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Case Report



# Screening and Construction of Score Based Risk Factors Assessment Questionnaire for Earlier Detection of Type-2 Diabetes Mellitus among Tangail Population

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## Abstract

**Objectives:** Type2 Diabetes (T2D) incidence rate is increasing alarmingly among Bangladeshi population. A very few data are available in Bangladesh for T2D disease**.** The main objectives of this study were to estimate significant risk factors of diabetes mellitus for the Tangail population and develop a valid and non-laboratory based questionnaire to asses risk of diabetic incidence.

**Method:** A structured questionnaire was administered to 400 respondents from the Diabetic Care Center of Tangail district. The most significant risk factors were identified using Binomial logistic regression and area under the curve-receiver operating characteristics method (ROC). The scoring of risk assessment questionnaire was performed and a cut-off score was also determined with suitable specificity/ sensitivity ratios.

**Results:** T2D occurred most in the age of ≥ 45 (69.5%) which made age as the significant risk factor. Other major risk factors are family history or hereditary ($p<0.001$), irregular exercise ($p = 0.042$), red meat intake ($p<0.001$), gender ($p=0.033$), BMI ($p=0.039$), and waist circumference ($p=0.037$).

**Conclusions:** The final score based questionnaire could be a reliable tool for early assessment of type 2 diabetes among Tangail population.

**Keywords:** Diabetes Mellitus; Risk factors; Risk assessment questionnaire; ROC curve

## Introduction

Diabetes is a metabolic disorder, which is a foremost health problem in the world [1]. There are two major forms of diabetes, type 1 (previously called insulin-dependent diabetes mellitus, IDDM or juvenile-onset diabetes, an autoimmune disease resulting in the destruction of insulin- producing cells) and type 2 (previously called noninsulin-dependent diabetes mellitus, NIDDM or maturity-onset diabetes) [2]. In type 2 diabetes (T2D), the pancreas is usually producing enough insulin, but for unknown reasons the body does not respond to the insulin effectively, a condition known as insulin resistance and after several years, insulin production decreases [3]. At present, the diabetic population number in Bangladesh is 8.4million, which is expected to double by 2030, according to International Diabetes Federation (Islam and Rahman 2012). Moreover, (90- 95) % of the diabetic patients in Bangladesh have T2D [4]. But only a few population based studies on T2D are undertaken in Bangladesh which is not sufficient for proper management [5-9], and most of the studies done based on prevalence of T2D and assessment of different risk factors of T2D [10-15]. To realize the risk of T2D many developed countries already have made an approach to identify risk factors of T2D for their population and from these to develop a score based questionnaire subsequently such as Australia [16], Canada [17], Finland [18], Libya [19], Qatar [20], West Indies [21] etc. From the previous studies 16 risk factors were considered for T2D assessment in Tangail population which includes- age, gender, hereditary, previous health examination, use of anti-hypersensitive drugs, smoking, food habit, physical activity, body mass index (BMI), waist circumference, mental trauma, uptake of red meat, hypertension, heart disease [5-15]. Similar studies also done for other disease like asthma [22], and heart diseases [23,24]. Therefore, the aim of our study was to identify whether the significant risk factors from these16 extracted factors are associated with T2D in Tangail population and from these to make a score based risk evaluation questionnaire from which it will be possible to predict the occurrence of T2D earlier.

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**Table 1:** The frequencies and significance levels of the all fourteen risk factors.

