



Diabetic Dyslipidemia Prevalence and its Predictors among People with Diabetes in Ethiopia: Systematic Review and Meta-Analysis

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Abstract

Background: Dyslipidemia is an imbalance of lipid profiles. In Ethiopia, around 2% to 6.5% of the populations live with diabetes, but their lipid profiles are inconsistent in terms of prevalence of dyslipidemia and its predictors across the studies. Therefore, this study aimed to estimate the pooled prevalence of diabetic dyslipidemia and its predictors among people with diabetes in Ethiopia. **Method:** The searches were carried out in Medline via PubMed and OVID, EMBSCO, Embase, Google, and Google Scholar. The articles screened by title, abstract, and full-text. The qualities of the eligible studies were checked by the Newcastle-Ottawa scale. The heterogeneity was detected by, Cochrane Q statistic test and the I-squared (I^2) test. Then subgroup analysis and meta-regression analysis were used to identify the source of the variations. A random or fixed-effect meta-analysis model was used to estimate the overall pooled prevalence and average effects. The publication bias was assessed by the funnel plot asymmetry test and/or Begg and Mazumdar's test for rank correlation (p -value < 0.05). The protocol has been PROSPERO with reference number: CRD42023441572. **Result:** A total of 14 articles with 3662 participants were included in this review. The pooled prevalence of diabetic dyslipidemia in Ethiopia was found to be 65.7% (95% confidence interval (CI): 57.5, 73.9), $I^2 = 97\%$, p -value < 0.001 . Being female (adjusted odds ratio ((AOR): 3.9, 95%CI: 1.5, 10.1)), physical inactivity (AOR: 2.6, 95%CI: 1.5, 4.3), and uncontrolled blood glucose (AOR: 4.2, 95% CI: 1.9, 9.4) were found to be the determinants of dyslipidemia among diabetic patients. **Conclusion:** This review revealed that the prevalence of diabetic dyslipidemia is high among people with diabetes in Ethiopia. Being female, having physical inactivity, and having uncontrolled blood glucose were found to be predictors of dyslipidemia among people with diabetes.

Keywords: diabetes mellitus, dyslipidemia, lipid profile abnormality, Ethiopia.

Introduction

Diabetes mellitus (DM) is the leading public health challenge worldwide (Arredondo, Azar, & Recamán, 2018). Globally, around 537 million people have DM. Over three in four adults with diabetes live in low- and middle-income countries (LMICs). It is one of the top ten leading causes of death globally (Nam H. Cho, 2018) and is responsible for the direct cause of 1.5 million deaths (Metrics, 2019). Similarly, diabetes

is one of the top nine causes of death in LMICs (Organization, 9 December 2020). The prevalence of DM in Ethiopia has been reported to range from 2% to 6.5% (Bishu et al., 2019).

Dyslipidemia is a lipoprotein metabolism disorder, including lipoprotein overproduction or deficiency (Kopin & Lowenstein, 2017; Mancini, Hegele, Leiter, & Committee, 2018). It is characterized by elevated fasting and postprandial triglycerides (TG), low in high-density lipoprotein-cholesterol (HDL-C), elevated low-density lipoprotein cholesterol (LDL-C), and the predominance of low density lipoprotein (LDL) particles (Wu & Parhofer, 2014). The causes of dyslipidemia may be primary (genetic) or secondary, which are caused by lifestyle or other factors. It affects the general population, but its prevalence is highest in diabetic patients (Pathak & Pathak, 2012). The mechanism for the development of dyslipidemia is not clearly understood in diabetics, but it is associated with insulin resistance, elevated blood glucose levels, excessive production of rich lipoproteins from the liver (Hirano, 2018), and problems with lipid enzymes. About 61% of diabetic patients have at least one or more elevated liver enzymes (Kathak et al., 2022). A high-fat and high-calorie diet can cause dyslipidemia and lead to endothelial dysfunction (Hedayatnia et al., 2020). Dyslipidemia clogs arteries, which contributes to the development of atherosclerosis and cardiovascular disease. These result in coronary artery diseases, peripheral vascular diseases, heart attacks, stroke, hypertension, heart failure, renal disease, and others (Chen & Tseng, 2013; Narindrarangkura, Bosl, Rangsin, & Hathachote, 2019). In order to overcome the negative effects of dyslipidemia, intervention strategies including regular follow-up care, health education on lifestyle modifications, and providing lipid-lowering agents have been implemented (Barragan, Fisac, & Podzamecz, 2006; Jialal & Singh, 2019; Pignone et al., 2001). In Ethiopia, studies have reported on the prevalence of dyslipidemia among people with diabetes, but their findings are inconsistent across studies. Therefore, this review aimed to estimate the pooled prevalence of dyslipidemia and identify its predictors among people with diabetes in Ethiopia.

Methods

Study design

A systematic review and meta-analysis was used among diabetic patients in Ethiopia.

Searching Strategies and Selections

The searches were carried out in Medline via PubMed and OVID, EBSCO, Embase, and other supplementary gateways such as Google and Google Scholar. The Boolean operators of OR and AND were used to combine the search terms. Articles were searched by title (ti), abstract (ab), and/or full-text (ft). The search string is stated as dyslipidemia, OR “abnormal lipid profile*” OR hyperlipidemia AND “diabetes mellitus” OR DM OR “Type 2 diabetes mellitus” OR T2DM OR “Type 1 diabetes mellitus” OR T1DM AND Ethiopia. All search results were exported to Rayyan software to screen and de-duplicate the articles. Two collaborators (ZBT and GJ) were invited and screened articles independently based on the eligibility criteria. Then, the disagreements were resolved through discussion. Endnote reference management software version 7 was used to cite the references. The searches included articles published up to June 2023. The search was carried out from June 1-30, 2023.

Inclusion and Exclusion Criteria

To include important articles various eligibility criteria were used. Studies were eligible for inclusion in the review if they reported on: 1) adult (age ≥ 18 years) diabetic (type 1 and/or type 2 diabetic) population groups 2) were observational in design (i.e., cross-sectional, cohort, and case-control), 3) reported the prevalence, proportion, or incidence of dyslipidemia 4) were conducted in Ethiopia, 5) were published or unpublished, 6) took place in primary, general, and/or tertiary hospitals were included in the study. On the contrary, articles with abstracts only and conference papers were excluded. Moreover, articles with narrative reviews, systematic reviews, and meta-analyses were also excluded.

Outcome Measurement

Dyslipidemia was defined as TC ≥ 200 mg/dl, or TG ≥ 150 mg/dl, or LDL-C ≥ 130 mg/dl, or HDL-C < 40 mg/dl (for men) and HDL-C < 50 (for women) (Hedayatnia et al., 2020). Diabetes was defined as

fasting blood glucose ≥ 126 mg/dl, HbA1c $\geq 7\%$, or patients on anti-diabetic medication treatments (WHO, 2006). The odds ratio for predictor variables were used.

Quality Assessment

The quality of the included studies were assessed by a modified Newcastle-Ottawa quality assessment scale (NOS) adapted from cross-sectional (Moskalewicz & Oremus, 2020) and case-control studies (Peterson, Welch, Losos, & Tugwell, 2011). The tool used a “star scoring system” based on three parameters. These were study selection, comparability of the group, and ascertainment of the exposure and outcome status. For cross-sectional studies, a maximum of nine stars could be allocated, and for case-control studies, a maximum of ten stars (Luchini, Stubbs, Solmi, & Veronese, 2017). For the current review, a study of any design that received a rating of 7 or more stars was considered to be of high methodological quality (Wells et al., 2000). Two reviewers independently reviewed the quality of the included studies, and any discrepancies between reviewers were resolved by discussion.

Data Extraction

The data were extracted using the Microsoft Word data extraction format. The format was developed by involving all the reviewers. The data extraction format was piloted among two eligible studies before extracting the data. Then, further modifications were made accordingly. The extracted data include author(s), year of publications, region, study design, population, sample size, data collection procedure, prevalence, and funding source. Furthermore, to assess the predictors of diabetic dyslipidemia, the effect estimates or called odds ratio was used. This was taken from the reports of the previous studies or calculated from their cross-tabs (Cleophas, Zwiderman, Cleophas, & Zwiderman, 2016). Two reviews (ZBT and GJ) independently retrieved the data from the studies. The disagreements between the reviewers were resolved by the discussion or involvement of the third reviewer.

