

EXPLORING LIPID PROFILE ABNORMALITIES AT FIRST CLINICAL VISIT IN PATIENTS WITH TYPE 2 DIABETES MELLITUS. A REGIONAL RETROSPECTIVE COHORT STUDY

ABSTRACT

Background: Dyslipidemia portends an elevated risk for type 2 diabetes mellitus patients in developing various cardiovascular complications thus leading to increased morbidity, mortality and poor quality of life in this subset of patients. Dyslipidemia is a precursor to the development of atherosclerosis which is a major cause of cardiovascular disease. This study looks at the prevalence and pattern of dyslipidemia in type 2 diabetes mellitus patients at their first clinic contact in a tertiary hospital setting.

Methodology: This is a retrospective study conducted in a medical outpatient endocrinology clinic of a tertiary referral health center (LASUTH), after approval was gotten from the Institution ethical committee. NO: LREC/06/10/1987. Cases within the period from November 2021 to June 2022 were studied. Data Analyses were performed using SPSS statistics version 23.0. $P < 0.05$ was considered statistically significant.

Result: A total number of 252 subjects attending the Endocrinology clinic were included in this study. The mean age was 56.7 ± 12.9 years with the youngest being 19 years and oldest being 90 years of age. Female to male ratio was 1.3:1. The mean TC was 181.0 ± 51.3 mg/dl, mean of HDL-C was 48.6 ± 12.5 mg/dl, mean of LDL-C was 121.5 ± 41.8 and mean of TG 102.6 ± 41.9 mg/dl. The mean HBA1C was $8.6 \pm 2.3\%$, mean BMI was 27.9 ± 5.6 Kg/m² and mean FBS was 173.6 ± 72.7 mgdl. The pattern of lipid derangement was low HDL-C in 113(44.8%), high LDL-C 100 (39.7%), high TC 78(31.0%) and high TG 30 (11.9%). Prevalence of dyslipidemia was 72.6%. The odds of having deranged HDL-C were 3.87 (95% CI: 2.170 – 6.902) times significantly higher in females. Odds of having deranged HDL-C were 3.0 (95% CI: 1.641 – 5.528) times significantly higher in subjects who are obese.

Conclusion: Our study found high prevalence of lipid profile derangement in patients with type 2 diabetes. Therefore, early screening, appropriate medical intervention and routine monitoring should form part of patient care to control the dyslipidemia and avoid cardiovascular complications.

Key Words: Type 2 diabetes mellitus, dyslipidemia, cardiovascular disease, fasting blood glucose, glycosylated hemoglobin.

Introduction

Diabetes mellitus (DM) with its attendant complications continues to be an increasing global health challenge. An estimated 15 million people are living with diabetes in Africa.¹ Diabetes is known to be associated with a 2-4fold increased risk of cardiovascular mortality independent of other factors.² About 90% or more of diabetes cases are diagnosed as type 2 diabetes mellitus (T2DM) in the world, including Africa.³ Type 2 diabetes is associated with various complications leading to cardiovascular morbidity and mortality.⁴ Dyslipidemia, which is a well-known risk factor for cardiovascular disease is commonly associated with type 2 diabetes.⁵ This co-existence further magnifies the cardiovascular complications that accompany each disorder.⁶ The prevalence of dyslipidemia in type 2 diabetes varies across countries and regions. A prior study in Jordan reported that the prevalence rate of high LDL-C, reduced HDL-C, high TC, and elevated TG were 75.9%, 59.5%, 44.3%, and 41.9 respectively.⁷ Other studies in Pakistan and South Africa also show diverse variations of derangement in lipid profiles among patients with type 2 diabetes.^{8,9} Diabetic dyslipidemia, also known as atherogenic dyslipidemia is a peculiar lipid pattern noted in type 2 diabetes mellitus patients. It is characterized by elevated TG, reduced level of HDL-C, and increased propensity of small dense LDL-C. It is particularly associated with high cardiovascular mortality. Across the globe, there are numerous studies implicating body mass index, fasting blood glucose, age, gender as well as some lifestyles as prime risk factors contributing to the rise in the prevalence of dyslipidemia among T2DM patients.^{10, 11,12} Generally, there is inadequacy of data in Nigeria on the prevalence and patterns of lipid profile derangement among patients with type 2 diabetes. **Dyslipidemia is associated with cardiovascular complications in these patients, and some of the complications can be prevented if diagnosed early enough and thus managed by appropriate intervention.** This study sets out to determine the prevalence and patterns of lipid profile abnormalities found in type 2 diabetes mellitus patients during their first visit at an endocrinology outpatient clinic of a tertiary hospital.

