Human Biology Review
www.humanbiologyjournal.com

Human Biology Review (ISSN 22774424) 10(3) 2021
Original scientific paper (Hasnin et al., 265-281)
Modified and Accepted on June 24, 2021

Effect of socio-demographic, behavioral, biochemical factors and knowledge regarding diabetes on glycemic control among type 2 diabetes patients: A hospital based cross-sectional study

K. Hasnin[1], M.M.Haque[2], M.M.U.Rashid[3], M.R. Karim[4] and M.G. Hossain[5]

Citation: Hasnin K, Haque MM, Rashid MMU, Karim MR and Hossain MG. 2021. Effect of socio-demographic, behavioral, biochemical *factors and knowledge regarding diabetes on glycemic control among type 2* diabetes *patients: A hospital based cross-sectional study. Human Biology Review, 10 (3), 265-281.*

[1]Kaniz Hasnin, Rajshahi Daibetic Association General Hospital, Jhaotola, Rajshahi, Rajshahi-6000, Bangladesh. E-mail: kanizhasnin@gmail.com
[2]Md. Monwarul Haque, Rajshahi Daibetic Association General Hospital, Jhaotola, Rajshahi, Rajshahi-6000, Bangladesh. E-mail: haque.mdmonwarul@gmail.com
[3]Md. Mamun Ur Rashid, Rajshahi Daibetic Association General Hospital, Jhaotola, Rajshahi, Rajshahi-6000, Bangladesh. E-mail: profmamun@gmail.com
[4]Md. Rezaul Karim, Department of Biochemistry and Molecular Biology, University of Rajshahi, Rajshahi-6205, Bangladesh. E-mail: drmrkarim@yahoo.com
[5]Md. Golam Hossain, Heath Research Group, Department of Statistics, University of Rajshahi, Rajshahi-6205, Bangladesh. E-mail:hossain95@yahoo.com
Corresponding author: Md. Golam Hossain, Heath Research Group, Department of Statistics, University of Rajshahi, Rajshahi-6205, Bangladesh. E-mail:hossain95@yahoo.com

ABSTRACT

Background: *Diabetes mellitus (DM) has become a major public health concern worldwide. The aim of this study was to investigate the factors affecting glycemia in type 2 diabetics in Rajshahi, Bangladesh.*

Methods: *A cross-sectional study was carried out on a total of 482 T2DM patients in Rajshahi. All available last readings for blood glucose (FBS and 2 h ABF), HbA1c, lipid profile, and other clinical characteristics were obtained from patients' records. Chi-square test and multivariable binary logistic model were applied in this study.*

Results: *64.2% DM patients was observed to have no glycemic control (FBS≥6.1mmol/L, HbA1c≥6.0). Multivariable binary logistic regression model provided the following twelve predictors of glycemic control: (i) knowledge on diabetes (p<0.01), (ii)* triglyceride (p<0.01), (iii) *low-density lipoprotein (p<0.05), (iv) hypertension (p<0.01), (v) dietary modulation (p<0.01), (vi) anti-diabetic drug (p<0.01), (vii) regular attended health education (p<0.01), (viii) financial support (p<0.05), (ix) family support (p<0.01), (x) regular hospital visit (p<0.01), (xi) diabetic relative (p<0.01) and (xii) patients' education (p<0.01).*

Conclusion: *A combined negative effects of several factors on the poor glycemic control was observed in this study. Health education and self-motivation of patient and family awareness are to be intensified by the health authorities of Bangladesh.*

Key words*: Glycemia; lipid profile; dietary modulation; health education; literacy*

INTRODUCTION

Currently, diabetes mellitus is a major cause of morbidity and mortality (Ajlouni et al., 2008). Globally, the number of affected people has exceeded 422 million in 2014 (WHO, 2016). There is an increasing tendency with assumed prevalence of 7.7%, particularly in low- and middle-income countries (Sanal et al., 2011). According to International Diabetes Federation report, prevalence will rise to 13% by 2030 (Akhter et al., 2014). Number of death in adult due to diabetes is estimated to be 3.96 million per year and mortality rate of diabetes in all ages is 6.8% at global level (Khanam et al., 2008). In Bangladesh, several small scale studies had been undertaken over the past few years which revealed an increasing prevalence of diabetes (King et al., 1993; Sayeed et al., 2003). Based on the present prevalence rates of T2DM (5.2%) and IGT (12.5%), more than 10 million Bangladeshi would suffer from DM by 2025 (Mohiuddin, 2019). Diabetes registry in Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorder (BIRDEM), a referral hospital in Bangladesh also reveals an increasing trend of the disease in the country supporting the above mentioned trend (Unnikrishnan et al., 2007).

Diabetes mellitus (DM) is a major public health problem in worldwide, and it is a major cause of morbidity and mortality especially in low-and middle-income countries. Bangladesh is a developing country where health and medically related reforms are being actively implemented. There is no adequate health facility to provide the essential services for the huge number of diabetes patients in Bangladesh. A large number of patients fail to keep their biochemical parameters to baseline.

There are some diabetes centers and hospitals in Rajshahi city, which is one of the biggest cities in Bangladesh. The biggest diabetes hospital is Diabetic Association General Hospital (RDAGH) in Rajshahi. The group lectures are destined by only RDAGH in Rajshahi city to generate awareness, self-education with respect to precise calorie maintenance, life style modifications, and drug treatment. But unfortunately a large number of patients fail to keep their blood glucose and other baseline biochemical parameters within limit. No exact data is available to assess the role and contribution of patients, doctors and health professionals to bring the hospital service to a satisfactory level and minimize the number of uncontrolled diabetic patients. With this end in view, a cross-sectional analytical study (Adeniyi et al., 2016) was planned to find out the exact causes contributing to poor control, thereby taking necessary measures to improve the quality of service.

