

## Original Article

# Prediction of HbA1c from Fasting Plasma Glucose: Comparison between Uncontrolled and Controlled Diabetes Mellitus among Adults in a Tertiary Care Hospital of Bangladesh

Parvin Akter Khanam<sup>1\*</sup>, Tanjima Begum<sup>1</sup>, Md Morshed Alam Khan<sup>2</sup>, Samira Humaira Habib<sup>3</sup>, A K Azad Khan<sup>4</sup>

## Abstract:

**Background and Objective:** Diabetes Mellitus has emerged as a major public health problem globally and uncontrolled diabetes mellitus plays important role to develop micro and macro vascular complications. So the present study is done to determine the prevalence of uncontrolled diabetes and to predict the HbA1c from the fasting plasma glucose (FPG) level for Type 2 diabetes mellitus (T2DM) patients.

**Method:** Cross-sectional study was conducted in adult out-patients department of BIRDEM Hospital, Dhaka from January 2019 to June 2019. Data were collected from diabetes guide book of patients who had tested FPG and HbA1c from the same blood sample. For determining the relationship between FPG and HbA1c, linear regression equation was used.

**Result:** A total of 554 T2DM patients were taken for this study. Of the total participants, male and female were 52.1% and 47.9% respectively. Mean±SD of age, FBG and HbA1c were 51.6±10.51 years, 10.89±4.14 mmol/L and 8.83±1.82% respectively. According to this study prevalence of controlled HbA1c (≤7.0%) and FPG (≤7.2mmol/L) were 16.6% and 18.6% respectively by ADA criteria. The prediction model between HbA1c and FPG, expressed as  $HbA1c = 5.369 + 0.32 FPG$  ( $R^2 = 0.529$ ,  $p < 0.001$ ) in the study subjects. The study found that the HbA1c level increased by approximately 0.32% per increment of 1.0 mmol/L in FPG.

**Conclusions:** The authors observed that the prevalence of uncontrolled HbA1c (>7.0%) and FPG (>7.2mmol/L) were 84.7% and 81.9% respectively based on ADA criteria. The study also concluded that HbA1c level could be predicted from FPG by using regression equation.

**Keywords:** Diabetes Mellitus, Glycated Hemoglobin, Prediction, ADA.

## Introduction:

Among the non-communicable diseases type 2 Diabetes Mellitus is one of the most alarming across the world as well as in Bangladesh. The slow onset of the disease, delayed detection, unhealthy dietary habits and lack of physical activities make the disease far more common in developing countries. Globally 463 million adults are living with diabetes<sup>1</sup>. Multiple chronic complications in patients with

long term uncontrolled diabetes creates a large number of economic and social burdens in the society<sup>2,3</sup>. In 2019, the American Diabetes Association (ADA) has recommended that HbA1c ≤7% can reduce the development and progression of vascular complications<sup>4</sup>. Previous studies such as Diabetes Control and Complications (DCCT), United Kingdom Prospective Diabetes Study (UKPDS) and Action in Diabetes and Vascular Disease (ADVANCE) in type 2 diabetes-confirmed that improved glycemic control significantly reduced the risk of microvascular complications, but it had no significant effect on cardiovascular (CV) outcomes<sup>5-7</sup>. Though, the secondary end point of all-cause death, stroke and Myocardial Infarction was significantly decreased by 16%. Therefore, glycemic control is fundamental rule to manage diabetes as well as to prevent vascular complications.

Thus, this study was taken to measure the prevalence of uncontrolled diabetes and to establish if HbA1c levels can be predicted from FPG level.