METHODOLOGY

This was a retrospective study carried out among adult type 2 diabetes mellitus patients presenting for the first-time clinic visit to the diabetes out-patient clinic in Lagos State University Teaching Hospital (LASUTH) Ikeja between November 2022 to June 2023

Inclusion criteria: All consecutive type 2 diabetes mellitus patients that presented for their first visit within the time frame of the study

Patients case notes were recruited consecutively from the Medical Records Department of the Institution and only those that satisfied the inclusion criteria were used for the study. Approval was given by the Ethics Committee of the Institution before commencement of the study. REF. NO: LREC/06/10/1987.

Serum lipid profile and blood glucose were estimated in the fasting state of at least 8 hours fast over-night. Demographic data recorded includes the gender, height, weight and body mass index. Biochemical parameters were performed in the institution clinical biochemistry laboratory using international standard method. The biochemical parameters performed includes the different subfractions of the lipid profile (TG, HDL-C, TC, LDL-C), fasting blood glucose and glycosylated hemoglobin (Hba1c). The values of the subfractions of the lipid profile were recorded using the NCEP ATP 111 recommended normal ranges as standards.

Exclusion criteria: Adult type 1 diabetic patients, pregnant diabetic patients, patients with thyroid dysfunction and drug induced diabetes mellitus. Type 2 diabetic patients on lipid lowering drugs were also excluded.

Data was analyzed using SPSS statistics version 23.0. P-value < 0.05 was considered statistically significant. Chi-squared test was used to compare continuous and categorical data respectively. Logistic regression was used to predict the odds of dyslipidemia compared with the risk factors

RESULT

A total number of 252 subjects attending Endocrinology clinic were recruited for this study

Table I: Demographic and Clinical characteristics of the subjects

	Variable	Freq (N= 252)	Percentage (%)
Age Group (Years)	18 – 44	41	16.2
	45 – 64	138	54.8
	≥65	73	29.0
	Age range	19 – 90	
	Mean ± SD	56.7 ± 12.9	
Sex	Male	110	43.7
	Female	142	56.3
Religion	Christianity	196	77.8
	Islam	56	22.2
BMI (Kg/m ²)	Under Weight	10	4.0
	Normal Weight	65	25.8
	Overweight	96	38.1
	Obese	81	32.1
	Mean ± SD	27.9 ± 5.6	

The mean of the subjects was 56.7 ± 12.9 , with the highest majority 138 (54.8%) within the age group of 45 - 64 years. There were more females 142 (56.3%) than males (43.7%) with a male-to-female ratio of 1:1.3. Majority 96 (38.1%) of the subjects were overweight with an average body mass index of $27.9 \pm 5.6\text{kg/m}^2$.

Table II: Lipid Profile parameters of the subjects

Variable (mg/dl)	Freq (N= 252)	Percentage (%)
Total Cholesterol (TC)		
High Cholesterol	78	31.0
Normal TC	174	69.0
Range	91 – 370	
Mean \pm SD	181.0 ± 51.3	
High-density lipoprotein (HDL)		
Low HDL	113	44.8
Normal HDL	139	55.2
Range	22 – 95	
Mean \pm SD	48.6 ± 12.5	
Low-density lipoprotein (LDL)		
High LDL	100	39.7
Normal LDL	152	60.3
Range	34 – 325	
Mean \pm SD	121.5 ± 41.8	
Triglyceride (TG)		
High TG	30	11.9
Normal TG	222	88.1
Range	20 – 299	38.1
Mean \pm SD	102.6 ± 41.9	32.1
Overall Prevalence of dyslipidemia (At least one abnormal lipid profile)		
Dyslipidemia	183	72.6
Normal Lipid	69	27.4

NCEP ATPIII (2002). Circulation 106, 3143-3421

Seventy-eight (31.0%) subjects presented with high total cholesterol levels, with mean total cholesterol of 181.0 ± 51 . More than half of the subjects 139 (55.2%) had normal High-Density Lipoprotein (HDL), with an average HDL of 48.6 ± 12.5 . One hundred (39.7%) subjects came up with high Low-Density

Lipoprotein (LDL) levels, while the Overall Prevalence of dyslipidemia (as defined by at least one abnormal lipid profile) was 183 (72.6%).