In this study, we aimed to (i) determine the prevalence of no glycemic control (FBS≥6.1 mmol/L, HbA1c≥6.0) among DM patients; (ii) identify the risk factors of glycemia control in type 2 diabetics in Rajshahi, Bangladesh.

We hope our findings will be of significant help to the authorities of diabetes centers and hospitals in Bangladesh as well to the health authorities of Bangladesh government to improve their policy for controlling glycemia among DM patients in Bangladesh.

METHODS

Study design, period and population: A descriptive cross-sectional study was conducted to determine the prevalence of glycemic control and its associated factors among DM patients at the Rajshahi Diabetic Association General Hospital (RDAGH) over a period of 1 year (July 2018-June 2019). It has registered 97,362 patients since 1986 till April, 2019. About 300 diabetics attend this hospital daily for their total management that includes clinical investigation, medical advice, diet therapy and group lectures. The study population was all T2DM patients who visited the outpatient department (OPD) of RDAGH during the study period and fulfilled the inclusion criteria.

Inclusion and exclusion criteria: All T2DM patients within an age range of 20-79 years who volunteered to give information about their knowledge, attitude, and practice towards glycemic control were included in the study. Patients with severe comorbidities such as coronary artery disease (CAD), cerebrovascular disease (CVD), peripheral vascular disease (PVD), chronic kidney disease (CKD- eGFR<30 ml/min/1.73 m^2), moderate to severe non proliferative and proliferative diabetic retinopathy, mental health problems, hearing impairments and those unable to provide the appropriate information were excluded from this study.

Sample size and sampling technique: The following formula was used to calculate the sample size for this study:

$n = \frac{z^2 p\,(1-p)}{d^2}$, where n is the number of required sample size, p is the proportion of DM control case, (p = 0.50), d is the margin of error (here, d = 0.05) and 95% confidence interval (CI) was considered (z=1.96). The formula provided that the sample size 385 was adequate for this study. Initially, we considered 525 samples (non-responds rate 2%) for getting more accurate results but 25 patients did not agree to provide their information. Finally, 500 patients were selected for collecting their information. We excluded abnormal and missing values; after exclusion 482 samples were analyzed.

Data collection procedure: Data were collected by two trained postgraduate students using a self-developed questionnaire which was draft, and sent to some experts for taking their opinions/suggestion to improve it. According experts' comments/suggestion the questionnaire was modified and finalized for data collection. The original questionnaire was in English, and the revised questionnaire was translated into Bangla (mother tongue of Bangladesh), and the Bangla questionnaire was checked by two authors. A pilot survey had been done for observing whether there was any lacking or drawback in the questionnaire. We did not get lacking or drawback. The objective of this study was explained in details to selected patients and their written consent was taken. Data were recorded in the formatted data sheet and analyzed.

The outcome variable of this study was glycemic control of DM patients. Screening of glycemic status was based on fasting blood glucose and HbA1C. The value of FBS≥6.1 mmol/L and HbA1c≥6.5, was considered as glycemic no control (code, 0), and the value of FBS<6.1mmol/L and HbA1c<6.5 was regarded as glycemic control (code, 1). The independent variables were socioeconomic, demographic, behavioral, biochemical parameters and duration of diabetes mellitus. Most of the variables were considered for this study on the basis of previous literature (4-6). In addition we considered patients' knowledge on diabetes as independent factors. Knowledge about glycemic control was assessed using 10 general questions which were considered to be known by diabetic patients like the importance of glycemic control, risk factors, and complications of poor glycemic control. Each correct response was scored as "1" and each incorrect response scored as "0". Knowledge scores of individuals were calculated and summed up to give the total knowledge score. Participants who correctly responded to 1-5 questions were supposed to have fair knowledge and those answering 6-10 questions were considered as having good knowledge about glycemic control, whereas those who scored 0 were considered as having poor knowledge about glycemic control.

Statistical analysis: Frequency distribution was used to calculate the percentage of T2DM controlling status. Chi-square and multivariable logistic regression model were applied to find the effect of selected independent variables on outcome variable (T2DM controlling status). The magnitude of the standard error (SE) was used for detecting the multicollinearity problem among the independent variables in multivariable logistic model, if the magnitude of the SE lies than 0.5, it is judged that there is no evidence of multicollinearity (Chan , 2004). All statistical analyses were carried out using SPSS (IBM version 21), and statistical significance was accepted at $p < 0.05$.

Ethics statement: The protocol of this study was submitted to ethical review committee of Rajshahi Diabetic Association for approval. This committee approved the study protocol and provided clearance letter (RDA/Raj/ERC Approved/35/2017). We also got permission from RDAGH authority for contacting with T2DM patients attending the OPD of the hospital. We had taken written consent from each selected DM patients.

RESULTS

A total of 482 T2DM patients were finally considered in this study as a sample to investigate the status of diabetes control among patients who were receiving hospital service from RDAGH, Rajshahi, Bangladesh. It was noted that a remarkable number (64.2%) of patients had no diabetes control in spite of the required service provided (Figure).