## Methods:

The study was cross-sectional and conducted in out-patients department of BIRDEM General Hospital during the period from January, 2019 to June, 2019. Patients who visited out-patients departments of BIRDEM General Hospital with Type 2 diabetes mellitus & aged ≥ 20 years were included in

1. Department Epidemiology and Biostatistics, BIRDEM General Hospital, Dhaka, Bangladesh.
2. Department of General Laboratory, BIRDEM General Hospital, Dhaka, Bangladesh
3. Health Economics Unit, Diabetic Association of Bangladesh (BADAS), Dhaka, Bangladesh
4. President, Diabetic Association of Bangladesh (BADAS), Dhaka, Bangladesh

## \*Corresponding Author:

Parvin Akter Khanam, PhD  
Associate Professor,  
Department Epidemiology and Biostatistics,  
BIRDEM General Hospital  
122, Kazi Nazrul Islam Avenue, Dhaka, Bangladesh.  
E-mail: parvin\_khanam@yahoo.com

the study. Patients with newly diagnosed type 2 diabetes mellitus, with type 1 diabetes mellitus & Gestational diabetes mellitus were excluded.

All patients' history and clinical parameters were taken from their personalized diabetic guide book. Study data included age, gender and lab parameters like FPG and HbA<sub>1c</sub>.

**Statistical Analysis:**

The statistical analysis was performed using SPSS version 20. Data were described as simple percentage. Mean with standard deviation (SD) were used for continuous variables. The association between FPG and HbA<sub>1c</sub> was examined using linear regression models and P value ≤ 0.05 was considered statistically significant.

**Results:**

A total 554 T2DM patients who met the inclusion criteria were studied. Of the total subjects, mean age was 51.62 ± 10.90 years and was ranges 22 to 80 years. The mean FPG and HbA<sub>1c</sub> were 10.9±4.29 mmol/L and 8.86±1.89 mmol/L respectively. Majority of the patients was in the age group of 40-50 and 50-60 years which were 30.5% and 31.9% respectively. About 18.0% participants were below or equal to 40 years of the age group and 19.6% of patients had age of older than 60 years (Table 1). Of the total participants, the male and female were 53.2% and 46.8% respectively. Approximately 18.1% patients had controlled (FPG ≤ 7.2mmol/L) diabetes and most of the patients had uncontrolled FPG (81.9%) by ADA criteria. Only 15.3% patients had controlled HbA<sub>1c</sub> (≤7.0%) and rest of patients had uncontrolled HbA<sub>1c</sub> (84.7%) i.e; below recommended level (Table 2)

**Table 1:**

Variables	N	Min	Max	Mean	SD
Age Yrs.	551	22	80	51.62	10.903
FPG mmol	554	4.3	35.1	10.901	4.2970
HbA <sub>1c</sub> %	554	5.5	16.2	8.858	1.8904

**Table 2:**

Variables	Number (%)
<b>Gender</b>	Male 295 (53.2%)
	Female 259 (46.8%)
<b>Age:</b>	≤ 40y 99(18.0%)
	40-50y 168(30.5%)
	50-60y 176(31.9%)
	>60 108(19.6%)
<b>FPG:</b>	≤ 7.2 100(18.1%)
	>7.2 454(81.9%)
<b>HbA<sub>1c</sub>:</b>	≤ 7.0 85 (15.3%)
	> 7.0 469 (84.7%)

By using linear regression model, prediction between HbA<sub>1c</sub> and FPG in the study population, expressed as HbA<sub>1c</sub> = 5.369 + 0.32× FPG (R<sup>2</sup> = 0.529; p<0.001), is shown in Fig.1. The HbA<sub>1c</sub> level increased by approximately 0.32% per increment of 1.0 mmol/L in FPG. Based on these calculations, the correspondence of HbA<sub>1c</sub> to specific FPG was shown in Table 3. In this table, we found that FPG of 5.6 and 7.0mmol/L and the predicted HbA<sub>1c</sub> were 7.39% and 7.61% respectively. However, the FPG of 8.0 and 10.0mmol/L and predicted HbA<sub>1c</sub> were 7.93% and 8.57% respectively. These results showed that when FPG ranges from 5.6 to 7.5 mmol/L, their corresponding regression estimated HbA<sub>1c</sub> was increasing gradually (HbA<sub>1c</sub>:7.39% to 7.77%) in study population. When FPG range from 8.0 to 15.1 mmol/L indicating uncontrolled DM than their corresponding actual HbA<sub>1c</sub> and regression estimated HbA<sub>1c</sub> did not increase in the same pace. There is a downward trend of gradual increase in both actual and regression estimated HbA<sub>1c</sub> in uncontrolled FPG in contrast with controlled FPG.

