Janaki Medical College Journal of Medical Sciences (2024); Vol.12 (2):13-24

JMCJMS

Research Article

Assessment of glycemic control and correlation of HbA1c level with lipid profile and duration of diabetes in type 2 diabetes mellitus patients

Birendra Kumar Jha[1*], Raman Mishra[2], Jitendra Kumar Singh[3], Satyam Prakash[4], Kamlesh Kumar Yadav[5]

Author's Affiliations

[1,4]Department of Biochemistry, Janaki Medical College, Tribhuwan University, Janakpurdham, Madhesh Province, Nepal
[2]Department of Internal Medicine, Janaki Health Care & Teaching Hospital, Janakpurdham, Dhanusha, Madhesh Province, Nepal
[2]Department of Internal Medicine, Janaki Medical College, Teaching Hospital, Tribhuwan University, Janakpurdham, Madhesh Province, Nepal
[3]Department of Community Medicine, Janaki Medical College, Tribhuwan University, Janakpurdham, Madhesh Province, Nepal
[5]Department of Clinical pathology, Janaki Health Care and Teaching Hospital, Janakpurdham, Dhanusha, Madhesh Province, Nepal

Correspondence to:
Dr. Birendra Kumar Jha
Department of Biochemistry,
Janaki Medical College, Tribhuwan University,
Janakpurdham, Madhesh Province, Nepal
Email: akshatjmc@yahoo.com

ABSTRACT

Background & Objectives: The prevalence of Type 2 diabetes mellitus, or Type 2 DM, is rising globally. A periodic estimation of HbA1c has been recommended to track the state of glycemic control of Type 2 DM patients, in order to control the diabetes associated disorders. The main consequence and cause of death in Type 2 diabetes has been identified as cardiovascular disease (CVD).Optimization of glycemic status along with decreasing CVD risk factors are critical to preventing morbidity and mortality in patients with Type 2 DM. Since there is a lack of data on these CVD risk factors, in Madhesh Province, Nepal, we aimed to evaluate the glycemic status, estimate the lipid profile, and ascertain their correlation, including duration of Type 2 DM among patients in tertiary care hospitals in Madhesh Province, Nepal.

Materials and Methods: The tertiary care hospital based cross-sectional study was conducted on 139 Type 2 DM patients, in Madhesh Province, Nepal. In order to gather information of the participants, a systematic questionnaire was introduced. A physical and clinical examination was performed, and an appropriate volume of blood was drawn with prior written consent. The lipid profile parameters, HbA1C, Fasting and post prandial serum glucose were estimated.

Results: In 84 (60.3%) and 106 (76.3%) cases, there was an increased fasting and postprandial blood sugar. The mean±SD HbA1c level was 8.40±0.8%. More than half (52.5%) of the patients

had poor glycemic control, while 22.3% had inadequate glycemic control, in reference to HbA1c >8% and 7 to 8%, respectively. A substantial increased level of LDL-C, triglycerides and total cholesterol was observed in 122 patients and 85.6% had reduced HDL-C. A significant strong positive association was found between HbA1c level and total cholesterol and triglycerides, in contrast, no discernible association with duration of disease observed.

Conclusion: Glycemic control was inadequate. Triglycerides and total cholesterol were significantly positively correlated with HbA1c, but not with HDL-C, LDL-C, or the course of diabetes.

Keywords: Diabetes Mellitus, Glycemic Control, HbA1C, Lipid profile, Madhesh Province

INTRODUCTION

The hallmark of type 2 diabetes mellitus (Type 2 DM) is characterized by the persistent hyperglycemia, which can be caused by a variety of factors, including abnormalities in insulin secretion, action, or combo of each [1]. Type 2 DM is growing progressively and thought to be the consequences of food customs, sedentary lifestyles, physical inactivity and obesity [2]. According to the WHO estimates, 422 million adults worldwide had diabetes in 2023. Type 2 DM is the most prevalent type making for around 90% of all cases of the diabetes [3]. In addition to its abnormal metabolism of carbohydrates, Type 2 DM has also been found connected to defective metabolism of both lipids and proteins, resulted by insulin resistance or insufficiency [4]. According to the International Diabetes Federation (IDF), there were approximately 90 million adults in south Asian countries (aged 20-79) who had diabetes. It is projected that by the year 2045, the figure will have surged by 69% to 152 million. In South East Asia, there are 74.2 million Type 2 DM patients, of these ,74.2 million are in India, 13.1 million are in Bangladesh, 1.4 million are in Sri Lanka, and 1.1 million are in Nepal [5].