Table III: Glycemic parameters of the subjects

Variable	Freq (N= 252)	Percentage (%)
HBA1C (%)		
Uncontrolled	213	84.6
Controlled	39	15.5
Range	4.3 – 16.4	
Mean ± SD	8.6 ± 2.3	
Fasting blood sugar(mg/dl)		
Abnormal	164	65.1
Normal	88	34.9
Range	72 – 300	
Mean ± SD	173.6 ± 72.7	

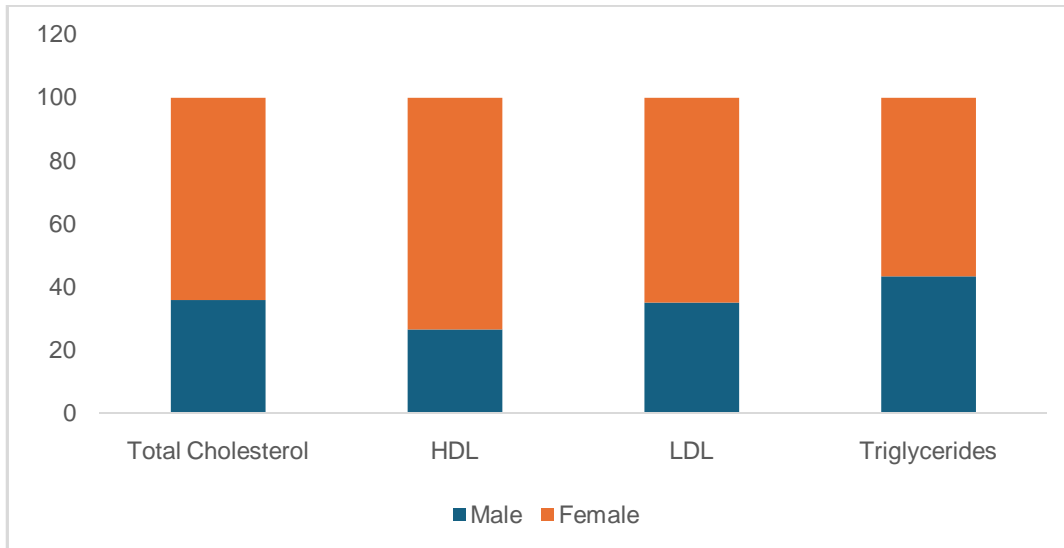
*Diabetes care. 32 (Suppl 1): S6 -S12. 2009

Deranged HBA1C level was found in most subjects 213 (84.5%) with an average HBA1C of 8.6 ± 2 . However, the majority 164 (65.1%) presented with an abnormal fasting blood sugar level.

Table IV: Patterns of Derangement by Gender Distribution

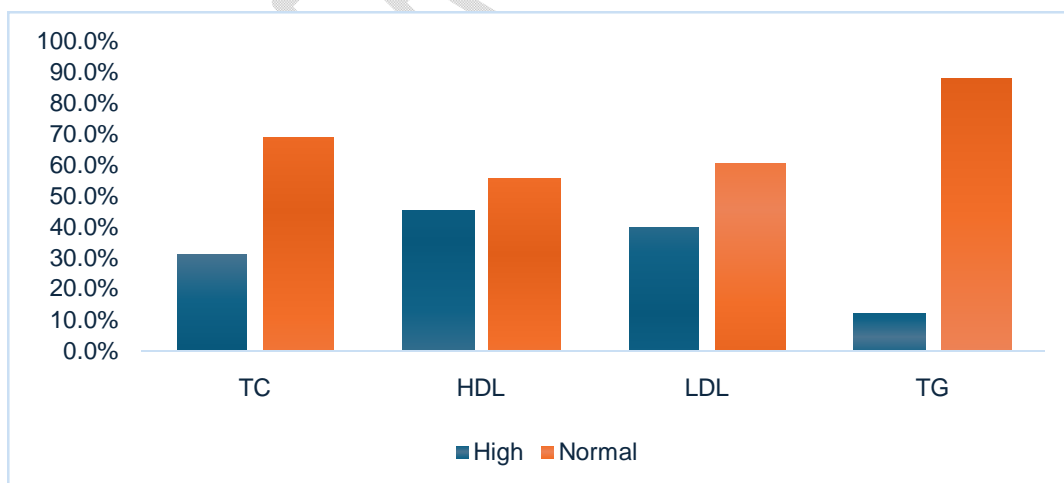
Variable	Male (freq(%))	Female (freq(%))
Total Cholesterol	28(35.9)	50(64.1)
High-Density Lipoprotein	30(26.5)	83(73.5)
Low-Density Lipoprotein	35(35.0)	65(65.0)
Triglyceride	13(43.3)	17(56.7)