| Variables | Total number of Respondents | % of total Respondents N=400 | Total number of Diabetes Patient | % of Diabetes Patient | % of Total with Diabetes Patient N=200 | P value <0.05 |
|---|---|---|---|---|---|---|
| **Age** | | | | | | |
| > 64years | 38 | 9.5 | 29 | 76.3 | 14.5 | <0.001 |
| 55-64 years | 72 | 18 | 45 | 62.5 | 22.5 | <0.001 |
| 45-54 years | 124 | 31 | 65 | 52.4 | 32.5 | 0.01 |
| 35-44 years | 120 | 30 | 44 | 36.7 | 22 | 0.019 |
| < 35years | 46 | 12 | 17 | 37 | 8.5 | 0.557 |
| **Gender** | | | | | | |
| Male | 230 | 57.5 | 126 | 54.8 | 31.5 | 0.033 |
| Female | 170 | 42.5 | 74 | 43.5 | 18.5 | |
| **BMI** | | | | | | |
| ≥ 25kg/m2 | 247 | 61.8 | 134 | 67 | 33.5 | 0.039 |
| < 25kg/m2 | 153 | 38.2 | 66 | 33 | 16.5 | |
| **Hereditary** | | | | | | |
| Yes | 215 | 53.8 | 145 | 67.44 | 72.5 | <0.001 |
| No | 185 | 46.25 | 55 | 29.72 | 28.5 | |
| **Medication** | | | | | | |
| Yes | 140 | 35 | 76 | 54.3 | 19 | 0.124 |
| No | 260 | 65 | 127 | 63.5 | 31.8 | |
| **Waist circumference** | | | | | | |
| ≥ 90cm for Male | 255 | 63.8 | 138 | 69 | 34.5 | |
| And ≥ 80cm for Female | | | | | | 0.037 |
| < 90cm for Male | 145 | 36.3 | 62 | 31 | 15.5 | |
| **Red meat** | | | | | | |
| Yes | 342 | 85.5 | 183 | 53.5 | 91.5 | 0.001 |
| No | 58 | 14.5 | 17 | 46.5 | 9.5 | |
| **Smoking** | | | | | | |
| Yes | 167 | 41 | 73 | 36.5 | 18.3 | 0.134 |
| No | 233 | 58 | 127 | 63.5 | 31.8 | |
| **Mental trauma** | | | | | | |
| Yes | 144 | 36 | 81 | 40.5 | 20.3 | 0.288 |
| No | 256 | 64 | 119 | 59.5 | 29.8 | |
| **Heart disease** | | | | | | |
| Yes | 93 | 23.2 | 64 | 32 | 16 | 0.107 |
| No | 307 | 76.8 | 136 | 68 | 34 | |
| **Systolic blood pressure** | | | | | | |
| ≥ 140mmHg | 73 | 18.3 | 42 | 21 | 10.5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| < 140mmHg | 327 | 81.8 | 158 | 79 | 39.5 | 0.098 |
| **Diastolic blood pressure** | | | | | | |
| ≥ 90mmHg | 73 | 18.3 | 42 | 21 | 10.5 | 0.098 |
| < 90mmHg | 327 | 18.8 | 158 | 79 | 39.5 | |
| **Food habit** | | | | | | |
| Everyday | 266 | 66.5 | 120 | 60 | 30 | 0.229 |
| Occasionally | 134 | 33.5 | 80 | 40 | 20 | |
| **Physical activity** | | | | | | |
| Yes | 130 | 31.5 | 55 | 28 | 14 | 0.042 |
| No | 270 | 68.5 | 145 | 72 | 36 | |

## Research Design and Methods

### Study design

First the population of Tangail was stratified according to diabetic or non- diabetic, gender and age. Then the principle of random sampling was used in each stratified area.

### Study area and Population

This study was conducted in Tangail district of Dhaka Division in Bangladesh over a period from January to May of 2012.Tangail was selected as a study area because it contains both rural and urban dwellers. The population of Tangail is 3253961 with nearly half male and female (50.02% male) (49.98% female) [5]. Data from 400 people with and without type 2 diabetes were collected from Diabetes Hospital of Tangail who came for regular check up in this hospital that covers the different Thana of this district by purposive sampling process. An ethical approval was obtained from the Research Ethics Committee of Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) hospital(Reference no: BIRDEM/Ethics/2012/45) before distributing the questionnaires .After an oral glucose tolerance test (OGTT) which includes both a fasting plasma glucose (FPG) and a 2-hour glucose level following administration of 75g of glucose, we selected 200 people who were type 2 diabetic patients and 200 people who were not diabetic patients. A diabetic patient was considered who had a fasting blood glucose leve l ≥ 7.0mmol/L and 2-hour post-prandial reading of ≥ 11.1mmol/L. Both men and women of 25-86 years ages were considered eligible as type 2 diabetic patients and for controls. After selection of type 2diabeticsand controls, the annual face-to-face survey was conducted in the hospital. The exclusion criteria was previously diagnosed diabetes, severe renal disease, disease with a strong impact on life expectancy, and therapy with drugs known to influence glucose tolerance (thiazide diuretics, artery -blockers, and steroids), patients with type1 diabetes who were confirmed by their general practitioner or doctors of that hospital as having type 1diabetes, gestational diabetes, and pregnant women.