Data Analysis

The retrieved data were exported into Stata version 14 for analysis. A random and/or fixed-effect meta-analysis model was used to estimate the pooled prevalence and average effects on dyslipidemia based on the presence of heterogeneity. The presence of heterogeneity was detected by a nonparametric statistical test called the Cochran Q test, whereas the proportion of heterogeneity was estimated using I squared (I^2) statistics. The I^2 test statistics of 0.0% to 30%, 30% to 60%, and 60% to 100% were considered minimal, moderate, and substantial heterogeneity (Fletcher, 2007; Rücker, Schwarzer, Carpenter, & Schumacher, 2008), respectively. To see the level of variation across the studies, subgroup analyses by region of the study were computed. Furthermore, a random effect meta-regression analysis was carried out to identify the covariates of the variations. As a result, publication years and sample size were used for the regression analysis. The publication bias was detected by visual inspection of the funnel plot and/or Begg's or Egger's linear regression test (p -value < 0.05).

Study Protocol Registration and Reporting

The protocol for this review has been registered on PROSPERO with reference number: CRD42023441572. The report of this review followed the systematic review and meta-analysis (PRISMA) guideline checklist (Page et al., 2021)

Results

Study Selection and Characteristics

The search retrieved 1644 original research articles. From this, 356, 997, and 105 articles were removed due to duplication, background articles, and population differences, respectively. Then, after 186 articles were retrieved and 168 articles were removed, of which ten were removed because not full-text (abstracts only) and 158 were not related to the topic of interest. About eighteen full-text articles were accessed for eligibility, of which four articles were excluded because of poor quality after NOS assessment, reporting without the outcome of interest, and outcome measurement (**Fig. 1**). Finally, 14 articles with 3662 diabetic

patients were included and retrieved for this review. From studies, five were in Ahmara (Biadgo et al., 2018; Birarra & Gelayee, 2018; Fikremariam, 2020; Kebede, Gizachew, & Mulu, 2021; Wuhib et al., 2022), four in SNNP (Abebe, Fikadu, Hailu, & Temesgen, 2022; Bekele, Yohannes, & Mohammed, 2017; S. B. Woyesa, Hirigo, & Wube, 2017; Wube, Begashaw, & Hirigo, 2020), three in Oromia (Abdissa & Hirpa, 2022; Haile & Timerga, 2020; S. Woyesa et al., 2021), one in Tigry (Gebremeskel et al., 2019), and one in Addis Ababa (Birlie, 2019). Thirteen were cross-sectional in design, and the remaining was case-control. The publication years of the included studies were between 2017 and 2022. The data collection methods of the majority of the included studies were interviewer-administered surveys. The overall quality appraisal of the included studies was ≥ 7 (**Table 1**).

The prevalence of diabetic dyslipidemia ranges from 37.5% (S. Woyesa et al., 2021) to 91.1% (Wube et al., 2020). The predominant lipid abnormality was elevated triglycerides. Regarding factors, two articles for sex (Abdissa & Hirpa, 2022; S. Woyesa et al., 2021), two articles for physical activity (Fikremariam, 2020; Haile & Timerga, 2020), and two articles for blood glucose control status (Fikremariam, 2020; Haile & Timerga, 2020) were used (**Table 2**).

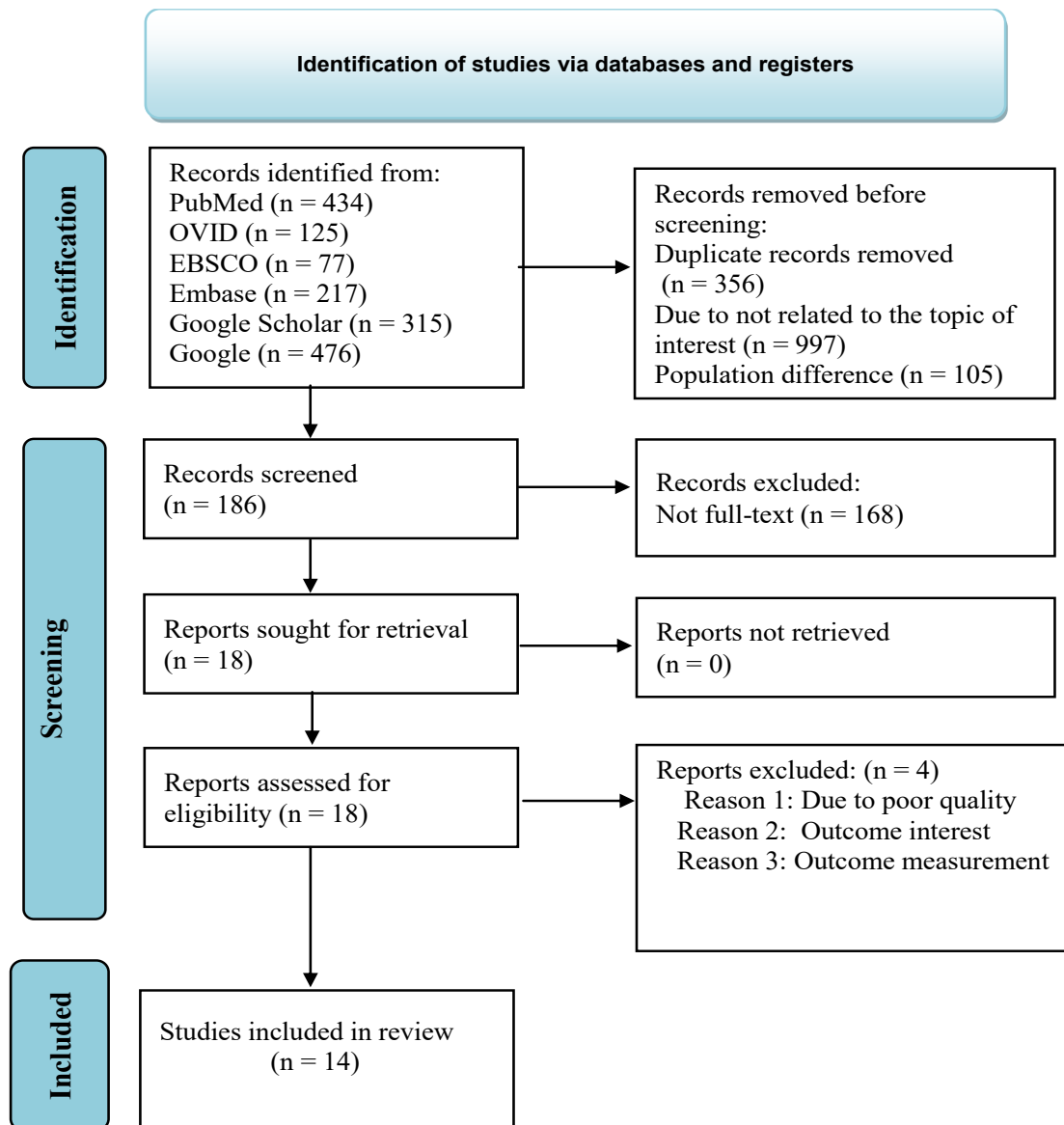


Figure 1: PRISMA flow diagram for the flow of information through the phases of the review