Fig 1: Patterns of Lipid Profile Derangement by Gender Distribution



In all lipid profile parameters, as shown in Table IV and Figure 1, the female subjects had the highest level of derangement with 64.1%, 73.5%, 65.0%, and 56.7% derangement in Total cholesterol, High-density lipoprotein, Low-density lipoprotein, and Triglycerides respectively.

Fig 2: General Patterns of Lipid Profile Derangement



TC= Total cholesterol, HDL = High density lipoprotein, LDL = Low density lipoprotein, TG = Triglyceride

Generally, the highest level of lipid profile derangement was in High-density lipoprotein 44.8%, Low-density lipoprotein 39.7%, Total cholesterol 31.0%, and Triglycerides 11.9%.

Table V: Factors that predicted Deranged Lipid Profiles among subjects

Variable	Gender		P-Value
	Male	Female	
TC (mg/dl)	28 (35.9)	50 (64.1)	0.06
HDL (mg/dl)	30 (26.5)	83 (73.5)	0.01*
LDL (mg/dl)	35 (35.)	65 (65.0)	0.02*
TG (mg/dl)	13 (43.3)	17 (56.7)	0.565

Variable	Age		P-Value
	≤60	>60	
TC (mg/dl)	42 (53.8)	36 (46.2)	0.02*
HDL (mg/dl)	72 (63.7)	41 (36.3)	0.53
LDL (mg/dl)	56 (56.0)	44 (44.0)	0.02*
TG (mg/dl)	18 (60.0)	12 (40.0)	0.39

Variable	BMI		P-Value
	<30		
TC (mg/dl)	32 (41.0)		0.04*
HDL (mg/dl)	52 (46.0)		0.01*
LDL (mg/dl)	42 (42.0)		0.01*
TG (mg/dl)	14 (46.7)		0.06

Variable	HBA1C (%)	P-Value
	<7.0	
TC (mg/dl)	19 (24.4)	0.320
HDL (mg/dl)	30 (26.5)	0.360
LDL (mg/dl)	26 (26.0)	0.446
TG (mg/dl)	5 (16.7)	0.489

TC=Total Cholesterol, HDL= High Density Lipoprotein-C, LDL= Low Density Lipoprotein-C, BMI=Body Mass Index, *=Statistically Significant

There was a statistically significant association between derangement in age (P=0.02), body mass index (P=0.04), and total cholesterol. There was however no significant association between gender, HBA1C, and total cholesterol. Also, there was a statistically significant association between derangement in gender (P=0.01), body mass index (P=0.01), and high-density lipoprotein. There was however no significant association between derangement in age, HBA1C, and HDL. There was a statistically significant association between derangement in gender (P=0.02), age (P=0.02) body mass index (P=0.01), and LDL. There was however no significant association between HBA1C and LDL.

Table VI: Logistics regression Model for factors that Predict Lipid Profile Derangement.