### Questionnaire design

Based on a literature review a well-organized questionnaire was developed and tested with a pilot survey. The same questionnaires were designed for both type 2 diabetic patients and those free of diabetes (control group). Sixteen risk factors were selected from the literature review and data were collected based on these risk factors. After the pilot study, some necessary corrections and modifications were needed for the validity of the questions. The questionnaire was modified and 14 risk factors were selected for the final questionnaire. These 14 risk factors included age, gender, BMI (body mass index), hereditary, waist circumference, red meat intake, smoking, mental trauma, heart disease, systolic blood pressure, diastolic blood pressure, food habit(eating plentiful vegetables and fruits), physical activity (at least 30 minutes walking in morning and evening everyday including normal daily activity), and medication.

### Physical measurements

Weight was measured in kilogram and height in meter to obtain BMI as the ratio of weight to the square of heights in kilogram/meter$^2$. Calculations of weight from participants were done by weight machine without shoes and any objects in the pocket. The heights were taken from toes of bare feet to head. According to the revised standards for adult obesity in Asia obese, over weight and healthy weight was classified [25]. Waist circumference was measured midway between the lowest rib and top of the iliac crest in meters by meterscale; where waist circumferences ≥ 0.90 meter for males and ≥ 0.80 meter for females were considered a risk factor for T2D (Chen et al. 2010). Moreover, hypertension was also identified through WHO criteria as systolic blood pressure (SBP) ≥ 140mmHg and diastolic blood pressure ≥ 90mmHg or currently taking medication for high blood pressure. Zero mercury sphygmomanometer was used to measure SBP and DBP from left arm of participants while seated. Two reading were taken 5 minutes apart and the mean of the two was recorded as final blood pressure.

### Behavioral risk measurements

A positive response for physical activity of participants was considered those who usually do walking or physical work daily at least 30 minutes or more. Daily, occasional smokers and non-smokers were classified according to currently smoking habit of non-diabetic participants and previous smoking record of diabetic patients as a risk factor of T2D.

**Table 2:** The value of relative risk ratio and chisquare test of the seven selected risk factors are given below.

| Risk factors | ChiSquare | P value | Relative risk ratio(RR) | 95% CI |
|---|---|---|---|---|
| Age | | | | |
| >64 years | | <0.001 | 3.22 | 1.56-6.63 |
| 55-64 years | 26.98 | <0.001 | 1.66 | 1.07-2.57 |
| 45-54 years | | 0.01 | 1.101 | 0.821-1.476 |
| 35-44 years | | 0.019 | 0.578 | 0.422-0.793 |
| <35 years | | 0.557 | 0.586 | 0.321-1.03 |
| hereditary | 55.07 | <0.001 | 2.268 | 1.792-2.889 |
| Red meat | 10.667 | 0.001 | 1.826 | 1.225-2.929 |
| BMI | 4.234 | 0.039 | 1.258 | 1.010-1.583 |
| Physical activity | 4.114 | 0.042 | 1.269 | 1.007-1.629 |
| Waist circumference | 4.327 | 0.037 | 1.266 | 1.013-1.603 |
| gender | 4.512 | 0.033 | 1.259 | 1.017-1.569 |