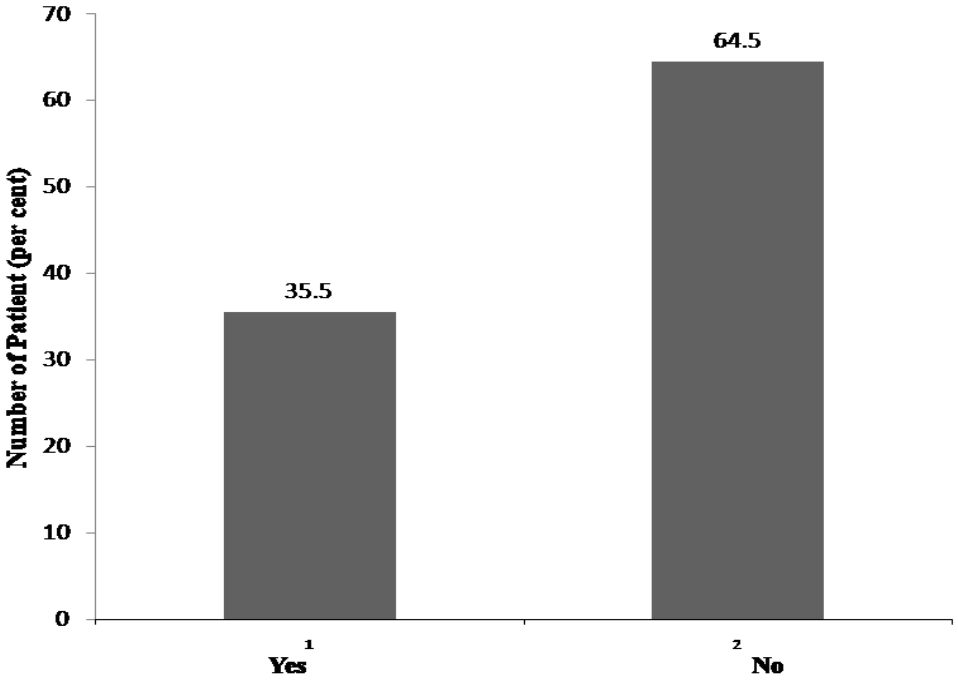

Figure: Prevalence of the glycemic control among selected patients. Screening of glycemic status was based on fasting blood glucose and HbA1C (FBS≥6.1mmol/L, HbA1c≥6.5) data

Table 1 summarizes the socio-demographic characteristics of the study samples at RDAGH, Rajshahi. The data revealed that the highest percentage (39.2%) of the patients fell into the 51-60 age group, females were higher in number (50.41%) than males, secondary education group was the largest literacy group (47%) and housewives were the largest occupation group (44.82%) among the samples. Most of the patients were from urban area (Table 1).

Table 1: Socio-demographic characteristics of the study samples at RDAGH, Rajshahi

Variables	Category of T2DM patients	Frequency	Percentage (%)
Age	<30 years	16	3.2
	31-40 years	50	10
	41-50 years	117	23.4
	51-60 years	196	39.2
	61-70 years	108	21. 6
	71-80 years	23	4. 6
Sex	Male	239	49.58
	Female	243	50.41
Literacy	Illiterate	67	13.4
	Primary	95	19
	Secondary	235	47
	Higher	103	20.6
Occupation	Government employee	64	12.98
	Business	71	14.4
	Farmer/ Day laborer	29	5.88
	Unemployed/Retired	79	16.02
	Housewife	221	44.82
	Others	29	5.88

The association of diabetes control with educational status, socio-economic, behavioral, and biochemical factors among selected patients is presented in Table 2. In this Table, only the significantly associated factors are presented. These significantly associated factors were again considered as independent variables in multiple binary logistic models for determining their effect on diabetes control among T2DM patients. The χ^2-test showed the association between diabetes control and the patients education level ($p<0.01$), dietary modulation ($p<0.01$), anti-diabetic drug ($p<0.05$), regular health education ($p<0.01$), triglyceride (TG) ($p<0.01$), current treatment received ($p<0.01$), financial support ($p<0.05$), family support ($p<0.01$), regular exercise ($p<0.01$), regular hospital visit ($p<0.01$), Hypertension (DBP) ($p<0.01$), Low density lipoprotein (LDL) ($\geq$100) ($p<0.01$) and diabetic relative ($p<0.01$). Additionally, it was noted that the number of patients controlling diabetes increased with increasing their level of knowledge on diabetes, and the association between the level of knowledge among DM patients and control of diabetes was statistically significant ($p<0.01$) (Table 2).

Table 2: Association between diabetes control and socio-economic, behavioral, knowledge and *biochemical* factors among diabetes patients

Variable	Category, N (%)	DM controlled? Yes, N (%)	χ^2-value	Variable	Category, N (%)	DM controlled? Yes, N (%)	χ^2-value
Education	Illiterate, 65(13.5)	14 (21.5)	13.85**	Family	Strong, 249(51.7)	97(39.0)	15.19**