Table 1: Characteristics of the included studies

Author	Year	population	Region	Design	Study setting	data collection	treatment	Funding	quality
Abdissa D & Hirpa (Abdissa & Hirpa, 2022)	2022	DM	Oromia	cross-sectional	primary, general and referral hospitals	IAS	oral agents and insulin	NR	7.5
Bekele S, et al. (Bekele et al., 2017)	2017	DM	SNNPR	cross-sectional	general hospital	IAS	not explained	NR	8
Haile K & Timerga A (Haile & Timerga, 2020)	2020	T2DM	Oromia	cross-sectional	tertiary hospital	IAS	not explained	JU	9
Kebede WM, et al. (Kebede et al., 2021)	2021	T2DM	Amhara	cross-sectional	tertiary hospital	IAS	not explained	nil	8.5
Woyesa S, et al. (S. Woyesa et al., 2021)	2021	DM	Oromia	cross-sectional	tertiary hospital	IAS	Insulin and oral agents	JU	7
Wuhib M, et al. (Wuhib et al., 2022)	2021	DM	Amhara	cross-sectional	tertiary hospital	IAS and lab test	not explained	NR	9
Fikremariam T & Reddy PP (Fikremariam, 2020)	2020	DM	Amhara	cross-sectional	tertiary hospital	IAS and lab test	not explained	BDR	7.5
Biadgo B, et al. (Biadgo et al., 2018)	2018	T2DM	Amhara	cross-sectional	tertiary hospital	IAS and lab test	not explained	nil	8.5
Birarra MK & Gelaye DA (Birarra & Gelaye, 2018)	2018	T2DM	Amhara	cross-sectional	tertiary hospital	IAS and lab test	not explained	NR	8
Woyesa SB, et al. (S. B. Woyesa et al., 2017)	2017	T2DM	SNNP	cross-sectional	tertiary hospital	IAS and lab test	not explained	JU	8.5
Gebreemeskel GG, et al. (Gebreemeskel et al., 2019)	2019	T2DM	Tigray	cross-sectional	tertiary hospital	IAS and record review	insulin and oral agents	nil	7
Abebe G et al. (Abebe et al., 2022)	2022	T2DM	SNNPR	case-control	general hospital	IAS and record review	not explained	AMU	9
wube BT, et al. (Wube et al., 2020)	2020	T2DM	SNNPR	cross-sectional	tertiary hospital	IAS	not explained	NR	8.5
Birle M, et al. (Birle, 2019)	2019	T2DM	AA	cross-sectional	tertiary hospital	IAS and lab test	not explained	AMU	7.5

Notes:- AA: Addis Ababa; AMU: Arba Minch University; BDU: Bahir Dar University; DM: Diabetes Mellitus; Jimma University; IAS: interviewer administered survey; T2DM: Type 2 Diabetes Mellitus; NR: not reported, SNNPR: Southern Nation, Nationalities and people of region

Table 2: Diabetes and lipid profiles related characteristics among people with diabetes in Ethiopia

Author	Sample	proportion of T1DM	Proportion of T2DM	dyslipidemia(%)	Lipid profiles (%)				variables	OR
					TC	LDLC	HDL C	TG		
Abdissa D &Hirpa(Abdissa & Hirpa, 2022)	390	28.50%	71.5%	81.5	29.2	16.7	47.9	63.3	Sex (female)	2.9
Bekele S, et al. (Bekele et al., 2017)	224	-not explained	not explained	65.6	23.7	43.8	41.9	40.6	-	-
Haile K &Timerga A(Haile & Timerga, 2020)	248	-	100%	68.1	13.7	28.6	50.8	48	physical inactivity	2.5
									uncontrolled blood glucose	3.1
Kebede WM, et al. (Kebede et al., 2021)	347	-	100%	59	36.1	59	83.8	42.2		
Woyesa S, et al. (S. Woyesa et al., 2021)	48	-not explained	not explained	37.5	21.8	32.3	24	26	Sex (female)	9.2
Wuhib M, et al. (Wuhib et al., 2022)	250	50%	50%	68	26.4	39.2	37.6	33.6	-	-
Fikremariam T & Reddy PP(Fikremariam, 2020)	112	not explained	not explained	69.6	25.9	18.8	69.6	43.8	physical inactivity	2.8
									uncontrolled blood glucose	7.3
Biadgo B, et al.(Biadgo et al., 2018)	159	-	100%	56.6	64.2	57.9	31.5	62.3	-	-
Birarra MK &Gelaye DA(Birarra & Gelayee, 2018)	256	-	100%	68.8	-	-	33.6	67.2	-	-
Woyesa SB, et al.(S. B. Woyesa et al., 2017)	319	-	100%	70.4	-	-	39.2	70.4	-	-
Gebremeskel GG, et al.(Gebremeskel et al., 2019)	419	-	100%	45.1	-	-	34.4	45.1	-	-
Abebe G et al. (Abebe et al., 2022)	204	-	100%	82.18	72.55	-	11.76	59.3	-	-
Wube BT, et al. (Wube et al., 2020)	314	-	100%	91.1	32.8	14.3	60.8	70.4	-	-
Birle M, et al.(Birlie, 2019)	372	-	100%	51.34	-	-	51.08	47.85	-	-

Notes: CI: Confidence interval, HDLC: HDL-C-high density lipoprotein-cholesterol, LDLC: Low density lipoprotein-cholesterol, OR: Odds ratio, TC: Total cholesterol, TG: Triglycerides

Prevalence of Diabetic Dyslipidemia

The pooled prevalence of dyslipidemia among people with diabetes in Ethiopia was found to be 65.68% (95% CI: 57.5,73.9), $I^2 = 97\%$, $p\text{-value} < 0.001$) using a random effect meta-analysis model(**Fig. 2**). Regarding the lipid profiles, the pooled prevalence of TG and HDL-C were 51.8% (95% CI: 45.1, 58.6) and 44.2% (95% CI: 32.8, 55.7), respectively (**Table 4**).