HbA1c, which depicts the average glycemic over a few months, is a highly reliable indicator of diabetes problems. Consequently, it has been advised to measure HbA1c every three months to track the state of glycemic control in diabetes patients [1]. Cardiovascular disease (CVD), which is the disease of heart and blood vessels, is the foremost cause of death in people living with diabetes. It has been shown that the risk of stroke doubles in individuals with Type 2 DM. Numerous studies have found a substantial positive correlation between glycemic control and CVD. According to reports, around 60% of all deaths in individuals with diabetes are attributed by CVD [6]. Atypical lipid profile parameters are thought to be the most significant risk factors contributing to the development of CVD, aside from metabolic syndrome [7]. LDL cholesterol levels rise among those with Type 2 DM partly because of a reduction in insulin levels accompanied by a decrease in the amount of the LDL receptor [8]. Dyslipidemia is defined as elevated triglycerides, total cholesterol, and low density lipoprotein cholesterol (LDL-C) along with decreased HDL-C. This condition has been noticed to be strongly associated with the progression of atherosclerosis [9]. Cardiovascular disease morbidity and mortality have been affected by central obesity, hypertension, dyslipidemia, and long-term poor glycemic control [10]. Research has shown a significant association between the duration of diabetes and lipid profile parameters, as well as HbA1c levels [2]. Previous published scientific literatures depicts that the Type 2 DM prevalence is trending upward in Nepal. Just 6.3% of

people were reported to have diabetes in 2000; by 2007, that number had risen to 9.5%. The pooled prevalence of Type 2 diabetes was 8.4%, as per a 2014 study [11-13]. Despite the fact that Type 2 DM is increasing in Nepal, the evidence regarding glycemic control and its correlation with the duration of diabetes and serum lipid profile is limited. Therefore, we aimed to evaluate the level of glycemic control and the correlation between HbA1c and lipid profile as well as the duration of diabetes in patients with Type 2 DM, visiting tertiary healthcare center in the Madhesh Province of Nepal.

MATERIALS AND METHODS

A hospital-based cross-sectional study was carried out among known Type 2 DM patients, who were receiving outpatient medical care at Janaki Medical College Teaching Hospital (JMCTH) and Janaki Health Care and Teaching Hospital (JHCTH), Janakpurdham, Madhesh Province, Nepal. The study was carried out between 1st October 2023, and 15th February 2024. Sample size was determined to be 120 based on an 8.5% anticipated prevalence of Type 2 DM at 95% confidence interval, using Cochran's sample size calculation formula; however, we could recruit up to 139 individuals who meet the eligibility requirements.

Participant's eligibility criteria: An individual with known Type 2 DM (as per WHO criteria: fasting plasma glucose level≥126mg/dl, post prandial plasma glucose level ≥200mg/dl, HbA1c ≥6.6 or random plasma glucose level ≥200mg/dl) either diagnosed for first time or who had followed up was included. Patients on steroids, contraceptive pills, statin and diagnosed with nephrotic syndrome, hypothyroidism, familial hyperlipoproteinemia and chronic kidney disease were excluded, on the basis of information obtained from the patients.

Procedure: The study was carried out from 25th of September 2023 to 15th of March 2024. Participants were enrolled using consecutive sampling, until the desired sample size was reached. To gather data on participants, a standardized questionnaire with anthropometric and sociodemographic parameters was employed. . Physical and clinical (waist circumference, Hip circumference, height, weight and blood pressure) examination were conducted by the trend medical health professionals (interns, medical officer) for all participants. A 5ml of fasting venous blood samples were collected, maintaining aseptic condition. Sterile gloves were worn while using a sterile disposable 5 ml syringe to draw blood, and methylated spirit was applied as an antiseptic around the puncture site.

Fasting blood sugar, total cholesterol, LDL-C, HDL-C, triglycerides were estimated using fully automated Accent 200 analyzer. For post prandial blood sugar, blood sample was collected at 2 hours of 75 gram glucose drink. HbA1C was estimated by fully automated D-10 (Bio-RAD), at the laboratory of JHCTH.

Statistical analysis: The data were entered in Excel sheet and analyzed by SPSS version 20. Frequencies and percentage were used for categorical variables. Central tendency and dispersion were used for numerical variables. The p value of less than 0.05 was considered as statistically significant.