Total Cholesterol	COR (95% C.I)	AOR (95% C.I)
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		High	Normal		
Age	>60	36	55	1.855(1.072 – 3.208)	1.631(.761 – 3.498)
	<60	42	119		
BMI	≥30	46	124	1.725(.987 – 3.014)	1.466(.635 – 3.383)
	<30	32	50		
		HDL		COR (95% C. I)	AOR (95% C. I)
Gender	Female	83	59	3.751(2.195 – 6.413)	3.870(2.170 – 6.902)
	Male	30	80		
BMI	≥30	61	109	3.097(1.791 – 5.357)	3.012(1.641 – 5.528)
	<30	52	30		
		LDL		COR (95% C. I)	AOR (95% C. I)
Gender	Female	65	77	1.809(1.076 – 3.041)	1.549(.733 – 3.273)
	Male	35	75		
Age	>60	44	47	1.755(1.040 – 2.963)	1.424(.696 – 2.915)
	≤60	56	105		
BMI	≥30	58	112	2.028(1.185 – 3.468)	1.741(.818 – 3.707)
	<30	42	40		

HDL=High Density Lipoprotein, LDL=Low Density Lipoprotein, OR=Odd Ratio, AOR=Adjusted Odd Ratio

The odds of having deranged TC were 1.855(1.072 – 3.208) significantly higher in subjects who are ≥60 compared to those <60. This association was lost upon adjusting (multivariate regression) for other variables. The odds of having deranged HDL were 3.751 (2.195 – 6.413) significantly higher in subjects who are female compared to the male. This association was lost upon adjusting (multivariate regression) for other variables. The odds of having a deranged BMI were 3.012 (1.641 – 5.528) significantly higher in subjects who are ≥30 compared to those <30.

DISCUSSION

Cardiovascular disease is the most prevalent cause of morbidity and mortality in the diabetic population.¹³ Dyslipidemia characterized by an abnormal lipid profile, is one of the major risk factors for cardiovascular disease in patients with diabetes.¹⁴ In this current study, we determined the prevalence and patterns of lipid profile derangement among type 2 diabetic patients. In our study, the mean age was 56.7 ± 12.9 years with the youngest being 19 years and the oldest being 90 years of age which is higher than the mean age submitted in a similar study in Lalitpur, Nepal but lower than the mean age obtained in Tanzania.^{15,16} Results obtained in the present study showed that subjects who are above sixty years were 1.855 times likely to present with deranged Total cholesterol. This might be due to the fact that there is drastic reduction of testosterone in this subset of people and testosterone may have an impact on cholesterol even though the reasons are not completely clear. This observed association was however lost after adjusting for other factors. A previous study reported a higher prevalence of dyslipidemia in females with type 2 diabetes in comparison with males.¹⁷ The current study submitted a female-to-male ratio of 1.3:1 with female subjects presenting with higher incidence of lipid derangements in all lipid profile parameters analyzed. This might be due to the fact that during menopause (50-55yrs) women's lipid subfractions especially total cholesterol and LDL cholesterol tend to rise while HDL cholesterol reduces because of the decline in oestrogen level. Majority of type 2 diabetes mellitus patients are in the older age group worldwide. Among the 78 subjects with deranged lipid profile pattern TC, 50(19.9%), 83(32.9%) of 113 subjects with HDL-C derangement, 65(25.8%) of 100 with LDL-C derangement and 17(6.8%) of 30 with TG derangement were female. Furthermore, findings from the present study reveal that the odds

