex widened in the older age group (>55 years). But for impaired glucose regulation, the difference in prevalence by sex was wider in the younger age group (25-40 years), while the difference was very narrow in the older age group (>55 years).

In Table **4** the characteristics of the participants were compared between subjects with diabetes, nondiabetes, and impaired glucose regulation (IGT+IFG). All the variables were found to be associated with diabetes mellitus in the univariate model (Table **5**). But in the multivariate model

**Table 3. Prevalence of Diabetes and Impaired Glucose Regulation (IGT + IFG) by Age and Gender Distribution**

| Age Group in Years | | Male | Female | No of Cases | | Prevalence per 100 | | Total Prevalence | P for Difference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | Female | Male | Female | | |
| Diabetes | 25-40 yrs | 162 | 164 | 10 | 8 | 6.2 | 4.9 | 5.5 | 0.609 |
| | 41-55 yrs | 172 | 128 | 12 | 9 | 6.9 | 7.0 | 6.9 | 0.985 |
| | above 55 yrs | 134 | 76 | 10 | 11 | 7.5 | 14.5 | 11.0 | 0.068 |
| | Total | 468 | 368 | 32 | 28 | 6.8 | 7.6 | 7.2 | 0.668 |
| IGT+IFG | 25-40 yrs | 162 | 164 | 6 | 12 | 3.7 | 7.3 | 5.5 | 0.104 |
| | 41-55 yrs | 172 | 128 | 10 | 10 | 5.8 | 7.8 | 6.8 | 0.492 |
| | above 55 yrs | 134 | 76 | 10 | 6 | 7.5 | 7.9 | 7.7 | 0.811 |
| | Total | 468 | 368 | 26 | 28 | 5.5 | 7.6 | 6.5 | 0.231 |

Results are expressed as frequency (percentage); $\chi^2$- test was done as a test of significance.

**Table 4. Baseline Characteristics of Nondiabetic, Impaired Glucose Regulation and Diabetic People**

| Variables | Nondiabetic (n=722) | IGT+IFG (n=54) | Diabetic (n=60) | P for Difference | | |
|---|---|---|---|---|---|---|
| | | | | Non Diabetic/ IGT+IFG | Non Diabetic/ Diabetic | IGT+IFG/ Diabetic |
| Age (yrs) | 45.3±11.8 | 47.0±11.4 | 48.8±10.7 | 0.285 | 0.019 | 0.408 |
| BMI (kg/m$^2$) | 21.7±3.6 | 23.1±4.4 | 23.9±4.7 | 0.006 | 0.002 | 0.235 |
| WHR * | 0.89±0.07 | 0.92±0.06 | 0.97±0.09 | 0.005 | 0.001 | 0.004 |
| SBP (mmHg) | 118.0±17.9 | 126.4±19.2 | 129.4±18.7 | 0.003 | 0.001 | 0.402 |
| DBP (mmHg) | 77.2±12.4 | 81.5±12.5 | 85.8±15.6 | 0.018 | 0.001 | 0.066 |
| FBG (mmol/l) | 4.7±0.60 | 6.3±0.40 | 10.5±3.1 | 0.001 | 0.001 | 0.001 |
| AG (mmol/l) | 5.3±1.0 | 9.2±1.5 | 14.9±4.1 | 0.001 | 0.001 | 0.001 |
| HbA1c (%) | 4.8±0.68 | 6.8±0.91 | 8.6±1.9 | 0.001 | 0.001 | 0.001 |
| Triglyceride (mg/dl) | 143.5±53.1 | 186.5±70.7 | 250.1±75.5 | 0.001 | 0.001 | 0.001 |
| Cholesterol (mg/dl) | 184.7±35.0 | 209.1±40.4 | 220.2±46.4 | 0.001 | 0.001 | 0.221 |
| HDL (mg/dl) * | 37.2±10.1 | 33.2±6.9 | 33.9±9.3 | 0.001 | 0.024 | 0.480 |
| LDL (mg/dl) | 119.5±32.8 | 138.1±38.3 | 136.2±46.1 | 0.001 | 0.008 | 0.804 |
| S Creatinine (mg/dl)* | 1.16±0.28 | 1.27±0.30 | 1.66±0.60 | 0.019 | 0.001 | 0.001 |

Data are presented as mean±SD; independent t- test was done as a test of significance.
Abbreviations: BMI, Body mass index; WHR, Waist hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; FBG, Fasting blood glucose; AG, After 2 hr glucose load; $HbA1_c$, Glycosylated hemoglobin; HDL, High density lipoprotein; LDL, Low density lipoprotein;
*Data were coded with reference value separately for male and female and then analyzed together.

using stepwise backward method (Table **5**) socio-economic status, BMI, WHR, hypertension and triglyceride were found to be associated with diabetes mellitus. BMI >23.0 showed to be an exceedingly risky state for the occurrence of diabetes. The risk for diabetes was almost 2-fold in subjects from middle socio-economic status (OR 1.78) and with high WHR (OR 1.92). The risk is more than 2-fold in subjects with BMI >23.0 kg/m$^2$ (OR 2.38, 3.77 and 4.36 for overweight, obese I and obese II category, respectively) and with triglyceride >150 mg/dl (OR 2.37). Hypertension was also found to be associated (OR 1.38) with diabetes in the multivariate model. However applying the same model, BMI >25.0 kg/m$^2$ (OR 1.80 and 2.48 for obese I and obese II category, respectively) and high triglyceride (OR 1.87) showed to be associated for developing impaired glucose regulation.