	Primary, 89(18.5)	24 (27.0)			Fair, 146(30.3)	41(28.1)	
	2ndary, 226(46.9)	89 (39.4)			Little,54(11.2)	15(27.8)	
	Higher, 102(21.2)	46 (45.1)			No, 33(6.8)	20(60.6)	
Dietary modulation	Yes, 396(82.2)	156(39.4)	11.83**	Regular exercise	Yes, 327(67.8)	131(40.1)	7.68**
	No, 86(17.8)	17(19.8)			No, 155(32.2)	42(27.1)	
Anti-diabetic drug	Yes,409(84.9)	154(37.7)	3.64*	Regular hospital visit	Yes,227(47.1)	107(47.1)	23.58**
	No, 73(15.1)	19(26.0)			No,255(52.9)	66(25.9)	
Regular health education	Yes,322(66.8)	130(40.4)	8.46**	Hypertension (DBP)	Yes, 64(13.3)	12 (18.8)	9.43**
	No, 160(32.2)	43(26.9)			No, 418(86.7)	161(38.5)	
TG	Yes (TG<150), 298(61.8)	127(42.6)	15.35**	LDL(≥100)	Yes, 281(58.3)	115(40.9)	7.42**
	No (TG≥150), 184(38.2)	46(25.0)			No, 201(41.7)	58(28.9)	
Current treatment received	Modified diet and Exercise 19(3.9)	10(52.6)	37.86**	Diabetic relative	Father, 41(8.5)	9(22.0)	37.86**
	OHA Only, 220(45.6)	108(49.1)			Mother, 40(8.3)	15(37.5)	
	OHA & insulin 153(31.7)	35(22.9)			Brother/Sister, 76(15.8)	25(32.9)	
	OHA-Insulin, 23(4.8)	4(17.4)			Multiple, 89(18.5)	31(34.8)	
	Insulin Only, 67(13.9)	16(23.9)			Others, 35(7.3)	20(57.1)	
Financial support	Good, 172(35.7)	73(42.4)	7.14*	Knowledge on DM management	No, 201(41.7)	73(36.3)	
	Fairly, 170(35.3)	61(35.9)			Poor (0-3), 133(27.6)	25(18.8)	26.69**
	Little, 118(24.5)	33(28.0)			Fair(4-6), 175(36.3)	66(37.7)	
	No, 22(4.6)	6(27.3)			Good (7-9), 174(36.1)	82(47.1)	

N.B.:LDL: Low density lipoprotein; TG: Triacyl glycerol.

These significantly associated factors were considered as independent variables in multivariable binary logistic regression model.

Adjusted odds ratio (AOR), 95% confidence interval (CI) for AOR and p-value were considered to interpret the results of binary multivariable logistic regression model. The standard error (SE) exhibited no evidence of multicellularity problems among our selected independent variables, because the magnitude of SE was less than 0.50, this value is not shown in Table 3. After controlling the effect of other selected variables, it was revealed that

patients with good knowledge were more likely to control their diabetes by 68.5% and 43.2%, respectively higher than those who had poor [AOR= 0.315, 95% CI: 0.162-0.612; p<0.01] and fair [AOR= 0.568, 95% CI: 0.336-0.958; p<0.05] knowledge on diabetes. It was noted that patients having normal triglyceride (TG) level who controlled their diabetes by 54.6% better than their counterpart [AOR= 0.454, 95% CI: 0.275-0.749; p<0.01]. Also, we found that patients having low-density lipoprotein (LDL) in normal range controlled their diabetes by 38.6% better than those who did not have normal LDL level [AOR=0.614, 95% CI: 0.382-0.988; p<0.05]. Non-hypertensive DM patients had a 2.814-fold higher chance to control their diabetes than hypertensive patients [AOR=2.814, 95% CI: 1.303-6.078; p<0.01]. Patients had a 2.221-fold higher chance to control their diabetes who followed the instruction and control their diet [AOR= 2.221, 95% CI: 1.114-4.428; p<0.05] than their counterpart. Patients who attended regularly in health education programme arranged by RDAGH were 1.842 times more likely to control their diabetes than those who did not attend [AOR= 1.842, 95% CI: 1.217-2.788; p<0.01]. DM patients who visited RDAGH regularly had a 2.324-fold higher chance to control their diabetes than those who were irregular [AOR= 2.324, 95% CI: 1.456-3.709; p<0.01]. It was found that patients who did not get family support were more likely to control their diabetes by 84.6%, 86.1% and 80.6%, respectively than patients who got strong [AOR= 0.154, 95% CI: 0.0.054-0.435; p<0.01], fair [AOR= 0.139, 95% CI: 0.048-0.409; p<0.01] and little [AOR= 0.194, 95% CI: 0.060-0.628; p<0.01] support from family. Financial support was an important risk factors for controlling diabetes; it was observed that patients who got good, fair and little financial support controlled their diabetes 4.567 [AOR= 4.567, 95% CI: 1.217-17.142; p<0.05], 4.564 [AOR= 4.564, 95% CI: 1.230-16.939; p<0.05] and 3.829 [AOR= 3.829, 95% CI: 1.046-14.009; p<0.05] times, respectively higher than patients who did not get financial support,. DM patients who had other diabetic relatives were more likely to control their diabetes by 86.3%, 72.4%, 76%, 76.3% and 65.1%, respectively than patients who had diabetic father [AOR= 0.137, 95% CI: 0.0.041-0.451; p<0.01], mother [AOR= 0.276, 95% CI: 0.089-0.857; p<0.05], brother/sister [AOR= 0.240, 95% CI: 0.088-0.657; p<0.01], multiple [AOR= 0.237, 95% CI: 0.089-0.630; p<0.01] and no diabetic relatives [AOR= 0.349, 95% CI: 0.139-0.876; p<0.05]. We noted that patients who currently used OHA only had 3.361times more likelihood to control their diabetes than those who used insulin alone [AOR=3.361, 95% CI: 1.514-7.462; p<0.01]. The model demonstrated that secondary [AOR= 2.367 95% CI: 1.237-4.528; p<0.01] and higher [AOR= 2.992, 95% CI: 1.474-6.077; p<0.01] educated patients could control their diabetes 2.367 and 2.992 times, respectively higher than the illiterate patients (Table 3).