of having deranged HDL-C were 3.87 (95% CI: 2.170 – 6.902) times significantly higher in females. This finding correlates with works done in Kushtia, Bangladesh but differs from the study by Gazza et al in Saudi Arabia which reported no statistically significant association between risk factors and dyslipidemia.^{18,19} Cheh,ade JM, Gladysz M, and Mooradian AD²⁰ reported that basic elements seen in diabetic dyslipidemia include elevated total cholesterol, high concentration of small dense LDL-C particles, decreased HDL-C concentration, and elevated triglyceride concentration. The results of the present study showed that the mean TC was 181.0 ± 51.3 mg/dl. This is lower than the values submitted in similar studies done in Egypt and India.^{21,22} Majority of the subjects (n=138, 69.3%) had desirable total cholesterol levels which correlates with results presented in Nepal.¹⁵ In the current study, 44.8% of the subjects presented with deranged HLD-C with a mean of 48.6 ± 12.5 mg/dl. This is below the prevalence submitted in Bangladesh but exceeds the prevalence submitted in a similar study by Noubiap JJ et al.²³ Our study found a 39.7% dyslipidemia in LDL-C with a mean of 121.5 ± 41.8 which is higher than the prevalence obtained in Jordan, but lower than the result obtained in Egypt.^{21,24} Additionally, our study also reveals that the odds of having deranged LDL-C were 1.81 (1.076 – 3.041) times significantly higher in females, this association was however lost upon adjusting for other factors. In this present study, 11.9% had high triglyceride with a mean of 102.6 ± 41.9 mg/dl. This value is higher than the values presented in Jordan but lower than the results obtained in Pakistan and Ethiopia.^{23,24,25} This result is not in line with some previous studies.^{16,18,20,21,24} But, it however correlates with the result obtained in Ethiopia.²⁵ These observed differences with the studies cited may be due to the sample size, the diet of the study subjects, and other modifiable risk factors. The current study submitted an overall prevalence of 72.6% dyslipidemia which is lower than the value reported in Tanzania and Jordan but higher than the result reported in Southwest Ethiopia and Ghana.¹⁶
^{24, 25,26} It is a well-established fact that patients with type 2 diabetes are vulnerable to cardiovascular disease due to sustained hyperglycemia resulting from derangement in glucose metabolism and associated dyslipidemia due to deranged lipid metabolism. Chronic hyperglycemia with associated dyslipidemia may result in atherosclerosis by initiating endothelial tissue damage.^{27,28} In the current study, 84.6% of the subjects came up with uncontrolled Hba1c, and 90.5% presented with elevated FBS with a mean of $8.6 \pm 2.3\%$ and 173.6 ± 72.7 mg/dl respectively. This exceeds the mean value submitted by Asamoah-Boakye O and Apprey C, but is lower than the result obtained in previous

studies conducted in Ghana and South Africa.^{26,29,30} The relationship between obesity and dyslipidemia in type 2 diabetes mellitus has been documented in previous studies.^{31,32} Our study found a mean BMI of 27.9 ± 5.6 Kg/m², 32.1% obesity, 38.1% overweight and 25.8% normal weight. This finding is slightly in line with previous studies done in Tanzania, Ghana, and South East Nigeria, but however, not in concordance with the study done in Jordan.^{16, 24, 29, 33} Also, the present study reveals that the odds of having deranged HDL-C were 3.0 (95% CI: 1.641 – 5.528) times significantly higher in subjects who are obese.

CONCLUSION

Our study found a high prevalence of dyslipidemia in patients with type 2 diabetes mellitus. The most common type of lipid profile derangement found in our study was low HDL-C followed by high LDL-C, high total cholesterol, and high triglyceride. The odds of having deranged HDL-C were 3.87 times significantly higher in females. Also, the odds of having deranged HDL-C were 3.0 times significantly higher in subjects who were obese. Therefore, early screening and intervention in the management of dyslipidemia in type 2 diabetes patients is sacrosanct in preventing cardiovascular complications.

LIMITATION

Our study is retrospective and was limited to patients in one health center which might limit the general application of the study findings to other centers. A multicenter study will be of more benefit for practicability and application of the study findings. This study was carried out on patients already diagnosed with Type 2 diabetes mellitus at primary and secondary health care centers with drugs treatment already initiated before presenting for the first time in our endocrinology outpatient clinic on referral. The time frame before presentation and drug use might partly explain the reasons why there are no significant associations between fasting blood glucose, glycosylated hemoglobin and lipid profile abnormalities in this study population

CONCLUSION

Our study found a high prevalence of dyslipidemia in patients with type 2 diabetes mellitus. The most common type of lipid profile derangement found in our study was low HDL-C followed by high LDL-C, high total cholesterol and high triglyceride. The odds of having deranged HDL-C were 3.87 times significantly higher in females. Also, the odds of having deranged HDL-C were 3.0 times significantly higher in subjects who are obese. Therefore, early screening and intervention in the management of dyslipidemia in type 2 diabetes patients is sacrosanct in preventing cardiovascular complications.