## DISCUSSION

This study addressed the prevalence of diabetes and impaired glucose regulation in a rural population in Bangladesh. The prevalence of diabetes was found to be 7.2% which is comparable to the recent rural studies [5, 6, 8], but it is significantly higher than the studies conducted in early 2000s [2-4]. However, moderate but steady rise in the prevalence of impaired glucose regulation (6.5%) was observed compared to a recent published data [2]; it was rather low compared to the prevalence in another study [5]. Data on the rising trend of diabetes in Bangladesh were based on the comparison of data collected from different parts of the country at different times and those were collected applying different procedures [4]. Therefore, it is difficult to make a scientific comprehension of the rising trend of diabetes. To compare secular trends, it would be more accurate to document the prevalence of diabetes applying the identical procedure.

The prevalence of diabetes documented in this study was comparatively higher than the prevalence found in rural China (5.6%), but more related to that of rural India (6.3%) and was almost equal to that of rural population in Turkey (7.2%) [14-16]. However, the observed prevalence rate of diabetes in this report is lower than the prevalence found in rural Pakistan (11.1%) [17]. However, the direct comparisons of prevalence rates are challenging owing to differential methodologies applied and diverse characteristics of the population.

Several studies showed that urbanization, economic development and affluent lifestyle are causing high prevalence of DM even in the developing countries [18-20]. The rural Bangladeshi population is undergoing lifestyle transition due to socio-economic growth, road communication, electrification, and mechanized cultivation in recent years which have changed the rural lifestyle. Such demographic transition due to improved living conditions in rural areas may have been responsible for the observed high rate of prevalence of diabetes in rural Bangladesh. But BMI in this population remain relatively low. Therefore, it would be difficult to ascribe the increased prevalence only due to higher calorie intake as a consequence of improved socio-economic condition. Rather higher impaired glucose regulation in a lean population may also indicate genetically susceptible population, who may convert to diabetes with a much lower change in obesity. Given the degree of fast expanding urbanized lifestyle and relative economic growth, the prevalence of diabetes will rise beyond control in resource constrain societies like Bangladesh, unless effective intervention program suitable for the local culture is put in

**Table 5. Odds Ratio (OR) and 95% CI of Diabetes and Impaired Glucose Regulation by the Following Characteristics**

| Variables | Diabetes | | Impaired Glucose Regulation | |
|---|---|---|---|---|
| | OR 1 (95% CI) | OR 2 (95% CI) | OR 1 (95% CI) | OR 2 (95% CI) |
| **Age (yrs)** | | | | |
| 25-40 * | 1.0 | | 1.0 | |
| 41-55 | 1.90 (1.18-3.66) | | 1.04 (0.42-1.92) | |
| Above 55 | 1.48 (0.98-2.78) | | 1.32 (0.54-2.23) | |
| **Sex** | | | | |
| Male * | 1.0 | | 1.0 | |
| Female | 1.12 (0.66-1.90) | | 1.14 (0.52-2.57) | |
| **Socio-economic status** | | | | |
| Poorest of the poor * | 1.0 | 1.0 | 1.0 | |
| Poor | 0.87 (0.36-2.45) | 0.81 (0.58-2.93) | 0.71 (0.42-1.92) | |
| Lower middle class | 1.06 (0.57-2.74) | 0.89 (0.64-2.79) | 0.84 (0.38-2.15) | |
| Middle class | 2.09 (1.48-5.21) | 1.78 (1.10-4.07) | 1.46 (0.97-2.74) | |
| **BMI ($kg/m^2$)** | | | | |
| 18.5-22.99 normal * | 1.0 | 1.0 | 1.0 | 1.0 |
| Below 18.49 underweight | 0.94 (0.62-6.32) | 0.89 (0.49-2.87) | 0.82 (0.37-2.51) | 0.68 (0.33-2.14) |
| 23.0-24.99 overweight | 2.92 (1.62-7.04) | 2.38 (1.49-5.79) | 1.87 (0.76-4.02) | 1.04 (0.64-3.29) |
| 25.0-29.99 obese I | 4.72 (1.83-12.17) | 3.77 (1.89-8.21) | 3.05 (1.95-5.32) | 1.80 (1.21-4.87) |
| Above 30.0 obese II | 5.88 (2.51-13.8) | 4.36 (2.43-9.27) | 3.63 (2.02-7.45) | 2.48 (1.53-5.07) |
| **WHR** | | | | |
| Normal * | 1.0 | 1.0 | 1.0 | |
| High | 2.54 (1.59-5.43) | 1.92 (1.36-4.72) | 1.26 (0.78-2.31) | |
| **Hypertension** | | | | |
| Normotensive * | 1.0 | 1.0 | 1.0 | |
| Hypertensive | 2.53 (1.45-3.97) | 1.38 (0.89-3.92) | 1.32 (0.89-2.48) | |
| **Triglyceride (mg/dl)** | | | | |
| Below 150 * | 1.0 | 1.0 | 1.0 | 1.0 |
| Above 150 | 3.64 (2.04-6.50) | 2.37 (1.55-5.37) | 2.37 (1.55-5.37) | 1.87 (1.17-4.25) |