Ethical consideration: The Ethical Review Board (ERB) of the Nepal Health Research Council (Ref. 463/2023) provided the ethical

approval for this study. Written as well as verbal consent were obtained from all the enrolled patients. All the enrolled participants were assured about the confidentiality.

RESULTS

Out of total 139 participants, a nearly equal number of males and females participated (males: 69, or 49.6%, females: 70, or 50.4%)).

The majority of study participants (42, or 30.2%) belonged to the 51–60 year age group, with a mean±2SD age of 53±12.2 years. A majority of study participants (117, or 84.2%) were Hindu, and nearly all of them were married (94.2%). In terms of education, a majority of study subjects (82, or 59%) had just completed their primary schooling. The

Table 1: Socio-demographic characteristics of study subjects (n=139)

Variables	Category	Frequency (%)
Age in years (mean±2SD)]		53.13±12.248
Age group (years)	**≤30**	7(5.0)
	31-40	19(13.7)
	41-50	32(23.0)
	51-60	42(30.2)
	61-70	31(22.3)
	71-80	8(5.8)
Gender	Male	69(49.6)
	Female	70(50.4)
Marital status	Unmarried	1(0.7)
	Married	131(94.2)
	Widowed	7(5.0)
Religion	Hindu	117(84.2)
	Muslim	22(15.8)
Educational level	Primary	82(59.0)
	Vocational training	2(1.4)
	Secondary	24(17.3)
	Graduation/Masters	14(10.1)
	Middle school	8(5.8)
	Certificate level/diploma	9(6.5)
Occupation	Professional	26(18.7)
	Semi-professional	9(6.5)
	Farmer/shopkeeper /clerk	79(56.8)
	Skilled manpower	13(9.4)
	Unemployment	12(8.6)
Monthly income	≥29166	66(47.5)
	14584-29166	14(10.1)
	10937-14583	25(18.0)
	7291-10936	15(10.8)
	4374-7290	14(10.1)
	1473-4373	5(3.6)

next most common level of education was secondary (24, or 17.3%), followed by master's or graduation-level education (10.1%).

Farmers, shopkeepers, and clerks accounted for more than half of the study subjects (79, or 56.8%), followed by professionals (26, or 18.7%). Approximately 47.5 percent of the study subjects (66, or 47.5%) had a monthly household income of ≥29166 (Table 1).

Table 2 indicates the mean±SD duration of 33, or 23.7%, were overweight, and 32, or 23%, were obese. Majority of the study subjects (98, or 70.5%) were non-smoker and 102, or 73.4% did not consume alcohol. However, 23 or 16.5% was current smoker and 15, or 10.8% was current alcohol consumer. Regarding comorbidities, 49, or 35.3% of study participants had hypertension and 7, or 5% have been diagnosed with dyslipidemia, table 2.

An elevated level of fasting and post prandial blood sugar was observed in 84, or 60% and

Table 2: Clinical characteristics and anthropometric parameters of study subjects (n=139)

Variables	Category	Frequency (%)
DM duration (mean±SD)		5.4±4.6
Anti-diabetic medication		
Oral (hypoglycemic tablet)		133(95.6)
Insulin		6(4.3)
Duration of DM (years)	1-5	89(65.44)
	6-10	36(25.89)
	≥11	14(10.0)
BMI (kg/m^2)	Under weight (<18.5kg)	12(8.6)
	Healthy weight (18.5-24.9kg)	62(44.6)
	Over weight (25.0-29.9kg)	33(23.7)
	Obese (≥30kg)	32(23.0)
Smoking status	Non smoker	98(70.5)
	Past smoker (>1year)	18(12.9)
Alcohol consumption status	Current smoker	23(16.5)
	Non consumer	102(73.4)
	Past consumer	19(13.7)
	Current consumer	15(10.8)
Comorbidities	Dyslipidemia	7(5)
	Hypertension	49(35.3)

(DM diabetes mellitus, *BMI* body mass index)

Type 2 DM was 5.4±4.6 years .The majority of the study subjects (89, or 65.44%) belong to the group with a Type 2 DM duration of 1-5 years. Among 139 subjects, 133 or 95.6%, were on oral hypoglycemic drugs, while the remaining people were taking insulin. Of them, 62, or 44.6%, were at a healthy weight, 106, or 76.3%, respectively, among study subjects. The mean±2SD HbA1c level was 8.40±0.8%. More than half (52.5%) of the study subjects had poor (>8%), 22.3% had inadequate and the remaining had good glycemic control as shown in Figure 1.