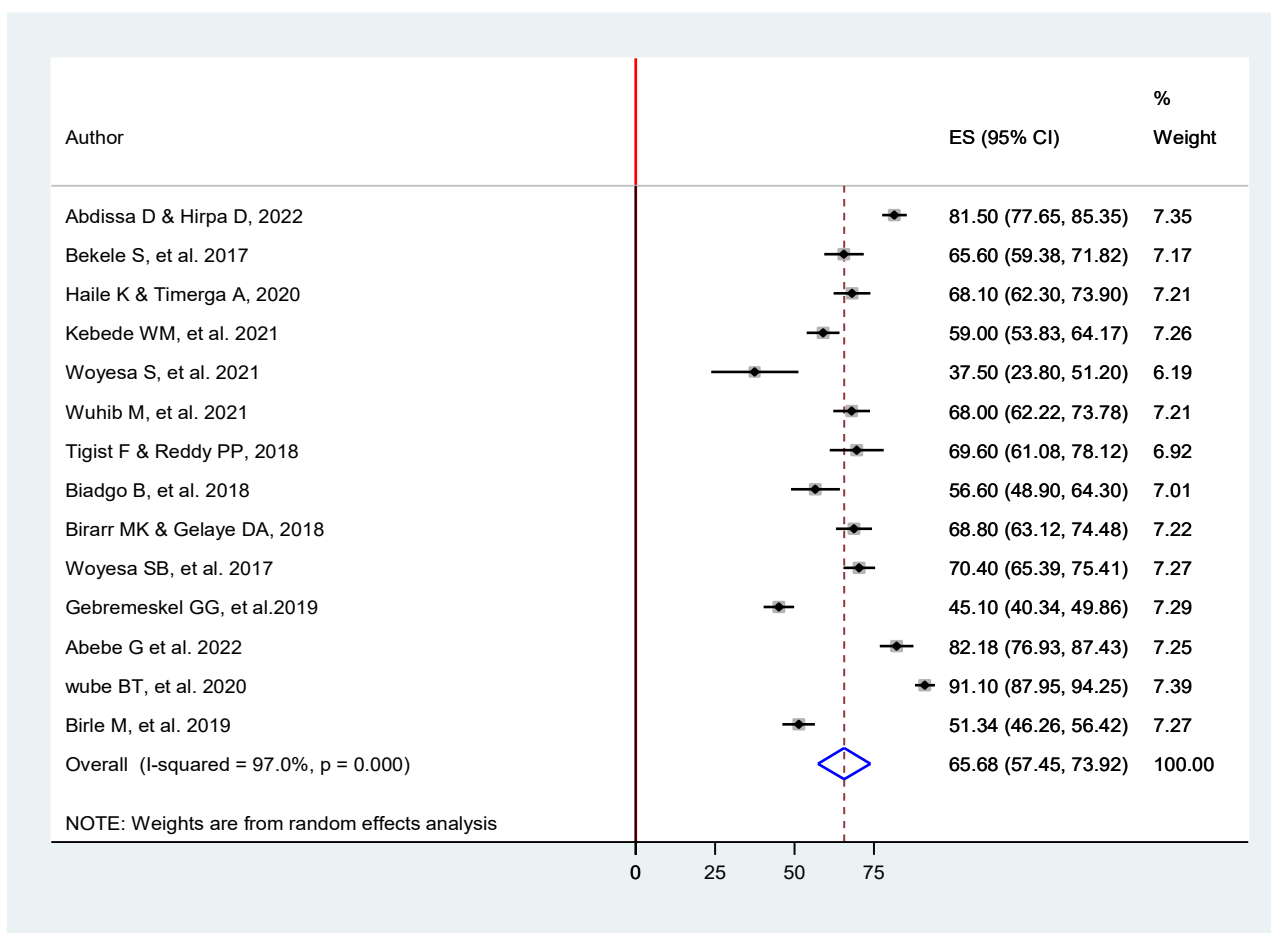


Figure 2: Forest plot shows the pooled prevalence of diabetic dyslipidemia in Ethiopia

Table 4: Lipid profiles among diabetic patients

Lipid profiles	Prevalence with 95%CI	I-square (%)	Cochrane (p-value)	Egger's test (p-value)	Model
TC	34.7%(23.3, 46.0)	97.3	p <0.001	0.39	Random effect meta-analysis
TG	51.8%(45.1, 58.6)	94.3	p <0.001	0.09	
LDL-c	34.4%(22.3, 46.6)	97.5	p <0.001	0.11	
HDL-c	44.2%(32.8, 55.7)	98.2	p <0.001	0.85	

Notes: CI- Confidence Interval, HDL-c-High density lipoprotein cholesterol, LDL-c - Low density lipoprotein cholesterol, TC-Total cholesterol, TG-Tryglyceride

Heterogeneity Test

As shown in the forest plot (**Fig. 2**), the proportion of variation was 97% and the Cochrane Q statistic p-value < 0.001, indicating there is considerable variation across the studies. Therefore, further subgroup analysis and random effect meta-regression analysis were computed.

Subgroup Analysis

The subgroup analysis was computed by the region of the studies. From the included studies, the pooled prevalence of dyslipidemia among people with diabetes was 77.5% (95% CI: 65.3, 89.6), $I^2=96.2\%$, $p<0.001$ in SNNP, 64.4% (95% CI: 59.2, 69.6), $I^2=70\%$, $p=0.01$ in Amhara, and 63.8% (95% CI: 46.0, 81.6), $I^2=95.6\%$, $p=0.001$ in the Oromia region using a random effect meta-analysis model (**Fig. 3**).

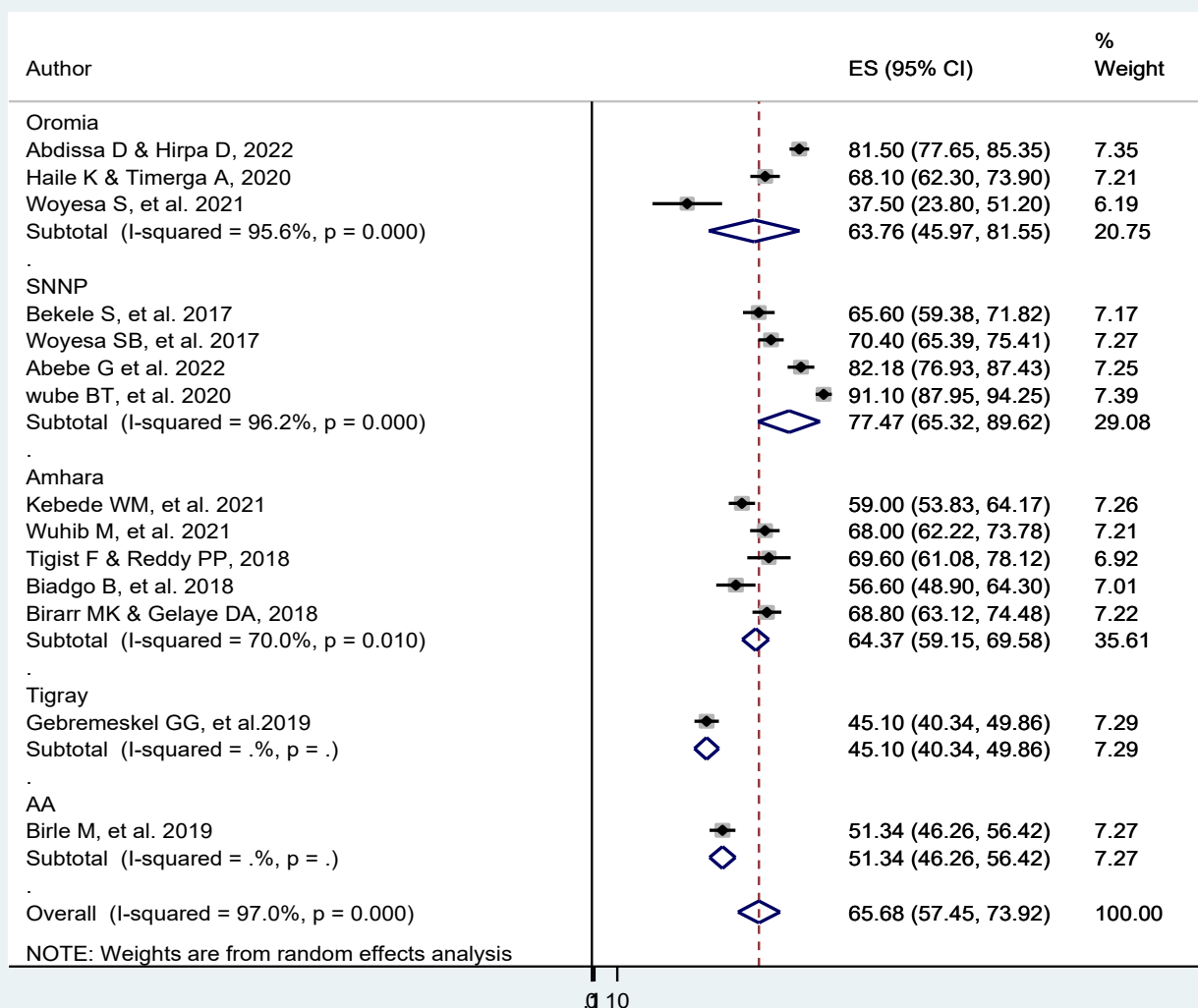


Figure 3: The subgroup analysis of the included studies.

Meta-regression

To identify the factors attributed to the variations across the included studies; sample size and publication years were used. In this random effect meta-regression analysis, the sample size is found to be the covariate, possibly the source of variation or heterogeneity across the included studies (p-value= 0.01) (Table 2).

Table 2: Meta-regression analysis of studies on diabetic dyslipidemia

Heterogeneity	Coefficient	Std. Err.	P-value	95% CI	Model
Sample Size	4.3	0.95	0.01	2.2, 6.4	Random effect meta-regression analysis
Publication year	-0.14	0.27	0.68	-4.7, 1.7	

Note: CI-Confidence Interval, Std Err- Standard error

Publication Bias

The publication bias was detected by visual inspection of the funnel plot, indicating a symmetrical distribution of articles, and Egger's linear regression test p-value was 0.37, meaning that there is no publication bias (Fig. 4).