Table 3: Effect of socio-economic, behavioral, *biochemical* factors and knowledge on diabetes control among DM patients

Variables	p-value	AOR	95% CI for AOR	
			Lower	Upper
Knowledge	0.002			
Poor Vs Good[R]	0.001	0.315	0.162	0.612
Fair Vs Good	0.034	0.568	0.336	0.958
LDL, High Vs Normal[R]	0.045	0.614	0.382	0.988
TG, High Vs Normal[R]	0.002	0.454	0.275	0.749
Hypertension, No Vs Yes[R]	0.008	2.814	1.303	6.078
Currently received drug	0.000			
Diet control + Exercise Vs Insulin only[R]	0.090	2.866	0.847	9.692
OHA only Vs Insulin Only	0.003	3.361	1.514	7.462
OHA & Insulin Vs Insulin only	0.673	1.197	0.519	2.762
OHA-Insulin Vs Insulin only	0.807	0.841	0.210	3.373
Diabetic relative	0.020			
Father Vs Others[R]	0.001	0.137	0.041	0.451
Mother Vs Others	0.026	0.276	0.089	0.857
Brother/Sister Vs Others	0.005	0.240	0.088	0.657
Multiple Vs Others	0.004	0.237	0.089	0.630
No Vs Others	0.025	0.349	0.139	0.876
Financial Support	0.147			
Good Vs No[R]	0.024	4.567	1.217	17.142
Fair Vs No	0.023	4.564	1.230	16.939
Little Vs No	0.043	3.829	1.046	14.009
Family Support	0.003			
Strong Vs No[R]	0.000	0.154	0.054	0.435
Fair Vs No	0.000	0.139	0.048	0.409
Little Vs No	0.006	0.194	0.060	0.628
Diet Control, Yes Vs No[R]	0.023	2.221	1.114	4.428
Exercise, Yes Vs No[R]	0.826	1.059	0.634	1.771
Anti-diabetic, Yes Vs No[R]	0.407	1.413	0.624	3.203
Regular visit, Yes Vs No[R]	0.000	2.324	1.456	3.709
Regular in health education programme, Yes Vs No[R]	0.004	1.842	1.217	2.788
Education	0.004			
Primary Vs Illiterate[R]	0.441	1.345	0.633	2.860
Secondary Vs Illiterate	0.009	2.367	1.237	4.528
Higher Vs Illiterate	0.002	2.992	1.474	6.077
Constant	0.226	0.290		

N.B.: R: Reference case, AOR: Adjusted odds ratio, CI: confidence interval, LDL: low-density lipoprotein, TG: *triglyceride,* OHA: Oral hypoglycemic agents.

DISCUSSION

To date, diabetes mellitus remained as a non-curable disease, but it can be kept under control by discipline, diet and drug (3Ds). A diabetic patient should adhere to 3Ds to keep blood sugar at optimum level and lead healthy life. Diabetic Association Hospitals in Bangladesh are playing vital roles in providing the patients with clinical tests, knowledge on diabetes, diet therapy and medical advice. Still, patients in major cases fail to keep their blood parameters to baseline. As a result, the patient gradually or rapidly loses its control and faces the ultimate fate of organ damage and death. It is, therefore, urgently needed to identify the causes behind the poor glycemic control. This study was undertaken to assess the glycemic status as affected by some variables. FBS and 2ABF were primarily used to determine glycemic status and it was further confirmed by monitoring HbA1c,a universal marker [9].Values for poor glycemia were set at FBS ≥6.1 mmol/L, 2ABF≥9.1 mmol/L, and HbA1c≥6.5%, according to IDF guideline (Principles and guidelines , 2010). The number of patient with poor glycemic control (64%) found in this study (female>male) were quite closer to that reported by Al-Rasheedi (2014) and Khattab et al. (2010).

Major predictors of worsening glycemic status were identified to be the lack of education and non-adherence to follow up schedule and medication. The result is quite consistent with the reports of Khattab et al. (2010), Khan et al. (2004) and Goudswarrd et al. (2004) who demonstrated education to be an important factor to positively affect diabetes control. Education can surely increase one's understanding, consciousness, sincerity, and responsibility about own self and others, thereby can easily adopt self-restrain to follow 3Ds. However, the report published by Al-Rasheedi (2014), Kirk et al. (2011), and Selea et al. (2011) demonstrated that education does not have correlation with control of diabetes. American diabetes association also published a report in 2013 stating that education does not have any impact on diabetes control (American Diabetes Association, 2013). However, a study carried out in Pakistan (Chaudhary & Chaudhary, 2010) demonstrated that higher education had positive correlation with T2DM control, which supports our findings. To our opinion, in spite of the controversy, education can make a positive change in human behavior which cannot be ignored. Yigazu and Desse opined that illiterate people might have low knowledge in diabetes, low self-management attitude, lower self-efficacy and lower commitment to care, leading to poor glycemic control (Yigazu & Desse, 2017).

The number of patients controlling diabetes increased with increasing their level of knowledge on diabetes. We found that patients with good knowledge were likely to control their diabetes than patients who had poor and fair knowledge on diabetes. Al-Rasheedi (2014) demonstrated that knowledge had positive impact on T2DM control. Knowledge is one of the best tools for perfection. Therefore there is no alternative to acquiring knowledge on diabetes that warrants further attending the health education lectures provided by RDAGH.