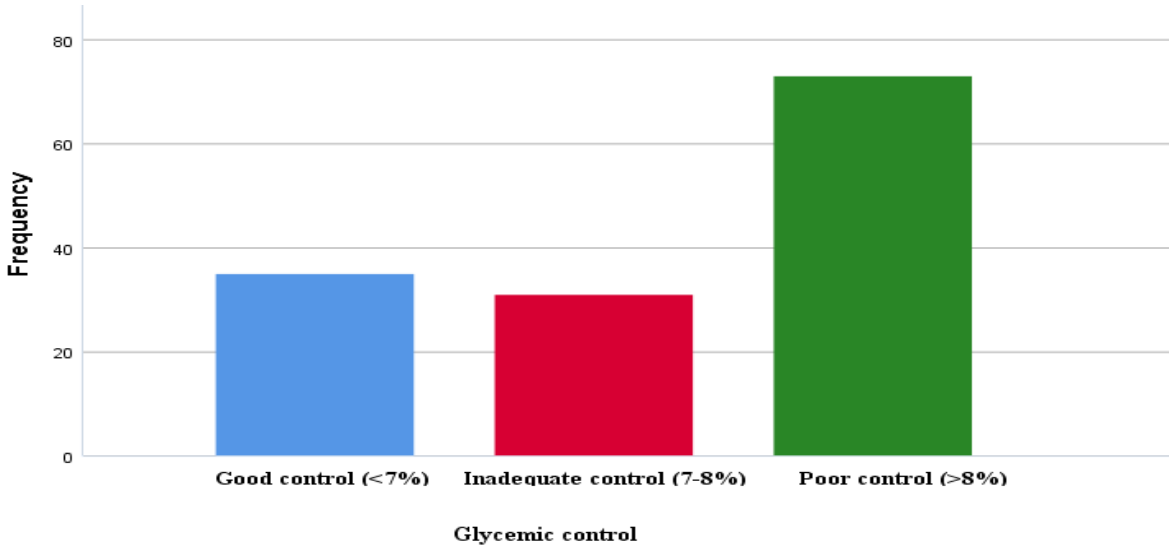

Figure 1: Glycemic control index among study subjects

Table 3: Biochemical parameters of study subjects (n=139)

Parameters	Category	Frequency
HbA1c (mean±SD)		8.40±0.8
Fasting blood sugar (mg/dl)	<110 ≥110	55(39.6) 84(60.4)
Post prandial blood sugar (mg/dl)	<140	33(23.7)
	≥1140	106(76.3)
Total cholesterol (mg/dl)	<200	122(87.8)
	≥200	17(12.2)
Triglycerides (mg/dl)	<150	96(69.1)
	≥150	43(30.9)
HDL-C (mg/dl)	M≥40, F≥150	20(14.3)
	M<40, F<150	119(85.6)
LDL-C (mg/dl)	<130	24(17.3)
	≥130	115(82.7)

(HDL-C high density lipoprotein cholesterol, *LDL-C* low density lipoprotein cholesterol)

Table 2 and 3 depicts that the prevalence of current alcohol users (15, or 10.8%) and smokers (23, or 16.5%) was found to be almost equal. A substantial increase in LDL-C (115 or 82.7%), triglycerides (96 or 69.1%), and total cholesterol (122 or 87.8%) was observed in with Type 2 diabetes. In contrast, 119 participants, or 85.6%, had reduced HDL-C levels. In addition, 49, or 35% of total had hypertension.

Table 4 signifies significant strong positive association was found between the HbA1c level and total cholesterol (r=0.215, p=0.05) and triglycerides (r=0.233, p=0.01). Nonetheless, there was no discernible association with the length of diabetes observed.

Table 4: Correlation of lipid profile with HbA1c and duration of DM

Biochemical parameters	Statistical test	HbA1c	Duration of DM
Total cholesterol	Spearman correlation Sig.(2-tailed)	0.215* 0.011	-0.110 0.197
Triglycerides	Spearman correlation Sig.(2-tailed)	0.233** 0.006	-0.154 0.071
HDL-C	Spearman correlation Sig.(2-tailed)	0.134 0.117	-0.19 0.826
LDL-C	Spearman correlation Sig.(2-tailed)	0.134 0.116	-0.107 0.209

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

DISCUSSION

Madhesh is the most populated province in Nepal according to the findings of the 2021 population census, containing 20.98% (61, 26,288) of the country's total population, with over 37,95,848 of those individuals being within the most susceptible age group of 15 to 59 years for Type 2 DM [14]. The main risk factors for developing diabetes are advanced age, ethnicity, a family history of the disease, smoking, obesity, and physical inactivity. These risk factors also raise the possibility of developing kidney disease, neuropathy, blindness, and lower-extremity amputation, which significantly raises the morbidity and mortality rates of diabetics [15,16].