**Table 3:** Results from the logistic regression analyses for predicting T2D and scores assigned to each variable.

| Variables | Odd ratio | 95% Confidence Interval | Score |
|---|---|---|---|
| **Age** | | | |
| ≥ 65 years | 6.73 | 2.16-19.143 | 7 |
| 55-64 years | 5.166 | 2.415- 14.732 | 5 |
| 45-54 years | 2.923 | 1.27-6.717 | 3 |
| 35-44 years | 1.334 | 0.614-2.897 | 1 |
| <35 years | 1 | | 0 |
| **Gender** | | | |
| Male | 1.7 | 0.721-2.868 | 2 |
| Female | 1 | | 0 |
| **BMI** | | | |
| ≥ 25kg/m2 | 1.8 | 0.533-2.89 | 2 |
| < 25kg/m2 | 1 | | 0 |
| **Hereditary** | | | |
| Yes | 4.8 | 2.591-8.264 | 5 |
| No | 1 | | 0 |
| **Physical Activity** | | | |
| No | 1.95 | 0.839-2.066 | 2 |
| Yes | 1 | | 0 |
| **Waist circumference** | | | |
| ≥ 90cm (male) and ≥ 80cm (female) | 1.76 | 1.048-2.596 | 2 |
| < 90cm (male) and < 80cm (female) | 1 | | 0 |
| **Red meat** | | | |
| Yes | 2.78 | 1.388-5.787 | 3 |
| No | 1 | | 0 |
| Total | | | 23 |

## Statistical analysis

Statistical Package for Social Sciences (SPSS, version14, SPSS Inc. Chicago, Illinois, USA) software was used to analyze obtained data for defining significant risk factors. 'Risk relative ratio' with 95% confidence interval (CI) of all risk factors was generated in the cross tabulation model. The significant and non-significant risk factors were classified on the basis of p-value that is described in Table1 and those with $p<0.05$ values were considered for the development of the final questionnaire. Significant risk factors were determined from relative risk ratio using the $\chi^2$ (chisquare) test. Scores of significant risk factors were calculated on the basis of odds ratio (OR) with 95% CI in the binary logistic model. Age ranges were established to find the highest risk age category. The final questionnaire was compared with hereditary and age prediction of accuracy level of the questionnaire through Receiver Operating Characteristic (ROC) curves. A score ranges for risk of developing T2D were established on the basis of the most appropriate sensitivity-specificity ratio of different cut-offs core points.

## Results

After pilot survey 14 risk factors were considered as variables for statistical analysis. Among these fourteen risk factors age and hereditary were more significant independent risk factors for diabetes. 69.5% of patients with diabetes were ≥ 45 years of age. Table 1 show the frequency of significant and non-significant risk factors and significant risk factors are separated here on the basis of their p value. Moreover, Table 2 describes that the prevalence of T2D of > 64 years group were 3. 22(RR) (95% CI, 1.56-6.63) times higher than individuals aged 55–64 years. In the same way, patients of 55-64yearshadprevalenceof T2D1.66 (RR) (95% CI, 1.07-2.57) times more likely than 45–54 years-old. Furthermore, the hereditary of diabetes (RR 2.268, 95% CI 1.792-2.889, $p<0.001$) and uptake of red meat ($p<0.001$, RR1.826, 95% CI1.225-2.929) were the most significant risk factors while BMI ($p=0.039$, RR1.258, 95% CI1.010-1.583), physical activity ($p=0.042$, RR1.269, 95% CI1.007-1.629) and waist circumference

**Table 4:** Sensitivity, specificity, positive and negative predictive values and likelihood ratios for the selected risk point levels

| Criterion | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | LR(+) | LR(-) |
|---|---|---|---|---|---|---|
| ≥10 | 97 | 28 | 57 | 90 | 1.34 | 0.1 |
| ≥11 | 91 | 35 | 58 | 79 | 1.4 | 0.26 |
| ≥12 | 81 | 49 | 61 | 72 | 1.58 | 0.39 |
| ≥13 | 72.5 | 58 | 63 | 68 | 1.71 | 0.47 |
| ≥14 | 59 | 71 | 67 | 63 | 2.03 | 0.57 |
| ≥15 | 52 | 77 | 70 | 62 | 2.26 | 0.62 |
| ≥16 | 45 | 85 | 76 | 60 | 3 | 0.64 |
| ≥17 | 31 | 91 | 78 | 57 | 3.4 | 0.75 |
| ≥18 | 25 | 95 | 83 | 56 | 5 | 0.78 |