Adherence to modulated diet was another statistically significant factor found in this study having positive impact on glycemic control. Adherence to modulated diet is a symbol of consciousness that prevails in patients who have good knowledge on diabetes as reported by Al-Rasheedi (2014) and Uchenna et al. (2010). Again, level of consciousness adds to the positive attitude towards self-care that is a prerequisite for glycemic control.

Adherence to health education programme revealed a good association with diabetes control, while the number of patients who could control their diabetes without attending the programme was poor. The difference between these two factors was significant ($p<0.01$). It can be mentioned here that adherence to health education program adds to the knowledge of the patient on diabetes which in turn increases consciousness and concern of his own health, thereby positively contributes to his diabetes control. Al-Rasheedi (2014) concluded from his study that health education program usually emphasizes adherence to treatment regimen as a whole, especially, to diet, exercise, and regular follow up which add to greater benefit of glycemic control.

Again, regular visit to RDAGH was found positively associated with glycemic control and the association was statistically highly significant. The finding is consistent with those of Al-Rasheedi (2014), Khattab et al. (2010) and Khan et al. (2012). Regularity in follow up is a positive outcome of diabetes knowledge and health education program which can motivate a patient to adhere to diabetes care.

Lack of family support was found to be another significant factor associated with poor glycemic control. However, strong family support was surprisingly found to have negative correlation with poor glycemic control. It might be due to development of dependence and reluctance of patient to self-care and perceived self-efficacy on self-management such as medication adherence, blood glucose monitoring, diet and exercise changes, owing to strong family support more than desired, leading to poor glycemic control. A study was conducted comparing diabetes management with and without family support found that patients enrolled with an informal caregiver showed a higher rate of engagement and more likely to decrease blood glucose level and to regularly check blood glucose (Aikens et al., 2014). Another study

showed that the practical and emotional support provided by family members had a positive influence on measures of diabetes management (Miller & Dimatteo, 2013). Support from family provides patients with practical help and can buffer the stresses of living with illness.

In this study, financial support was found to be important risk factors for controlling diabetes, and the association between glycemic control and financial support was significant. Financial support is a vital tool to manage hyperglycemia. Because, receiving medication and healthy foods involve financial cost. Moreover, other supplies, such as regular follow up also require a lot of money. Campbel et al. (2017) demonstrated that the financial barriers predominantly affected medications, diabetes supplies, and healthy food. Morris and Chasens (2017) also reported similar findings.

Association of heredity with glycemic control was investigated in this study. The patients who had other diabetic relatives demonstrated best control, followed by those with diabetic mother, none, multiple, brother/sister and diabetic father. There are lots of studies relating diabetes onset to heredity, but to our knowledge no study was found regarding correlation of glycemic control with heredity. From the result of this study it can be assumed that T2DM patients having direct genetic relation (father, mother, brother, sister etc) are somehow less hopeful of keeping good control and they are prepared for the consequence. On the other hand, patients having other diabetic relatives get frightened by the onset and consequently get serious in following the guidelines and medications.

Association of some biochemical factors with glycemic control was also studied. Hypertension, elevated TG, and elevated LDL were the factors significantly associated with poor glycemic control. Several studies have demonstrated that poor glycemic control always has vice-versa correlation with dyslipidemia and hypertension (Khattaba et al., 2010; Kakade et al., 2018; LeRoith, 2008; Gopinath et al., 2013; Mullugeta et al., 2012).

Impact of hypoglycemic drug on diabetes control was also monitored. It was found that an appreciable number of patients could control their diabetes who used anti-diabetic drug than those who did not. It was noted that patients who currently used OHA only were more likely to control their diabetes than those who used insulin alone. It is evident that a patient during its early stage of diabetes uses oral hypoglycemic agents and he turns to use insulin after a gradual deterioration of the disease. Such patients are usually reluctant and do not adhere to advice and medication. So, it is quite likely that those who take insulin have less glycemic control than those who still do not have to take insulin. Usually, patients prefer oral drug to insulin to avoid the hazel of insulin injection and they do not go to insulin unless they are

compelled by deterioration of the disease. There is exception that some patients prefer insulin over oral drugs to avoid side effects.

This study demonstrated that regular exercise has positive correlation with diabetes control. The difference between patient taking exercise and not taking exercise with controlled glycemia was statistically significant. Exercise can improve glycemic status by activating muscle cells and increases its sensitivity to insulin, thereby increasing the cell membrane permeability to glucose and glucose homeostasis (Bassuk & Manson, 2005; Maiorana et al., 2002; Lima et al., 2008; Sriwijitkamol et al., 2007).

Strength and limitation of this study: Perhaps it was the first attempt to investigate the effect of socio-economic, behavioral, *biochemical* factors and knowledge regarding diabetes on diabetes control among DM patients attended in a big diabetes hospital in the northern part of Bangladesh. At the same time, we also investigated the effect of education programme arranged by hospital only for diabetic patients on controlling their diabetes. However, there were many limitations of this study, the main limitations were; (i) it was a cross-sectional study in which it could not be possible to observe the change of patients' condition with respect to change of time, (ii) some related factors of controlling diabetes were not considered in this study such as, life style before getting diabetes, body mass index before getting diabetes etc. (iii) male and female patients were analyzed together, they should have been analyzed separately, (iv) we considered only one diabetes hospital in a particular city of Bangladesh. To draw a general conclusion, all big diabetes hospitals in the different cities of Bangladesh needed to be considered, finally, (v) most of our DM patients were city dwellers, it patients living in urban and rural environment across the country should be considered. To reach a clear conception, more research is required with DM patients in Bangladesh.