Population aging has emerged as an obvious concern impacting public health as society continues to advance at an extremely rapid rate. According to this study, the age group of 51–60 years was found as the most affected by Type 2 DM (42 30.2%), followed by the 61–70 years age group (31 22.3%). Previous national and international studies have shown that an important risk factor influencing the elevated risk of pre-diabetes and diabetes is advanced age [15-17] which is in support of our findings. Results were found to be consistent with a similar hospital-based study conducted in Nigeria, which showed that 28.7% of Type 2 DM cases were of the same age range [18]. A study form Netherlands has reported that almost 50% of all type 2 DM patients were of age >70 years [19]. Additionally, the most impacted age group of 55-64 years was reported for Ehiopians [20]. A previous similar study conducted in the Kathmandu, Nepal has reported that 95% of type 2 DM patients was of age group 41 to 80 years [21]. Furthermore, a survey found that the prevalence of pre-diabetes and diabetes among people aged 40–49 was 40.3% and 11.1%, respectively, while the comparable figures for people aged 60–69 surged to 23.9% and 47.6%, respectively [22]. The elderly are consequently more prone than the young and middle-aged to have diabetes and

prediabetes, as well as to experience issues with their cardiovascular, retinal, and renal systems [23,24]. Moreover, there may be a correlation between a surge in lifestyle modification and the decreasing trend in the onset age of type 2 diabetes in developing nations like Nepal. Due to the fact that age affects both clinical and socioeconomic characteristics, age may have a significant impact on the contribution of risk factors for diabetes and pre-diabetes. Thus, it is important for healthcare institutions to create accurate diabetes prevention and control programs in Madhesh Province, it is imperative that they should provide clarity on the relationship between age and factors that influence the abnormal state of glucose metabolism.

The abnormal lipid profile that coexists with type 2 diabetes contributes to the elevated risk of cardiovascular diseases in T2DM patients. Numerous studies have shown a correlation between HbA1c and one or more lipid profile characteristics in T2DM patients, and some have proposed HbA1c as a potential biomarker for identifying T2DM patients at risk of CVD and for identifying the abnormal lipid profile of T2DM patients [25,26]. Our findings depicts statistically significant strong positive correlation was found in Type 2 DM patient's lipid profile parameters and the level of HbA1c. The importance of routinely assessing HbA1c as a diagnostic tool for monitoring glycemic control and diabetes treatment goals is widely acknowledged. This suggests that HbA1c helps to determine the risk of micro- and macrovascular issues indirectly and is directly linked to dyslipidemia in T2DM diabetic patients [27,28]. Dyslipidemia in T2DM patients is thought to be caused by insulin resistance. Increased TG levels in T2DM patients are reported to be associated with insufficient insulin secretion or function through several of mechanisms [25,29].

In our findings, one out of 2 (73, or 52.5%) of the Type 2 DM patients had reported having poor glycemic control, which was found higher than the previous hospital based study documented from the western Nepal [21]. The possible explanation for this could be that diabetes management is challenging owing to the chronic nature of the disease and its associated complications. Other potential causes of poor glycemic control may include different contributing factors such as inadequate or poor adherence to prescribed therapies, unhealthy diet, physical inactivity, rising levels of obesity, growing urbanization, changing lifestyle habits and modified sedentary lifestyle. Furthermore, the majority of healthcare facilities are located in urban regions, while rural healthcare facilities lacks in staff, infrastructure, and resources.

In the line with our study, similar incidence (70%) of poor glycemic control had been reported in a study carried out in the capital city of Nepal [30]. The study findings showed that 74.8%, almost three quarters of the type 2 DM patients had inadequate and poor glycemic control. Nearly the same, 73.8% of inadequate and poor glycemic control has been reported in a similar study documented from Ethiopia [20]. Furthermore, a study from India has also reported the similar incidence of poor glycemic status (urban population: 68.9% and rural population: 69.2%) conducted in self-reported Type 2 DM patients [31]. Our results, which are consistent with earlier studies carried out in Nepal, indicates that controlling and managing diabetes is a significant challenge in Nepal, including low disease awareness

among the general public, a variety of sociocultural factors, educational approaches, and a lack of programs to identify, treat, and prevent diabetes and its complications [13]. Consequently, it is vital that health care providers and policymakers should collaborate together to evaluate the growing diabetes burden in Madhesh province and develop effective preventative and control strategies.