**Table 5:** Score ranges with corresponding risk rating.

| Score range | % with diabetes | Risk rating |
|---|---|---|
| 0-8 | 3 | negligible |
| 12-Sep | 34 | Low |
| 13-16 | 73 | High |
| ≥ 17 | 90 | Very high |

(measure of obesity) (p=0.037, RR1.26, 95% CI 1.013-1.603) were found as significant risk factors from their independent relative risk ratio.

Seven risk factors were eliminated because they were not significant including food habit, mental trauma, heart disease, medication, SBP and DBP. A history of smoking was omitted in this analysis because most females in our country are not habituated with smoking for their religion or social rituals and male patients could not quantify units of smoking accurately. The characteristics and significance levels of the all risk factors were displayed in Table1.

The odds ratio for all the off to the nearest integer to obtain the final score points for the variables ranges and these score points were shown in Table 3. The total score points obtained in the score card was 23. However, the entire sample of 400 participants yielded an AUC of 0.836 for the seven risk factors (total risk associated questionnaire) in both ROC curves (Figure1). The total risk associated questionnaire (AUC0.836) was significantly better than age (AUC0.640) and hereditary (AUC0.688). Before choosing a minimum score, several cut-off scores were examined with respect to specificity and sensitivity Table 4. 97% sensitivity was found for score of ≥ 10 with acceptable specificity. However, a cut-off score of 18 was chosen with a high specificity (95%) to minimize additional testing and false positive results to maximum 5%. On the basis of percentage of diabetic patients, risk scores were divided into four categories (negligible, low, high and very high) (Table 5). Age, gender, waist circumference, BMI, physical activity and red meat- risk factors were combined to form a modifiable risk factors score (9 modifiable Criterions in total). The positive likelihood ratios (LR+) were >1.0 whereas; the negative likelihood ratios (LR-) were<1.0 for all score categories (Table 4).

## Discussion and Conclusion

The World Health Organization (WHO) ranked 10 countries according to the highest diabetic patients where Bangladesh was in 10$^{th}$ position for 2000 and will be the 7$^{th}$ position for 2030 (**1**). The risk assessment tools for T2D diabetes has been developed for diagnosis of T2D at early stage on the basis of 7 risk factors (age, hereditary, physical activity, red meat, BMI, waist circumference and gender) were identified as significant risk factors ($p<0.05$) and these risks factors are easily self-assessed.

Among the risk factors, age, hereditary and uptake of red meat were the most significant followed by BMI. Smoking and alcohol were not significant. This may be attributed to the Tangail people's lifestyle. In the Tangail district the majority of people live in rural areas. BMI, waist circumference and smoking received higher scores in the final questionnaire of many countries like AUSDRISK [16], CANRISK [17], and TRAQ-D [21]. This may be since Asian people have smaller waist circumferences and BMI than in people of Europe origin [10]. The people aged >64 were at the highest risk to attain T2D; whereas, the lowest score was found for people of <35years. Moreover, the prevalence of T2D in the individuals aged 55-64 were higher than aged 45-54 and 35-44. The results were consistent with other studies conducted in Bangladesh [10-13]. The prevalence of diabetes increased with increasing age. Hereditary was the second most proximal risk factor in the Tangail area. Hereditary was a leading risk factor for 53.5% of T2D patients. Some studies also found strong relation between family history and T2D incidence [10,14,15]. The percentage of male participants (54.8%) with T2D was higher than that of female participants (43.2%). This data was supported by the IDF atlas which reported that 63% of the T2D patients were male [26]. In contrast, most of the studies conducted in Bangladesh found higher occurrence of the disease among female (8, 13, 14, and 27). Therefore, gender and life style of people play a significant role in T2D occurrence. Lifestyle variables consist of four risk factors-BMI, waist circumference, physical activity and red meat uptake. Approximately one-third (36%) of diabetic patients did not meet minimum physical activity requirements (30 minutes, twice per day), making low physical activity a significance risk factor. On the other hand, 39.5% of the total diabetic patients consumed red meat making it on par with low physical activity as a risk factor. To our knowledge it is the