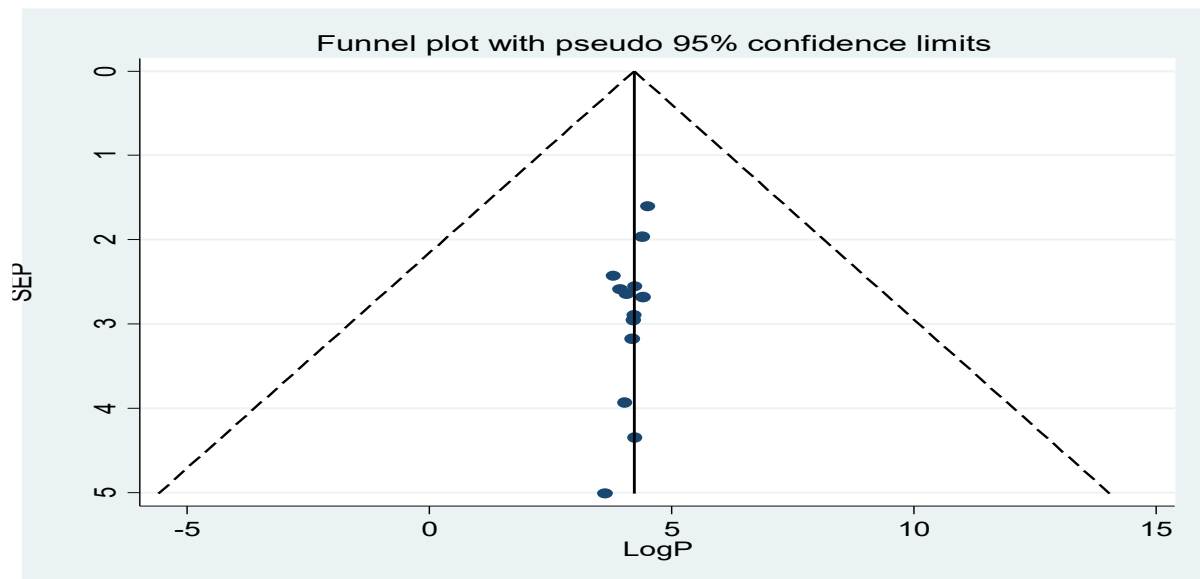


Figure 4: Funnel plot shows the distribution of included articles

Determinants of diabetic dyslipidemia

Female

Being female is found to be the determinant factor of dyslipidemia among people with diabetes. Female diabetic patients are 3.9 times more likely to develop dyslipidemia compared with their male counterparts (AOR: 3.9, 95%CI: 1.5, 10.1; $I^2=35.3\%$, $p=0.21$) using a random effect model (**Fig. 5**). As shown in the forest plot, the variation between studies is 35.3%, indicating there is minimal heterogeneity. Regarding publication bias, Begg and Mazumdar's test for rank correlation gave a p-value of 0.32, indicating no evidence of publication bias.

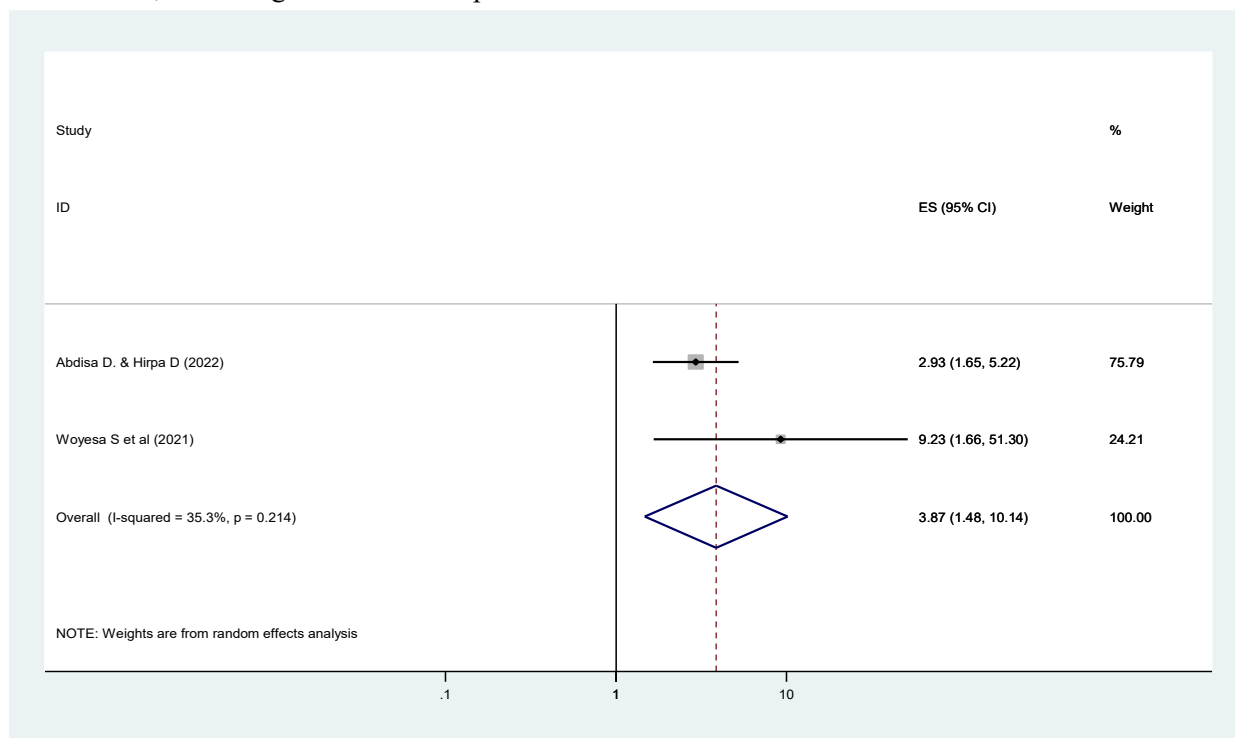


Figure 5: The effect of sex on diabetic dyslipidemia among diabetic patients

Physical inactivity

Physical inactivity is found to be the determinant factor of dyslipidemia among people with diabetes. Diabetic patients who do not do physical activity were 2.6 times more likely to develop dyslipidemia compared to those people with diabetes who do physical activity (AOR: 2.6, 95%CI: 1.5, 4.3; $I^2 = 0.0\%$, $p = 0.82$). The I^2 test statistic is 0.0%, and the p-value is 0.82, which indicates there is minimal heterogeneity across the included studies (**Fig.6**). On further testing, Begg and Mazumdar's test rank correlation gave a p-value of 1.00, indicating there is no publication bias.