Hyperglycemia and the duration of the disease are major risk factors for the progress of various micro-angiopathic-associated complications [32]. In uncontrolled diabetes, dysglycemia increases reactive oxygen species, and changes in signaling pathways lead to a variety of vascular dysfunctions [33]. It can additionally induce several complications in all organs, including the cardiorespiratory system [34]. A notable beneficial correlation was found in this study between the lipid profile parameter and the HbA1c level, an indicator of glycemic control. Similar finding was reported by a study done by Moss et al. [35]. Furthermore, a study done from eastern India has also reported the similar association between dyslipidemia and HbA1c level in diabetic patients [20].

However, the correlation of HbA1c and duration of diabetes was found not to be significant, which is in contrast of the previous similar study conducted in Bangladesh [36]. The positive correlation between HbA1c and duration of diabetes has been marked in a study suggesting that an incidence of complications can significantly increase in number in conjunction with elevated HbA1c levels. Fewer DM complications were found at HbA1c levels of 7% HbA1c levels [37]. It is possible that improving glycaemic control is typically thought to reduce type 2 diabetes symptoms and may be plausible cause for no relation between duration of diabetes and HbA1c as depicted in our findings. The other probable reason may be due to the limited number of subjects in this study and bias from study subjects responding during the data collection.

Among type 2 diabetes patients, dyslipidemias is one of the modifiable risk factors for coronary heart disease. Diabetic or atherogenic dyslipidemia is characterized by a high triglyceride and low- and high-density lipoprotein profile. It is a reliable indicator of silent myocardial ischemia or coronary artery disease [38,39]. Our results showed a significant positive correlation between HbA1c and triglycerides (r=0.233, p=0.01) and HbA1c and total cholesterol (r=0.215, p=0.05), however it did not show any significant correlation with LDL-C and HDL-C. The findings of current study agree with some previous studies, reported significant correlation between HbA1C and one or more parameters of the lipid profile in Type 2 DM patients [40,41].

The similar positive correlation of HbA1c with serum triglycerides and total cholesterol but no significant correlation shown with LDL-C, documented by a study carried out in Bangladesh [36]. However, the correlation of HbA1c and duration of diabetes did not found to be significant, which is in contrast of the previous similar study conducted in Nepal [21]. The positive correlation of HbA1c with high triglycerides signifies HbA1c as a direct marker of hypertriglyceridemia and an indirect marker of risk assessment of coronary artery disease [28]. However, the study was limited in its ability to reflect the entire population of Madhesh Province,

Nepal, due to its hospital based design and implementation in only two tertiary care institutions located in the province's capital city.

CONCLUSION

The significant number of Type 2 DM patients had inadequate and poor glycemic control while being on medication. HbA1c showed a significant positive association with triglycerides and total cholesterol, but not with HDL-C, LDL-C, or the course of diabetes. A notable positive correlation between HbA1c and lipid profile parameters suggests that, in addition to serving as a glycemic status indicator, HbA1c can also be employed as a dyslipidemia prediction in the treatment plan, helping to avert future CVD issues.

ACKNOWLEDGEMENT

We extend our since thanks to JMCTH and JHCTH for their constant support as well as the study participants, without whose participation it would not have been possible.

Conflict of interest: The authors declared no conflict of interests.

Funding: None

Author's Contribution: Conceptualization and writing of 1st draft- **BKJ, RM;** Data analysis-**BKJ; JKS;** Data collection, laboratory analysis, reviewed literatures, manuscript writing-**KKY, BKJ, SP**; Reviewing, reference management and editing final draft of manuscript-**SP, JKS, BKJ.** All author read the final version of manuscript and agreed to publish.