CONCLUSIONS

In conclusion, it can be remarked that the glycemic control is associated with multi-factors among which the level of education and lack of regular follow up were the independent variables. All T2DM patients who visited the outpatient department (OPD) of RDAGH during the study period and fulfilled the inclusion criteria were considered our study population, and 482 were samples. Our selected statistical tools/models provided that 64.2% DM patients did not control their glycemic. Regular attended health education, regular hospital visit, knowledge on diabetes, triglyceride (TG), low-density lipoprotein (LDL), hypertension, dietary modulation, anti-diabetic drug, financial support, family support, diabetic relative and patients' education were predictors of glycemic control.

We observed poor literacy and self-motivation (knowledge on diabetes, routine follow up, following modulated diet and medication etc) were major players which co-worked with the negative role of family support. Therefore, health education and self-motivation of patient and family awareness are to be intensified by the health authorities of Bangladesh.

Implications: Our study suggested that diabetes centers or hospitals should develop mechanism to increase motivation work/counseling so that the patients be regular in diabetes education class and increase their knowledge regarding 'to do and not to do' for better control of glycemia. Health education program emphasizing adherence to prescribed treatment as a whole, especially to regular follow up, to diet, and to exercise are of greater importance in controlling glycemia as compared to adherence to medications alone.

Consent for publication: We had taken consent for publication from hospital and patients.

Availability of data and material: Data is available on request.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Abbreviations: ABF: After breakfast; AOR: Adjusted odds ratio; BIRDEM : Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorder; CAD: Coronary artery disease, CI: Confidence interval; CKD: Chronic kidney disease; CVD: Cerebrovascular disease; DM: Diabetes mellitus; eGFR: Estimated glomerular filtration rate; FBS: Fasting blood sugar; HbA1c: hemoglobin A1c or glycated hemoglobin; IBM: International Business Machines; IGT: Impaired glucose tolerance; LDL: Low-density lipoprotein; OHA: Oral hypoglycemic agents; OPT: Outpatient Department; PVD: peripheral vascular disease; RDAGH: Rajshahi Diabetic Association General Hospital; SPSS: Statistical Package for the Social Sciences; TG: triglyceride; T2DM: Type 2 diabetes mellitus.

Authors Contributions: KH, MRK and MGH conceptualized and designed the research; KH and MGH analyzed the data; KH, MMH and MRK drafted the original manuscript; KH, MMH, MMUR, MRK and MGH critically reviewed and edited the manuscript. All authors read the final version of the manuscript and approved it for publication.

REFERENCES

Adeniyi, O.V., Yogeswaran, P., Longo-Mbenza, B., Goon, D.T., & Ajayi, A. I. (2016). Cross-sectional study of patients with type 2 diabetes in OR Tambo district, South Africa. *BMJ Open*, doi:10.1136/bmjopen-2015- 010875.

Aikens, J.E., Zivin, K., Trivedi, R., & Piette, J.D. (2014). Diabetes self-management support using mHealth and enhanced informal caregiving. *Journal of Diabetes and Its Complications*, 28: 171–176.

Ajlouni, K., Khader, Y.S., Batieha, A., Ajlouni, H., & El-Khateeb, M (2008). An increase in prevalence of diabetes mellitus in Jordan over 10 years. *Journal of Diabetes and Its Complications*, 22:317-24.

Akhter, S., Rahman, M.M., Abe, S.K., & Sultana, P. (2014). Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bulletin of the World Health Organization*, 92: 204-213A.

Al-Rasheedi, A.A.S. (2014). The role of educational level in glycemic control among patients with type II diabetes mellitus. *International Journal of Health Sciences* (Qassim Uninversity), 8: 177-187.

American Diabetes Association (2013). Standards of Medical Care in Diabetes. Diabetes care, 36:supplements1. Available at https://care.diabetesjournals.org/content/diacare/36/Supplement_1/S11.full.pdf

Bassuk, S.S., & Manson, J.E. (2005). Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology*, 99:1193–1204.

Campbell, D.J., Manns, B.J., Hemmelgarn, B.R., Sanmartin, C., Edwards, A., & King-Shier, K. (2017). Understanding Financial Barriers to Care in Patients With Diabetes. *Diabetes Educator*, 43:78-86.

Chan, Y.H(2004). Biostatistics 202: logistic regression analysis. *Singapore Medical Journal*, 45:149-53.

Chaudhary, F.M., & Chaudhary, S.M. (2010) Awareness about diabetes risk factors and complications in diabetic patients: A cross sectional study. *Nishtar Medical Journal*, 2:10-15.

Clinical management of diabetes mellitus in Bangladesh: *Principles and guidelines*, (endorsed by ADA in April, 2010). PP: 11.

Global report on diabetes (2016). World Health Organization: p 25. Available at https://www.who.int/publications-detail/global-report-on-diabetes.

Gopinath, B., Sri Sai Prasad, M., Jayarama, N., & Prabhakara, K. (2013). Study of factors associated with poor glycemic control in Type -2 Diabetic patients. *Global Journal* of *Public Health Medicine*, 2: 59-63.