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REFERENCES

1. Kibirige D, Lumu W, Jones AG, Smeeth L, Hattersley AT, Nyirenda MJ. Understanding the manifestation of diabetes in sub-Saharan Africa to inform therapeutic approaches and preventive strategies: a narrative review. *Clinical diabetes and endocrinology*. 2019 Dec; 5:1-8.
2. Raghavan S, Vassy JL, Ho YL, Song RJ, Gagnon DR, Cho K, et al. Diabetes mellitus -related all-cause mortality and cardiovascular mortality in a national cohort of adults. *J Am Heart Assoc* 2019 ;8: e011295
3. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, Colagiuri S, Guariguata L, Motala AA, Ogurtsova K, Shaw JE. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. *Diabetes research and clinical practice*. 2019 Nov 1; 157:107843.
4. United Kingdom Prospective Diabetes Study group. Plasma lipids and lipoproteins at diagnosis of NIDDM by age and sex. UKPDS 27. *Diabetes care*. 1997 Nov; 20:1683-7.
5. Shahwan MJ, Jairoun AA, Farajallah A, Shanabli S. Prevalence of dyslipidemia and factors affecting lipid profile in patients with type 2 diabetes. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*. 2019 Jul 1; 13(4):2387-92.
6. Zamili A. The coexistence of hypertension and dyslipidemia in a cohort of Iraqi patients with essential hypertension: cross sectional study. *American Journal of Biomedical Science & Research*. 2019; 3(1):15-8.
7. Abujbara M, Batiha A, Khader Y, Jaddou H, El-Khateeb M, Ajlouni K. The prevalence of dyslipidemia among Jordanians. *Journal of lipids*. 2018 Oct 28; 2018.
8. Sarfraz M, Sajid S, Ashraf MA. Prevalence and pattern of dyslipidemia in hyperglycemic patients and its associated factors among Pakistani population. *Saudi journal of biological sciences*. 2016 Nov 1; 23(6):761-6.
9. Omodanisi EI, Tomose Y, Okeleye BI, Ntwampe SK, Aboua YG. Prevalence of dyslipidemia among type 2 diabetes mellitus patients in the Western Cape, South Africa. *International Journal of Environmental Research and Public Health*. 2020 Nov; 17(23):8735.

10. Haile K, Timerga A. Dyslipidemia and its associated risk factors among adult type-2 diabetic patients at Jimma University Medical Center, Jimma, Southwest Ethiopia. *Diabetes, Metabolic Syndrome and Obesity*. 2020 Nov 26: 4589-97.
- 11.. Haile K, Timerga A. Dyslipidemia and its associated risk factors among adult type-2 diabetic patients at Jimma University Medical Center, Jimma, Southwest Ethiopia. *Diabetes, Metabolic Syndrome and Obesity*. 2020 Nov 26: 4589-97.
12. Bayram F, Kocer D, Gundogan K, Kaya A, Demir O, Coskun R, Sabuncu T, Karaman A, Cesur M, Rizzo M, Toth PP. Prevalence of dyslipidemia and associated risk factors in Turkish adults. *Journal of clinical lipidology*. 2014 Mar 1; 8(2): 206-16.
13. Henning RJ. Type-2 diabetes mellitus and cardiovascular disease. *Future cardiology*. 2018 Nov 1; 14(6): 491-509.
14. Qi L, Ding X, Tang W, Mao D, Wang Y. Prevalence and risk factors associated with dyslipidemia in Chongqing, China. *Int J Environ Res Public Health*. 2015 Oct 26; 12(10): 13455-65
15. Dhoj TS, Raj KS, Santosh G, Deepika /G. Dyslipidemia in type 2 diabetes mellitus. *J Pathol Nepal*. 2017; 7(2): 1149-54
16. Chamba NG, Shao ER, Sonda T, Lyarru IA. Lipid profile of Type 2 diabetic patients at a tertiary hospital in Tanzania: cross sectional study. *J Endocrinol Diab*. 2017; 4(1): 1-6.
17. Ghouth AS, Ba-Karman AA, Alaidroos HA, Alajely MH, Bin-Talib MH. Prevalence and patterns of dyslipidemia among type 2 Di-abetes mellitus patients in Mukalla city, Yemen, in 2017. *J Community Med Public Health Care*. 2019; 6(048): 10-24966.
18. Ahmmed MS, Shuvo SD, Paul DK, Karim MR, Kamruzzaman M, Mahmud N, Ferdous MJ, Elahi MT. Prevalence of dyslipidemia and associated risk factors among newly diagnosed Type-2 Diabetes Mellitus (T2DM) patients in Kushtia, Bangladesh. *PLoS Global Public Health*. 2021 Dec 7; 1(12)
- 19 Gazzaz ZJ, Iftikhar R, Jameel T, Baig M, Murad MA. Association of dyslipidemia and comorbidities with risk factors among diabetic patients: a retrospective analysis. *Diabetes, Metabolic Syndrome and Obesity*. 2020 Mar 30: 935-41