REFERENCES

1. Care D. 12. Older adults: standards of medical care in diabetes-2020. Diabetes Care 2020 ;43(January):S152-62.
2. Priya S, Begum N. Correlation of lipid profile with duration of diabetes and HbA1c levels in type 2 diabetes mellitus patients: a descriptive cross-sectional study. Age. 2020;40(4):3-2.
3. Diabetes. Who.int. 2020 [cited 14 May 2021]. Available from: https://www. who.int/news-room/fact-sheets/detail/diabetes
4. Ozder A. Lipid profile abnormalities seen in T2DM patients in primary healthcare in Turkey: a cross-sectional study. Lipids Health Dis 2014;13(1):183.
5. IDF. Nepal Country report 2017 & 2045. Available: https://reports. instantatlas.com/report/view/704ee0e6475b4af885051bcec15f0e2c/ NPLcollaborative study).
6. Mendis S, Puska P, Norrving BE, World Health Organization. Global atlas on cardiovascular disease prevention and control. World Health Organization; 2011.
7. Al-Alawi SA. Serum lipid profile and glycated hemoglobin status in Omani patients with type 2 diabetes mellitus attending a primary care polyclinic. Biomedical Research 2014;25(2):161-6.
8. Ravipati G, Aronow WS, Ahn C, Sujata K, Saulle LN, Weiss MB. Association of hemoglobin A(1c) level with the severity of coronary artery disease in patients with diabetes mellitus. Am J Cardiol 2006;97(7):968-9
9. Deeg R, Ziegenhorn J. Kinetic enzymic method for automated determination of total cholesterol in serum. Clin Chem 1983;29(10):1798–1802.
10. Diabetes Control and Complications Trial. Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study Research Group Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes. N engl j med 2005;353(25):2643-53.
11. Karki P, Baral N, Lamsal M, Rijal S, Koner BC, Dhungel S, Koirala S. Prevalence of non-insulin dependent diabetes mellitus in urban areas of eastern Nepal: a hospital based study. Southeast Asian journal of tropical medicine and public health. 2000 Mar 1;31(1):163-6.
12. Ono K, Limbu YR, Rai SK, Kurokawa M, Yanagida J, Rai G, Gurung N, Sharma M, Rai CK. The prevalence of type 2 diabetes mellitus and impaired fasting glucose in semi-urban population of Nepal. Nepal Medical College journal: NMCJ 2007;9(3):154-6.
13. Gyawali B, Sharma R, Neupane D, Mishra SR, van Teijlingen E, Kallestrup P. Prevalence of type 2 diabetes in Nepal: a systematic review and meta-analysis from 2000 to 2014. Global health action. 2015;8(1):29088.