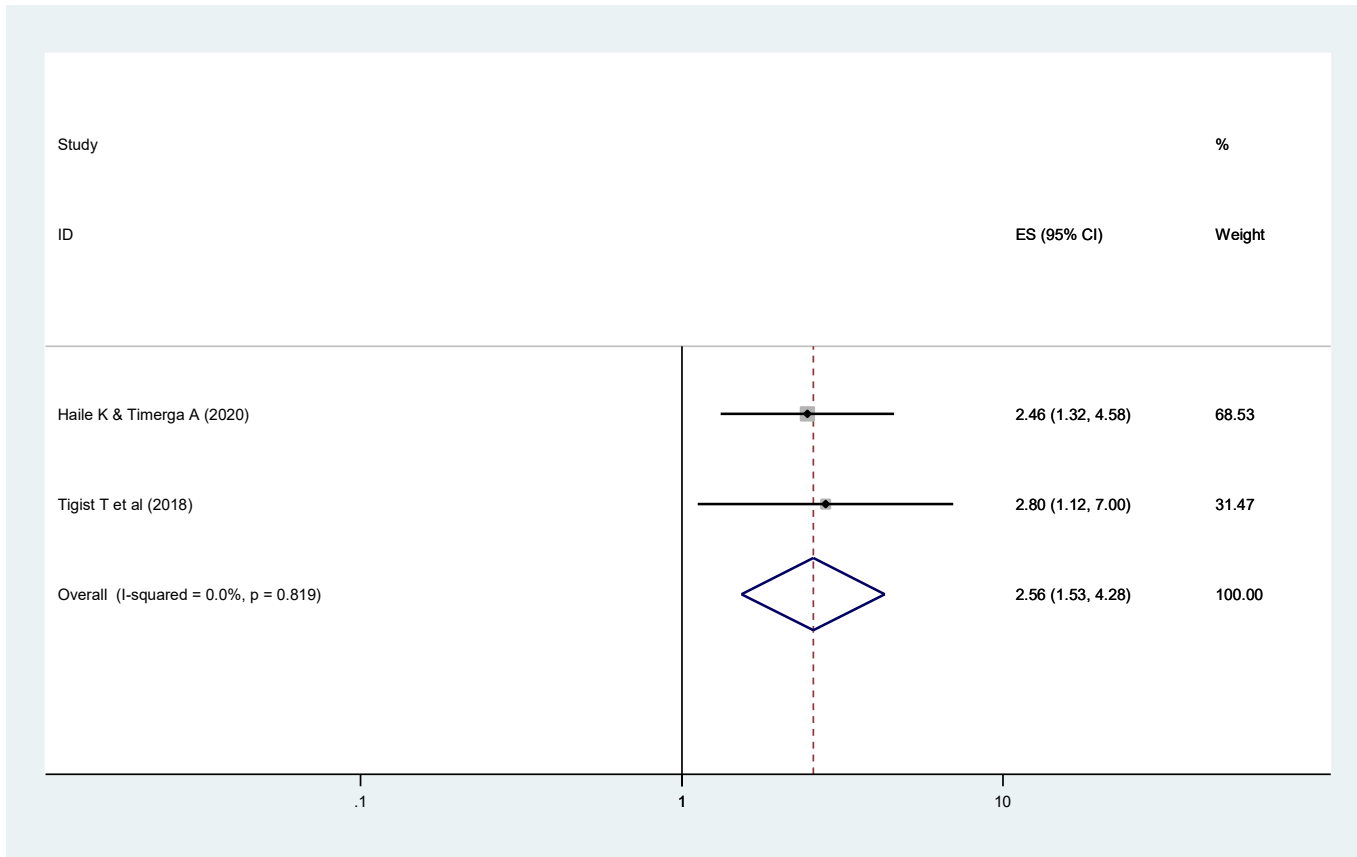


Figure 6: The effect of physical inactivity on diabetic dyslipidemia among diabetic patients

Uncontrolled blood glucose

In this systematic review and meta-analysis, diabetic patients who have uncontrolled blood glucose are at risk for dyslipidemia. People with diabetes who have uncontrolled blood glucose are 4.2 times more likely to develop dyslipidemia compared to those with controlled diabetes (AOR: 4.2, 95%CI: 1.9, 9.4; $I^2 = 19.4\%$, $p = 0.27$). The I^2 and Cochrane Q statistics p-values are 19.4% and 0.27, respectively (**Fig. 7**). These indicate that there is minimal variation across the studies. Begg and Mazumdar's test for rank correlation gave a p-value of 0.32, indicating there is no evidence of publication bias.

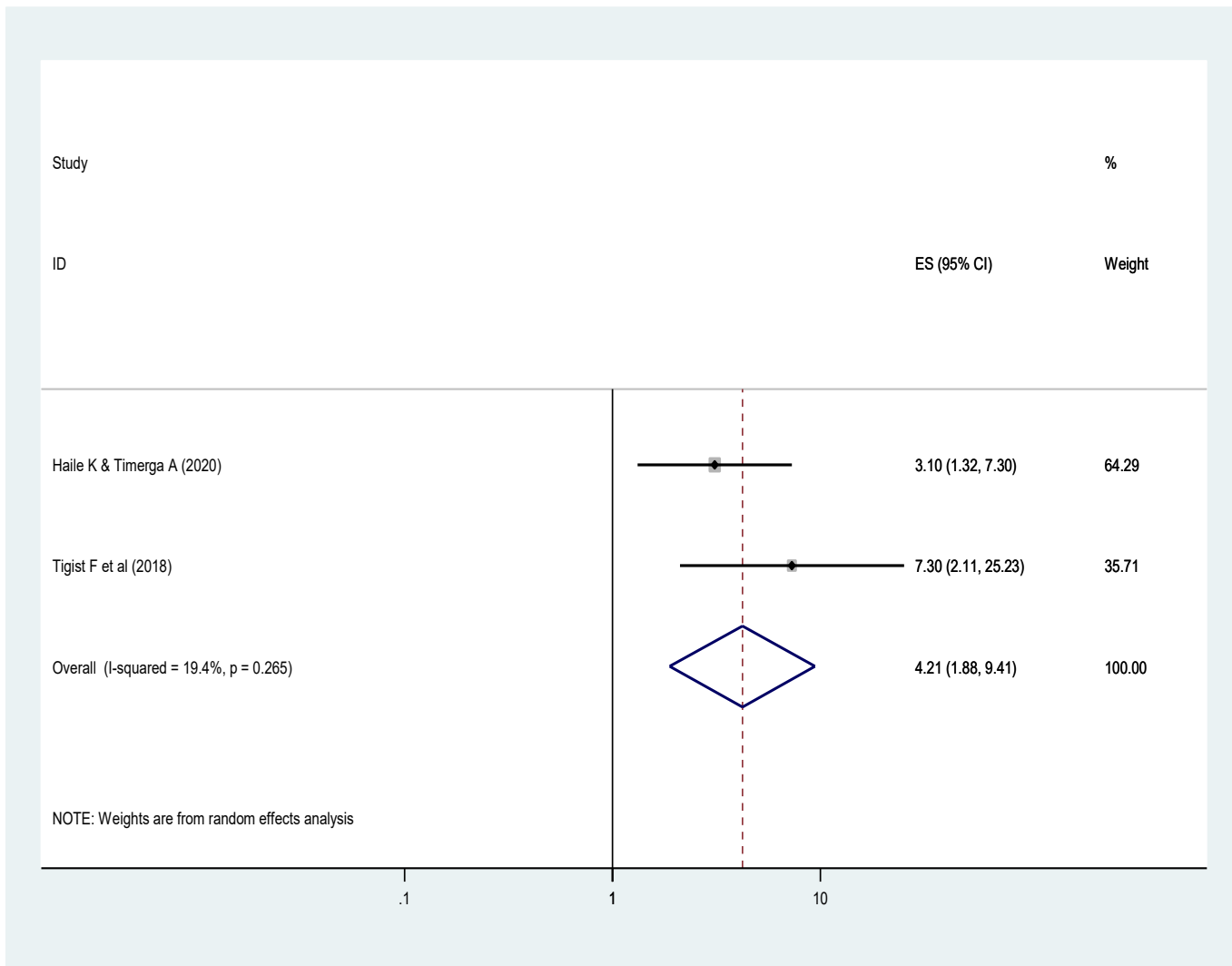


Figure 7: The effect of uncontrolled blood sugar on diabetic dyslipidemia among diabetic patients

Discussion

In this systematic review and meta-analysis, the pooled prevalence of diabetic dyslipidemia was 65.7% (95% CI: 57.5, 73.9). The study includes both type 1 and type 2 diabetic patients in Ethiopia. Based on the regions of Ethiopia, the prevalence of diabetic dyslipidemia was 77.5% (95% CI: 65.3, 89.6) in SNNP, 64.4% (95% CI: 59.2, 69.6) in Amhara, and 63.8% (95% CI: 46.0, 81.6) in the Oromia region. The findings of this study are higher than those of the studies conducted in ten African countries: 52.8% (Obsa et al., 2022) and 25.5% (Noubiap et al., 2018). The possible discrepancy is variation in the study population. In the African studies, the participants were both diabetic and non-diabetic populations and the general population, but the current study focused on diabetic patients.

Based on the lipid profiles, the pooled prevalence of TC, TG, LDL-c, and HDL-c were found to be 34.7% (95% CI: 23.3, 46.0), 51.8% (95% CI: 45.1, 58.6), 34.4% (95% CI: 22.3, 46.6), and 44.2% (95% CI: 32.8, 55.7), respectively. This finding is in line with the study in Orlando, Florida, TC 30.08% (Das, Kerr, Chakravarthy, & Hogg, 2015). In this study, the findings of TG and LDL-c are higher than those of the study conducted in Orlando, Florida: TG 24.82% and LDL-c 18.62%. The variation may be associated with lifestyle modification issues such as physical activity and healthy eating. In addition, socio-economic status plays a vital role in this discrepancy.