20. Chehade JM, Gladysz M, Mooradian AD. Dyslipidemia in type 2 diabetes: prevalence, pathophysiology, and management. *Drugs*. 2013 Mar; 73:327-39.
- 21 Masahhit M, Husain HA, Samir R. Pattern of dyslipidemia in type 2 diabetic patients in Fayoum (Egypt). *Asian Journal of medicine and health*. 2017 Jan 10; 8(1):1-2.
- 22 Singh D, Singh A, Kumar R, Khan I. Dyslipidemia in type 2 diabetes mellitus patients of Udaipur population. *Scholars Journal of Applied Medical Sciences (SJAMS)*. 2015; 3(2D):813-5
- 23 Noubiap JJ, Bigna JJ, Nansseu JR, Nyaga UF, Balti EV, Echouffo-Tcheugui JB, Kengne AP. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *The Lancet Global Health*. 2018 Sep 1; 6(9):e998-1007.
- 24 Hyassat D, Al-Saeksaek S, Naji D, Mahasneh A, Khader Y, Abujbara M, El-Khateeb M, Ajlouni K. Dyslipidemia among patients with type 2 diabetes in Jordan: prevalence, pattern, and associated factors. *Frontiers in Public Health*. 2022 Nov 8; 10:1002466.
- 25 Haile K, Timerga A. Dyslipidemia and its associated risk factors among adult type-2 diabetic patients at Jimma University Medical Center, Jimma, Southwest Ethiopia. *Diabetes, Metabolic Syndrome and Obesity*. 2020 Nov 26:4589-97.
- 26 Asamoah-Boakye O, Charles A, Reginald A. Prevalence of dyslipidemia and atherogenic risk among type 2 diabetic outpatients in Ghana. *International Journal of Public Health and Clinical Sciences*. 2017 Aug 4; 4(3):152-63.
- 27 Bhutto MG, Lokesh MR, Shah SK, Afroze MK, Ghouse P, Abhilash D. Association between lipid profile and silent coronary artery disease in south Indian patients with type 2 diabetes mellitus. *Int J Adv Med*. 2017 Jan; 4(1):1.
- 28 Mokta J, Mokta K, Ranjan A, Garg M. Prevalence of Cardiovascular Risk Factors among Diabetic Population and Awareness of Diabetes among Diabetic Patients: A Population Based Himalayan Study. *The Journal of the Association of Physicians of India*. 2017 Feb 1; 65(2):48-52
- 29 Ofori EK, Owusu-Ababio D, Tagoe EA, Asare-Anane H. Dyslipidaemia is common among patients with type 2 diabetes: a cross-sectional study at Tema Port Clinic. *BMC Research Notes*. 2019 Dec; 12(1):1-5

30 Vezi ZB, Naidoo DP. Dyslipidaemia among black patients with type 2 diabetes: Cardiovascular topic. Cardiovascular Journal of South Africa. 2005 Jul 1; 16(4):194-8.

31 Yanai H, Hirowatari Y. Different associations of body mass index and visceral fat area with metabolic parameters and adipokines in Japanese patients with type 2 diabetes. Diabetes Metab. 2015; 41:261-262

32. Yanai H, Hirowatari Y. Correlations of body mass index, Japan-defined and IDF-defined waist circumference, visceral and subcutaneous fat area with metabolic parameters in Japanese patients with type 2 diabetes. Journal of Diabetes Mellitus. 2015; 5:290-294

33 Anioke IC, Ezedigboh AN, Dozie-Nwakile OC, Chukwu IJ, Kalu PN. Predictors of poor glycemic control in adult with type 2 diabetes in South-Eastern Nigeria. African Health Sciences. 2019; 19(4):2819-28.

UNDER PEER REVIEW