14. National population and housing census. Available at: National Population and and Housing Census 2021 Results (cbs.gov.np)
15. Junker K, Buckley CM, Millar SR, et al. The prevalence and correlates of pre-diabetes in middle- to older-aged Irish adults using three diagnostic methods. PLoS One 2021;16(6):e0253537.
16. Xia M, Liu K, Feng J, et al. Prevalence and Risk Factors of Type 2 Diabetes and Prediabetes Among 53,288 Middle-Aged and Elderly Adults in China: a Cross-Sectional Study. Diabetes Metab Syndr Obes 2021;14:1975–1985.
17. Shi M, Zhang X, Wang H. The Prevalence of Diabetes, Prediabetes and Associated Risk Factors in Hangzhou, Zhejiang Province: a Community-Based Cross-Sectional Study. *Diabetes Metab Syndr Obes* 2022;**15**:713–721
18. Fadare J, Olamoyegun M, Gbadegesin BA. Medication adherence and direct treatment cost among diabetes patients attending a tertiary healthcare facility in Ogbomosho, Nigeria. Malawi Med J 2015;27(2):65-70
19. Ubink-Veltmaat LJ, Bilo HJ, Groenier KH, Houweling ST, Rischen RO, Meyboom-de Jong B. Prevalence, incidence and mortality of type 2 diabetes mellitus revisited: a prospective population-based study in The Netherlands (ZODIAC-1). European journal of epidemiology. 2003;18:793-800.
20. Abera RG, Demesse ES, Boko WD. Evaluation of glycemic control and related factors among outpatients with type 2 diabetes at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia: a cross-sectional study. BMC endocrine disorders 2022;22(1):54.
21. Khanal MK, Bhandari P, Dhungana RR, Gurung Y, Rawal LB, Pandey G, Bhandari M, Devkota S, Courten MD, Courten BD. Poor glycemic control, cardiovascular disease risk factors and their clustering among patients with type 2 diabetes mellitus: A cross-sectional study from Nepal. PloS one 2022;17(7):e0271888.
22. Wang L, Peng W, Zhao Z, et al. Prevalence and Treatment of Diabetes in China, 2013–2018. JAMA 2021;326(24):2498–2506.
23. Fong HK, Desai R, Faisaluddin M, et al. Sex disparities in cardiovascular disease outcomes among geriatric patients with prediabetes. Prim Care Diabetes 2021;15(1):95–100.
24. Amir R, Suhl S, Alexander CM. Renal Evaluation and Protection. Clin Geriatr Med 2020;36(3):431–445.
25. Alzahrani SH, Baig M, Aashi MM, Al-Shaibi FK, Alqarni DA, Bakhamees WH. Association between glycated hemoglobin (HbA1c) and the lipid profile in patients with type 2 diabetes mellitus at a tertiary care hospital: a retrospective study. Diabetes, metabolic syndrome and obesity: targets and therapy 019:1639-44.
26. Savelieff MG, Callaghan BC, Feldman EL. The emerging role of dyslipidemia in diabetic microvascular complications. Current Opinion in Endocrinology, Diabetes and Obesity 2020;27(2):115-23.
27. Hussain A, Ali I, Ijaz M, Rahim A. Correlation between hemoglobin A1c and serum lipid profile in Afghani patients with type 2 diabetes: hemoglobin A1c prognosticates dyslipidemia. Therapeutic advances in endocrinology and metabolism 2017;8(4):51-7.
28. Naqvi S, Naveed S, Ali Z, Ahmad SM, Khan RA, Raj H, Shariff S, Rupareliya C, Zahra F, Khan S. Correlation between glycated hemoglobin and triglyceride level in type 2 diabetes mellitus. Cureus 2017;9(6).
29. Goldberg IJ. Lipoprotein lipase and lipolysis: central roles in lipoprotein metabolism and atherogenesis. Journal of lipid research. 1996;37(4):693-707.
30. Thakur SK, Dhakal SP, Parajuli S, Sah AK, Nepal SP, Paudel BD. Microalbuminuria and its risk factors in type 2 diabetic patients. Journal of Nepal Health research Council 2019; 17(1):61-65.
31. Unnikrishnan R, Anjana RM, Deepa M, Pradeepa R, Joshi SR, Bhansali A, Dhandania VK, Joshi PP, Madhu SV, Rao PV, Lakshmy R. Glycemic control among individuals with self-reported diabetes in India—the ICMR–INDIAB study. Diabetes technology & therapeutics 2014;16(9):596-603.
32. Duwayri Y, Jordan Jr WD. Diabetes, dysglycemia, and vascular surgery. Journal of Vascular Surgery 2020;71(2):701-11.
33. Kitada M, Zhang Z, Mima A, King GL. Molecular mechanisms of diabetic vascular complications. Journal of diabetes investigation 2010;1(3):77-89..
34. Kolahian S, Leiss V, Nürnberg B. Diabetic lung disease: fact or fiction? Reviews in Endocrine and Metabolic Disorders 2019;20:303-19.
35. Moss SE, Klein R, Klein BE, Meuer SM. The association of glycemia and cause-specific mortality in a diabetic population. Archives of internal medicine 1994;154(21):2473-9.
36. Begum A, Irfan SR, Hoque MR, Habib SH, Parvin S, Malek R, Akhter S, Sattar S, Sarkar S. Relationship between HbA1c and Lipid Profile Seen in Bangladeshi Type 2 Diabetes Mellitus Patients Attending BIRDEM Hospital: A Cross-Sectional

Study. Mymensingh medical journal: MMJ. 2019 Jan 1;28(1):91-5.

37. Timar B, Albai O. The relationship between hemoglobin a1c and chronic complications in diabetes mellitus. Romanian Journal of Diabetes Nutrition and Metabolic Diseases. 2012;19(2):115-22.
38. Naseem S, Khattak UK, Ghazanfar H, et al. Prevalence of non-communicable diseases and their risk factors at a semi-urban community, Pakistan. Pan Afr Med J 2016;23:151.
39. Ama Moor VJ, Ndongo Amougou S, Ombotto S, Ntone F, Wouamba DE, Ngo Nonga B. Dyslipidemia in patients with a cardiovascular risk and disease at the University Teaching Hospital of Yaoundé, Cameroon. International journal of vascular medicine 2017: 6061306.
40. Kumar S, Kumari B, Kaushik A, Banerjee A, Mahto M, Bansal A. Relation between HbA1c and lipid profile among prediabetics, diabetics, and non-diabetics: A hospital-based cross-sectional analysis. Cureus 2022;14(12) :e32909.
41. Bekele S, Yohannes T, Mohammed AE. Dyslipidemia and associated factors among diabetic patients attending Durame General Hospital in Southern Nations, Nationalities, and People's Region. Diabetes, metabolic syndrome and obesity: targets and therapy. 2017;265-71.