**Table 3**

Study Population		Regression Estimated HbA <sub>1c</sub> (%)
FPG	HbA <sub>1c</sub>	
5.6	6.6	7.39
6.0	7.7	7.29
6.5	6.3	7.45
7.0	7.2	7.61
7.5	7.4	7.77
8.0	8.8	7.93
8.5	8.8	8.09
9.0	9.3	8.25
9.5	9.2	8.41
10.0	9.5	8.57
10.5	9.4	8.73
11.0	8.6	8.89
11.5	10.4	9.05
12.0	8.3	9.21
13.0	9.7	9.53
14.0	9.4	9.85
15.1	10.0	10.20

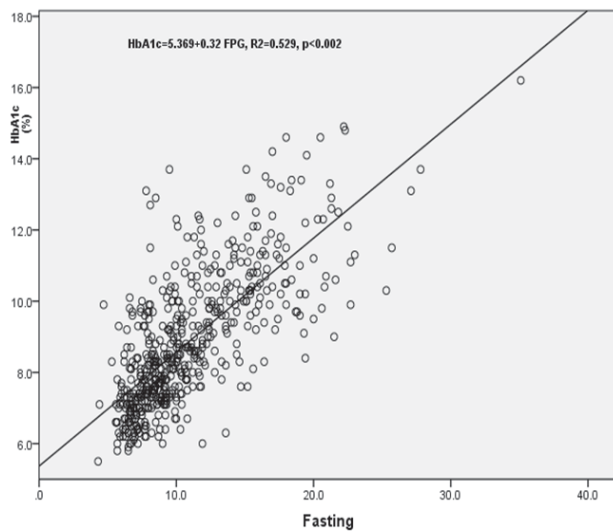


Fig. 1

### Discussion:

Diabetes is a complex and chronic illness all over the world. It is well known fact that poor glycemic control increases the risk of micro and macro vascular complications. Continuous medical support can help the patients with multifactorial risk-reduction strategies beyond glycemic control. Glycemic control is to prevent acute complications and reducing the risk of long-term complications. The American Diabetes Association (ADA) has been actively involved in the development and dissemination of diabetes care standards and guidelines related documents for 25 years<sup>4</sup>. ADA's current clinical practice recommendations are viewed as important resources for health care professionals who care for people with diabetes. Therefore, we studied glycemic status in our diabetic patients by ADA criteria and to predict the HbA1c from the FPG level using regression equation for T2DM subjects.

The key focus of diabetes management should be adequate control of blood glucose level and to reduce the progression of different types of vascular complications. This study found that most of the patients (84.7%) had uncontrolled glycated hemoglobin (HbA1c) >7% and only 15.3% patients had controlled diabetes based on ADA criteria. In a study done by Borgharkar SS *et al*, the prevalence of uncontrolled HbA1c >7.0% was 76.6%, which was lesser when compared with our study<sup>8</sup>. Another study done by Anusuya GS *et al*. reported the prevalence of uncontrolled blood sugar levels among known diabetics was 65.4% in south Chennai<sup>9</sup> which was also lesser than in our study. The United Kingdom Prospective Diabetes Study in type 2 diabetes and the DCCT in type 1 diabetes confirmed that glycemic control significantly reduced both microvascular and cardiovascular (CV) complications<sup>11-13</sup>. Therefore we also suggest that it is necessary to control the blood glucose level in diabetic patients to reduce the vascular complications.