Abbreviations: OR, Odds ratio; CI, Confidence interval; BMI, Body mass index; WHR, Waist hip ratio; OR 1, Crude odds ratio after univariate logistic regression; OR 2, Adjusted odds ratio after multivariate logistic regression using stepwise backward model for age, sex, socio-economic status, BMI, WHR, hypertension and triglyceride.
*Referent.

place. However, prospective studies are required to assess the exact changes occurring with regard to the diabetes epidemic in Bangladesh including its risk factors.

Overall we have observed a higher, though non-significant, occurrence of diabetes and impaired glucose regulation among females compared with males. However, males have a higher prevalence of diabetes compared to females in the ages 25-40 years (although not significant), and almost identical in the ages 41-55 years, but the scenario is differing in the highest age (above 55 years) strata. The gender difference is otherwise interesting, with a higher risk for men among lower ages and for women among higher, but as this is not significant it is hard to draw any conclusions out of this. The prevalence of impaired glucose regulation was higher among females in all age categories compared with males. The finding of female predominance in the development of diabetes is consistent with the most previous studies in Bangladesh [3, 4, 6, 7]. Gender difference was not significant in India [21], though non-significant higher prevalence of type 2 diabetes was found among women in another investigation in India [22]. Higher prevalence of diabetes in women was also reported from Pakistan and Turkey [16, 17].

We have observed an important association of both general obesity and central obesity with diabetes. It is of interest to note that general obesity was found to be a risk indicator for developing diabetes and impaired glucose regulation in this population. General obesity showed more than 2-fold higher risk for developing diabetes in subjects with BMI >23.0 $kg/m^2$ in the present study. We had previously noted that the risk of diabetes occurred at a lower BMI threshold (<23 kg/m2) in Asian Indians [23]. However, the association of DM and BMI in Bangladesh was inconsistent in previous studies [2-4, 6, 8]. One possible explanation may have been due to lower mean BMI in previous studies in rural Bangladesh [2, 4]. This may indicate that the general obesity is on the rise even in the rural population of Bangladesh.

WHR also appeared to be a significant risk factor for diabetes in the multivariate analysis. The association between WHR and DM was evident in the earlier studies in Bangladesh [6, 24]. It was also reported that the occurrence of diabetes was prevalent with central obesity even among subjects with lower BMI threshold in Asian Indians [23]. We have also observed higher central obesity even among people with normal BMI in our population (data not shown). Therefore, the transition in lifestyle occurring in the rural population seems to produce rapid adverse changes favoring diabetogenesis.

Another risk factor evident in the study was the higher social class. This is a very common finding which is consistent in the most previous Asian studies [5, 7, 21]. We have observed that hypertension was also associated with diabetes mellitus. Another striking observation from this data demonstrates that triglyceride was associated with both diabetes and impaired glucose regulation in this rural population. But this association was contradictory to an earlier rural study [5].

Population based study design was the main strength of the study. It was the most appropriate and useful approach where samples from a representative population were tested. Therefore this study would contribute to prevention approaches and suggestions to address these problems. But we would have needed a much larger sample size in order to generalize our results in Bangladeshi population. As we had limited time frame and resources to conduct the study, we used the most convenient formula for calculate the sample size. Therefore, the sample size became smaller which may decrease the statistical power. Moreover, clinical sensitivity and specificity for the selection of different methods for different variables were considered here, which have increased the reliability of the data and results.

The indices of obesity (increased BMI and WHR) and hyperlipidemia (increased triglyceride) may at least in part explain the rising trend of diabetes mellitus in this rural population of Bangladesh. The higher prevalence of diabetes in the present study may also be indicated the changing environmental factors where rapid urbanization may have influenced individual's lifestyle leading to increased level of obesity and occurrence of diabetes. In order to address this issue, large-scale cohort studies are required with control population in order to develop proper strategy for screening and prevention.

## CONCLUSION

A high prevalence of both diabetes and impaired glucose regulation exists even in rural population of Bangladesh and it seems to be associated with obesity. Considering Bangladesh, as a developing country where the state of affairs warrants immediate measures necessary to prevent the epidemic particularly in the localities that are in the transition phase from rural to semi-urban facilities.

## DECLARATION OF CONFLICTING INTERESTS

We declare no potential conflicts of interests with respect to the authorship and/or publication of this article.

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