In the meta-regression analysis, sample size is the source of the variation for the included studies. The finding of this study is supported by the study conducted in the USA, which dictates that heterogeneity between small studies is greater than between larger studies (IntHout, Ioannidis, Borm, & Goeman, 2015). This is due to studies with a large sample size, which gives a narrow confidence interval and good precision (Liu, 2015).

In this systematic review and meta-analysis, female diabetic patients are at risk for developing dyslipidemia. The finding is supported by a large survey study in Spain (Soriano-Maldonado et al., 2021) and China (Wang et al., 2020). In their reproductive years, the females have a low LDL level, but it rises after menopause. This is associated with female sex hormones such as estrogens, which have a lowering effect specifically on LDL (El Khoudary et al., 2023; Thacker & Thacker, 2007). After the menopause phase, the estrogen level decreased, which in turn increased the LDL levels. Estrogen in women causes a high level of good HDL cholesterol and maintains the bad LDL cholesterol to a lower normal limit during the monthly menstruation cycle (Kennedy, December 27, 2021). But at a later age, these conditions reverse and lead to a progressive rise in LDL cholesterol levels (Currie & Williams, 2008).

People with diabetes who are physically inactive are at risk for dyslipidemia. This is due to the fact that physical inactivity increases visceral fat accumulation, stimulates chronic low-grade systemic inflammation, and leads to insulin resistance and dyslipidemia (Yaribeygi, Maleki, Sathyapalan, Jamialahmadi, & Sahebkar, 2021). Sedentary lifestyles increase the deposit of bad cholesterol. This contributes to endothelial dysfunction and atherosclerosis (Laufs et al., 2005), and in later life, this results in life-threatening cardiovascular complications (Chen & Tseng, 2013). Furthermore, the findings of this study showed that uncontrolled blood glucose is the determinant of dyslipidemia among people with diabetes. Glucose and lipid metabolism are linked to each other in many ways, which leads to diabetic dyslipidemia or increased lipid profiles (Parhofer, 2015). Evidence has been reported that dyslipidemia is associated with insulin resistance and increased lipid metabolism (Bonen, Dohm, & van Loon, 2006; Howard, 1999).

This review has the following important limitations: 1) The study included both diabetic patients, such as type 1 and/or type 2, and as a result, it doesn't clearly show which population type is more affected. Therefore, further study is needed on type 1 or type 2 diabetic patients separately. In the positive aspects, the authors used major databases to search related articles and screened them independently using Rayyan software.

Implications of the study

The main finding is the considerable, unexplained variation in prevalence though heterogeneity detections such as random effect model and subgroup analysis were used. The study highlights the prevalence of dyslipidemia among people with diabetes. The findings of the study provide input to healthcare workers on how to carry out regular lipid profile screening to prevent, detect, and treat lipid profile abnormalities to minimize possible complications. Furthermore, it helps decision-makers and policymakers plan preventive measures before the occurrence of life-threatening cardiovascular complications.

Conclusion

This review revealed that the prevalence of diabetic dyslipidemia is high among people with diabetes in Ethiopia. Being female, having physical inactivity, and having uncontrolled blood glucose were the predictors of dyslipidemia. In Ethiopia, lipid-lowering agents and anti-diabetic treatments have been routinely provided for people with diabetes with co-morbid dyslipidemia. Therefore, regular screening of lipid profiles and treatment of hyperglycemia should be strengthened. Furthermore, lifestyle modification interventions such as a healthy diet, regular physical exercise, and adequate blood glucose control need to be encouraged to reduce life-threatening cardiovascular complications. Healthcare providers should also give special attention to women living with diabetes.

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Abbreviations

CVD-cardiovascular diseases, DM-diabetes mellitus, HDL-C-high density lipoprotein-cholesterol, LDL-C-low density lipoprotein-cholesterol, PRISMA-preferred reporting item of systematic review and meta-analysis, PROSPERO-prospective register of systematic reviews, SNNPR-Southern Nation, Nationalities and People Region, T2DM-type 2 diabetes mellitus.

References

- Abdissa, D., & Hirpa, D. (2022). Dyslipidemia and its associated factors among adult diabetes outpatients in West Shewa zone public hospitals, Ethiopia. *BMC Cardiovascular Disorders*, 22(1), 39.
- Abebe, G., Fikadu, T., Hailu, T., & Temesgen, R. (2022). Determinants of metabolic syndrome among type two diabetic patients following diabetic clinic of Arba Minch General hospital, southern Ethiopia-a case-control study.
- Arredondo, A., Azar, A., & Recamán, A. L. (2018). Diabetes, a global public health challenge with a high epidemiological and economic burden on health systems in Latin America. *Global public health*, 13(7), 780-787.
- Barragan, P., Fisac, C., & Podzamczar, D. (2006). Switching strategies to improve lipid profile and morphologic changes. *AIDS reviews*, 8(4), 191-203.
- Bekele, S., Yohannes, T., & Mohammed, A. E. (2017). 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*, 265-271.
- Biadgo, B., Melak, T., Ambachew, S., Baynes, H. W., Limenih, M. A., Jaleta, K. N., . . . Abebe, M. (2018). The prevalence of metabolic syndrome and its components among type 2 diabetes mellitus patients at a tertiary hospital, northwest Ethiopia. *Ethiopian journal of health sciences*, 28(5).
- Birarra, M. K., & Gelayee, D. A. (2018). Metabolic syndrome among type 2 diabetic patients in Ethiopia: a cross-sectional study. *BMC Cardiovascular Disorders*, 18(1), 1-12.
- Birlie, M. (2019). Assessment of metabolic syndrome in relation to sex among type II diabetes mellitus patients in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia: Addis Ababa university institutional repository.
- Bishu, K. G., Jenkins, C., Yebyo, H. G., Atsbha, M., Wubayehu, T., & Gebregziabher, M. (2019). Diabetes in Ethiopia: a systematic review of prevalence, risk factors, complications, and cost. *Obesity Medicine*, 15, 100132.
- Bonen, A., Dohm, G. L., & van Loon, L. J. (2006). Lipid metabolism, exercise and insulin action. *Essays in biochemistry*, 42, 47-59.
- Chen, S.-c., & Tseng, C.-H. (2013). Dyslipidemia, kidney disease, and cardiovascular disease in diabetic patients. *The review of diabetic studies: RDS*, 10(2-3), 88.
- Cleophas, T. J., Zwinderman, A. H., Cleophas, T. J., & Zwinderman, A. H. (2016). Odds ratios, a short-cut for analyzing cross-tabs. *Clinical Data Analysis on a Pocket Calculator: Understanding the Scientific Methods of Statistical Reasoning and Hypothesis Testing*, 249-252.
- Currie, H., & Williams, C. (2008). Menopause, cholesterol and cardiovascular disease. *US Cardiology*, 5(1), 12-14.
- Das, R., Kerr, R., Chakravarthy, U., & Hogg, R. E. (2015). Dyslipidemia and diabetic macular edema: a systematic review and meta-analysis. *Ophthalmology*, 122(9), 1820-1827.
- El Khoudary, S. R., Chen, X., Qi, M., Derby, C. A., Brooks, M. M., Thurston, R. C., . . . Jackson, E. A. (2023). The independent associations of anti-Müllerian hormone and estradiol levels over the menopause transition with lipids/lipoproteins: The Study of Women's health Across the Nation. *Journal of Clinical Lipidology*, 17(1), 157-167.
- Fikremariam, T., Reddy PCJ Prasad. (2020). Evaluation of Dyslipidemia, Nutritional Status and other associated factors Among Diabetic Mellitus Patients at Felege Hiwot Referral Hospital, Bahir Dar, Ethiopia, 2018. *Dspace Repository, Dspace Institution's institutional repository*.
- Fletcher, J. (2007). What is heterogeneity and is it important? *Bmj*, 334(7584), 94-96.