This study also found a close association between HbA1c and FPG levels for T2DM which is in concordance with the other recent study<sup>10</sup>. The HbA1c level corresponding to FPG of 6.0

mmol/L was 7.7% in the study subjects and predicted HbA1c was 7.29%. Similarly, FPG of 7.0 mmol/L and corresponding HbA1c was 7.2% in the study population and predicted HbA1c was 7.77%. However, in the subjects with uncontrolled diabetes by the HbA1c criteria, 8.0 and 9.0 mmol/L of FPG and their corresponding HbA1c were 8.8% and 9.3% and predicted HbA1c were 7.93% and 8.25% respectively for the study subjects. These results suggested that controlled diabetic subjects had slightly increasing estimated HbA1c level but uncontrolled diabetic subjects had slightly decreasing estimated HbA1c level with corresponding FPG. So the study noted that if the FPG level is known, it will be possible to calculate its predicted HbA1c. But prediction will differ between controlled and uncontrolled group. To our knowledge, it was the first epidemiological study showing the correlation between FPG concentrations and HbA1c levels in our population. These findings will likely benefit the patients and their treating physicians to ensure optimal glycemic control. This has the potential to reduce the overall healthcare expenditures in our country by reducing complication of DM.

### Conclusion:

The study showed the prevalence of uncontrolled HbA1c (>7.0%) and FPG (>7.2mmol/L) to be 84.7% and 81.9% respectively based on ADA criteria. The study also concluded that HbA1c level could be predicted from FPG by using regression equation. Large-scale longitudinal study is needed to determine more precisely the relation between HbA1c and FPG.

**Acknowledgement:** We are grateful to the Diabetic Association of Bangladesh for allowing us to conduct the study in BIRDEM General Hospital.

### References:

1. IDF Diabetes Atlas. 9<sup>th</sup> edition 2019
2. [https://www.diabetes.org/resources/statistics/statistics-about-diabetes?language\\_content\\_entity=en](https://www.diabetes.org/resources/statistics/statistics-about-diabetes?language_content_entity=en). It is a snapshot of the page as it appeared on 22 Nov 2019 13:34:04 GMT.
3. Yokoyama H, Oishi M, Takamura H, Yamasaki K, Shirabe S, Uchida Det al. Large-scale survey of rates of achieving targets for blood glucose, blood pressure, and lipids and prevalence of complications in type 2 diabetes (JDDM 40). *BMJ Open Diabetes Research and Care* 2016;4:e000294. doi:10.1136/bmjdr-2016-000294.
4. American Diabetes Association (ADA). Glycemic Targets: Standards of Medical Care in Diabetes-2019. *Diabetes Care* 2019; 42 (1): 61-70. <https://doi.org/10.2337/dc19-S006>.
5. Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993; 329(14): 977-986.
6. Adler AI, Stratton IM, Neil HA, Yudkin JS, Matthews DR, Cull CA *et al*. Association of systolic blood pressure with macrovascular and microvascular complications of type 2 diabetes (UKPDS 36): prospective observational study. *BMJ* 2000;321:412-419.

7. ADVANCE Collaborative Group. Intensive bloodglucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2008;358 (24):2560–2572.
8. Borgharkar SS, Das SS. Real-world evidence of glyceimic control among patients with type 2 diabetes mellitus in India: the TIGHT study. *BMJ Open Diab Res Care* 2019;7:e000654. doi:10.1136/bmjdr-2019-000654
9. Anusuya GS, Ravi R, Gopalakrishnan S, Abiselvi A, Stephen T. Prevalence of undiagnosed and uncontrolled diabetes mellitus among adults in South Chennai. *Int J Community Med Public Health* 2018;5:5200-4
10. Hong S, Kang JG, Kim CS, Lee SJ, Lee CB, Ihm SH. Fasting plasma glucose concentrations for specified HbA1c goals in Korean populations: data from the Fifth Korea National Health and Nutrition Examination Survey (KNHANES V-2, 2011). *Diabetol MetabSyndr.* 2016;8(1):62. doi: 10.1186/s13098-016-0179-8.
11. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998; 352:837-53.
12. UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet* 1998; 352(9139): 854-65.
13. Diabetes Control and Complications Trial (DCCT)/ Epidemiology of Diabetes Interventions and Complications (EDIC) Study Research Group. Intensive diabetes treatment and cardiovascular outcomes in type1 diabetes: The DCCT/EDIC study 30-year follow-up. *Diabetes Care* 2016; 39:686-93