first study which included red meat intake history as variables. Moreover, 17.5% of the total diabetic patients were overweight: 17.8% had BMI >25 and17.8% of the total diabetic patient had waist circumference over 90. This result was similar with the other studies of Bangladesh [17-24]. The score points from the four risk factors were considered as modifiable risk factors. The mean numbers of modifiable risk factors among patients without and with diabetes < 65 years were 2.03 and 6 respectively. Among diabetic patients, 95% had a modifiable risk factor score of > 3. If they ceased eating red meat, reduced their weight and decreased t heir waist circumference and engaged in walking continuously for 30 minutes twice per day, overall 65% of all participants could have reduced their diabetic risk score by an average of 6.4 points.

A risk estimate can be made on the basis of a combination of risk factors, rather than using a single cut-off value. A positive likelihood ratio >1.0 for a diagnostic test is considered to be strong evidence to' rule in' disease, where as a negative likelihood ratio < 1.0 is considered sufficient evidence to' rule out' disease. From the Table 5, it was found that if any participant does score ≤ 8, it can be considered as negligible score. This is because in this range, presentence diabetic patient was very low. Similarly, the range of score points-9-11, 12-15, ≥ 16 were considered as low, high, very high risk respectively as prevalence of T2D.

In the conclusion, a simple and easily self-administered scorecard can be developed using statistically significant risk factors. This could be a screening tool for the population of Tangail for the early detection of T2D. The final questionnaire prepared from this study was an approach to predict T2D among Tangail population. This score-based T2D risk assessment tool may play a role in assessing current risk of occurring T2D and prevalence of T2D for next 5 or 10 years of Tangail people. Moreover, this tool can be used in public health campaigns and public health care centers of Tangail.

## Limitation and Further study

The limitations of the study were the small sample size and that ethnicity is not included as a risk factor. Another limitation could be that smoking, hypertension and food habits were not found as significant risk factors because most of the participants in this study were from rural areas where there are healthier lifestyles than in urban areas. Future studies should be conducted with are presentative sample of Bangladesh people including urban, rural and tribal people of different areas of Bangladesh. These studies should consider additional relevant demographic and clinical measures.

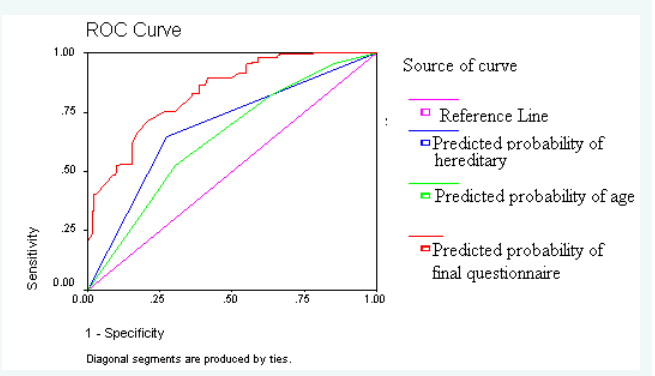


**Figure 1** Significance level of Total Risk Associated Questionnaire against only age or hereditary for the entire sample.

## Ethical Consideration

During collection of data written consent was taken from literate volunteers both in English and native language and verbal consent was taken from those who are ill.

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## Authors' Contributions

UF conceived the research idea and perform the data collection. UF, MM and PJ actively involved in the data collection and PJ, UF perform the statistical analysis and results preparation. AAE and AHT helped in designing the study and supervision of the work. UF, MM and PJ prepared the manuscript. AHT and AAE contributed intellectual thought, final revision and editing of the manuscript. All authors have read and approved the submitted version of manuscript.

## Competing Interests

The authors declare that they have no competing interests.

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