Goudswaard, A.N., Stolk, R.P., Zuithoff, P., & Rutten, GE. (2004). Patient characteristics do not predict poor glycaemic control in type 2 diabetes patients treated in primary care. *European Journal of Epidemiology*, 19:541-545.

Kakade, A.A., Mohanty, I.R., & Rai, S. (2018). Assessment of factors associated with poor glycemic control among patients with Type II Diabetes mellitus. *Integrative Obesity and Diabetes*, 4: 1-6.

Khan, A.R., Al-Abdul Lateef, Z.N., Al Aithan, M.A., Bu-Khamseen, M.A., Al Ibrahim, I., & Khan, S.A. (2012). Factors contributing to non-compliance among diabetics attending primary health centers in the Al Hasa district of Saudi Arabia. *Journal* of *Family* and *Community Medicine*, 19: 26–32.

Khanam, P.A., Mahtab, H., Ahmed, A.U., Sayeed, M.A. & Khan, A.K.A. (2008). In Bangladesh diabetes starts earlier now than 10 years back: a birdem study. *IMC Journal of Medical Science*, 2: 1-3.

Khattab, M., Khader, Y.S., Al-Khawaldeh, A., & Ajlouni, K. (2010). Factors associated with poor glycemic control among patients with type 2 diabetes. *Journal of Diabetes and its Complications*, 24: 84 –89.

King, H., & Rewers, M. (1993). Global estimates for prevalence of diabetes mellitus and impaired glucose tolerance in adults. *Diabetes care*, 16:157–177.

Kirk, J.K., Davis, S.W., Hildebrandt, C.A., Strachan, E.N., Peechara, M.L., & Lord, R. (2011). Characteristics associated with glycemic control among family medicine patients with type 2 diabetes. *North Carolina Medical Journal*, 72: 345-350.

LeRoith, D. (2008). Hyperglycemia, hypertension, and dyslipidemia in type 2 diabetes mellitus: goals for diabetes management. *Clinical Cornerstone*, 9: S8-S16.

Lima, L.C., Assis, G.V., Hiyane, W., Almeida, W.S., Arsa, G., Baldissera, V., Campbell, C.S., & Simões, H.G. (2008). Hypotensive effects of exercise performed around anaerobic threshold in type 2 diabetic patients. *Diabetes Research and Clinical Practice*, 81:216–222.

Maiorana, A., O'Driscoll, G., Goodman, C., Taylor, R., & Green, D. (2002). Combined aerobic and resistance exercise improves glycemic control and fitness in type 2 diabetes. *Diabetes Research and Clinical Practice*, 56:115–123.

Miller, T.A., & Dimatteo, M.R. (2013). Importance of family/social support and impact on adherence to diabetic therapy. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 6: 421–426.

Mohiuddin, A.K. (2019). Diabetes Fact: Bangladesh Perspective. *International Journal* of *Diabetes Research*, 2: 14-20.

Morris, J.L., & Chasens, E.R. (2017). Financial Difficulty: A barrier to self-care in patients with diabetes. *Diabetes Educator*, 43:247-248.

Mullugeta, Y., Chawla, R., Kebede, T., & Worku, Y. (2012). Dyslipidemia associated with poor glycemic control in type 2 diabetes mellitus and the protective effect of metformin supplementation. *Indian Journal of Clinical Biochemistry*, 27: 363-369.

Sanal, T.S., Nair, N.S., & Adhikary, P. (2011). Factors associated with poor control of type 2 diabetes mellitus: A systematic review and Meta-analysis. *Journal of Diabetology*, 3: 1-4.

Sayeed, M.A., Mahtab, H., Khanam, P.A., Latif, Z.A., Ali, S.M.K., Banu, A., Ahren, B., Khan, A.K.A. (2003). Diabetes and impaired fasting glycemia in a rural population of Bangladesh. *Diabetes Care*, 26:1034-9.

Selea, A., Šumarac-Dumanović, M., Pešić, M., Šuluburić, D., Stamenković-Pejković, D., Cvijović, G., & Micić, D. (2011). The effects of education with printed material on glycemic control in patients with diabetes type 2 treated with different therapeutic regimens. *Vojnosanitetski pregled*, 68: 676–683.

Sriwijitkamol, A., Coletta, D.K., Wajcberg, E., Balbontin, G.B., Reyna, S.M., Barrientes, J., Eagan, P.A., Jenkinson, C.P., Cersosimo, E., DeFronzo, R.A., Sakamoto, K., & Musi, N. (2007). Effect of acute exercise on AMPK signaling in skeletal muscle of subjects with type 2 diabetes: a time-course and dose-response study. *Diabetes*, 56:836–848.

Uchenna, O., Ijeoma, E., Pauline, E., & Sylvester, O. (2010). Contributory factors to diabetes dietary regimen non adherence in adults with diabetes. *World Academy* of *Science, Engineering and Technology*, 45:735-742.

Unnikrishnan, R., Rema, M., Pradeepa, R., Deepa, M., Shanthirani, C.S., Deepa, R., & Mohan, V. (2007). Prevalence and risk factors of diabetic nephropathy in an urban South Indian population the Chennai Urban Rural Epidemiology Study (CURES 45). *Diabetes Care*, 30: 2019-2024.

Yigazu, D.M., & Desse, T.A. (2017). Glycemic control and associated factors among type 2 diabetic patients at Shanan Gibe hospitals, Southeast Ethiopia. *BMC Research Notes*, 10: 597-603.