- Gebremeskel, G. G., Berhe, K. K., Belay, D. S., Kidanu, B. H., Negash, A. I., Gebreslasse, K. T., . . . Birhanu, M. M. (2019). Magnitude of metabolic syndrome and its associated factors among patients with type 2 diabetes mellitus in Ayder Comprehensive Specialized Hospital, Tigray, Ethiopia: a cross sectional study. *BMC research notes*, 12, 1-7.
- Haile, K., & Timerga, A. (2020). 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*, 4589-4597.
- Hedayatnia, M., Asadi, Z., Zare-Feyzabadi, R., Yaghooti-Khorasani, M., Ghazizadeh, H., Ghaffarian-Zirak, R., . . . Sadabadi, F. (2020). Dyslipidemia and cardiovascular disease risk among the MASHAD study population. *Lipids in health and disease*, 19, 1-11.
- Hirano, T. (2018). Pathophysiology of diabetic dyslipidemia. *Journal of atherosclerosis and thrombosis*, 25(9), 771-782.
- Howard, B. V. (1999). Insulin resistance and lipid metabolism. *The American journal of cardiology*, 84(1), 28-32.
- IntHout, J., Ioannidis, J. P., Borm, G. F., & Goeman, J. J. (2015). Small studies are more heterogeneous than large ones: a meta-meta-analysis. *Journal of clinical epidemiology*, 68(8), 860-869.
- Jialal, I., & Singh, G. (2019). Management of diabetic dyslipidemia: An update. *World journal of diabetes*, 10(5), 280.
- Kathak, R. R., Sumon, A. H., Molla, N. H., Hasan, M., Miah, R., Tuba, H. R., . . . Ali, N. (2022). The association between elevated lipid profile and liver enzymes: a study on Bangladeshi adults. *Scientific Reports*, 12(1), 1711.
- Kebede, W. M., Gizachew, K. D., & Mulu, G. B. (2021). Prevalence and risk factors of dyslipidemia among type 2 diabetes patients at a referral hospital, north eastern Ethiopia. *Ethiopian journal of health sciences*, 31(6).
- Kennedy, M. (December 27, 2021). How does high cholesterol affect women and men differently?
- Kopin, L., & Lowenstein, C. J. (2017). Dyslipidemia. *Annals of internal medicine*, 167(11), ITC81-ITC96.
- Laufs, U., Wassmann, S., Czech, T., Münzel, T., Eisenhauer, M., Böhm, M., & Nickenig, G. (2005). Physical inactivity increases oxidative stress, endothelial dysfunction, and atherosclerosis. *Arteriosclerosis, thrombosis, and vascular biology*, 25(4), 809-814.
- Liu, X. S. (2015). Sample Size and the Precision of the Confidence Interval in Meta-analyses. *Therapeutic Innovation & Regulatory Science*, 49(4), 593-598.
- Luchini, C., Stubbs, B., Solmi, M., & Veronese, N. (2017). Assessing the quality of studies in meta-analyses: Advantages and limitations of the Newcastle Ottawa Scale. *World Journal of Meta-Analysis*, 5(4), 80-84.
- Mancini, G. J., Hegele, R. A., Leiter, L. A., & Committee, D. C. C. P. G. E. (2018). Dyslipidemia. *Canadian journal of diabetes*, 42, S178-S185.
- Metrics, I. (2019). for H. & Evaluation. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2016 (GBD 2016) Results.(2017). 5. *Institute for Health Metrics and Evaluation Seattle*.
- Moskalewicz, A., & Oremus, M. (2020). No clear choice between Newcastle–Ottawa Scale and Appraisal Tool for Cross-Sectional Studies to assess methodological quality in cross-sectional studies of health-related quality of life and breast cancer. *Journal of clinical epidemiology*, 120, 94-103.
- Nam H. Cho. (2018). *Diabetes: A Global Health Challenge*.
- Narindrarangkura, P., Bosl, W., Rangsin, R., & Hatthachote, P. (2019). Prevalence of dyslipidemia associated with complications in diabetic patients: a nationwide study in Thailand. *Lipids in health and disease*, 18, 1-8.
- Noubiap, J. J., Bigna, J. J., Nansseu, J. R., Nyaga, U. F., Balti, E. V., Echouffo-Tcheugui, J. B., & Kengne, A. P. (2018). Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *The Lancet Global Health*, 6(9), e998-e1007.

- Obsa, M. S., Ataro, G., Awoke, N., Jemal, B., Tilahun, T., Ayalew, N., . . . Haji, Y. (2022). Determinants of dyslipidemia in Africa: a systematic review and meta-analysis. *Frontiers in cardiovascular medicine*, 8, 778891.
- Organization, W. H. (9 December 2020). The top 10 causes of death.
- Parhofer, K. G. (2015). Interaction between glucose and lipid metabolism: more than diabetic dyslipidemia. *Diabetes & metabolism journal*, 39(5), 353-362.
- Pathak, R., & Pathak, A. (2012). Study of life style habits on risk of type 2 diabetes. *International Journal of Applied and Basic Medical Research*, 2(2), 92.
- Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2011). The Newcastle-Ottawa scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. *Ottawa: Ottawa Hospital Research Institute*, 2(1), 1-12.
- Pignone, M. P., Phillips, C. J., Atkins, D., Teutsch, S. M., Mulrow, C. D., & Lohr, K. N. (2001). Screening and treating adults for lipid disorders. *American journal of preventive medicine*, 20(3), 77-89.
- Rücker, G., Schwarzer, G., Carpenter, J. R., & Schumacher, M. (2008). Undue reliance on I² in assessing heterogeneity may mislead. *BMC medical research methodology*, 8, 1-9.
- Soriano-Maldonado, C., Lopez-Pineda, A., Orozco-Beltran, D., Quesada, J. A., Alfonso-Sanchez, J. L., Pallarés-Carratalá, V., . . . Carratala-Munuera, C. (2021). Gender differences in the diagnosis of dyslipidemia: ESCARVAL-GENERO. *International Journal of Environmental Research and Public Health*, 18(23), 12419.
- Thacker, H. L., & Thacker, H. (2007). *Women's Health: Your Body, Your Hormones, Your Choices*: Cleveland Clinic Press.
- Wang, M., Liu, M., Li, F., Guo, C., Liu, Z., Pan, Y., . . . Wu, Y. (2020). Gender heterogeneity in dyslipidemia prevalence, trends with age and associated factors in middle age rural Chinese. *Lipids in health and disease*, 19(1), 1-11.
- Wells, G. A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2000). The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.
- WHO. (2006). Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia: report of a WHO/IDF consultation.
- Woyesa, S., Mamo, A., Mekonnen, Z., Abebe, G., Gudina, E. K., & Milkesa, T. (2021). Lipid and lipoprotein profile in HIV-infected and non-infected diabetic patients: a comparative cross-sectional study design, Southwest Ethiopia. *HIV/AIDS-Research and Palliative Care*, 1119-1126.
- Woyesa, S. B., Hirigo, A. T., & Wube, T. B. (2017). Hyperuricemia and metabolic syndrome in type 2 diabetes mellitus patients at Hawassa university comprehensive specialized hospital, South West Ethiopia. *BMC endocrine disorders*, 17, 1-8.
- Wu, L., & Parhofer, K. G. (2014). Diabetic dyslipidemia. *Metabolism*, 63(12), 1469-1479.
- Wube, T. B., Begashaw, T. A., & Hirigo, A. T. (2020). Prevalence of dyslipidemia and its correlation with anthropometric and blood pressure variables among type-2 diabetic patients. *Journal of Diabetes and Endocrinology*, 11(1), 10-17.
- Wuhib, M., Tegegne, B., Mekonnen, L., Mengesha, Z., Girma, M., Solomon, M., & Wuhib, G. (2022). Correlation of dyslipidemia and atherogenic index of plasma with anthropometric measurements and clinical variables among diabetic patients in Dessie Comprehensive Specialized Hospital, Ethiopia, 2021. *Annals of Clinical Gastroenterology and Hepatology*, 6(1), 025-033.
- Yaribeygi, H., Maleki, M., Sathyapalan, T., Jamialahmadi, T., & Sahebkar, A. (2021). Pathophysiology of physical inactivity-dependent insulin resistance: a theoretical mechanistic review emphasizing clinical evidence. *Journal of Diabetes Research*, 2021.