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Abstract

Background Metabolic syndrome has become a major public health problem worldwide and is attributable to the spread of di erent non-communicable diseases such as type 2 diabetes mellitus, coronary artery diseases, stroke, and

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Introduction

Metabolic syndrome (Mets) is non-communicable; a group of metabolic risk factors encompasses central obe-

“Metabolic Syndrome X” OR “Insulin Resistance Syndrome X” OR “Dysmetabolic Syndrome X” OR “Metabolic Cardiovascular Syndrome” OR “Cardio-metabolic Syndrome” AND “diabetes patients” OR “adult diabetic patients” OR “Insulin non-dependent diabetes” OR

ree articles [22–24] were used by WHO with a total sample of 900 where two studies were located in the Amhara region, Ethiopia and one South region, Ethiopia. Two articles [23, 28] were located in South region Ethiopia which used the Harmonized diagnosis criteria with a sample of 708 study participants (Table 3).

Prevalence of metabolic syndrome using NCEP-ATP III diagnosis criteria in Ethiopia

A total of 12 primary articles were appraised and retrieved to pool the overall prevalence of metabolic syndrome among type 2 diabetic patients in Ethiopia. However, we did not get the overall prevalence of metabolic syndrome in the reviewed articles, all the authors rather reported the outcome using IDF, NCEP-ATP III, WHO, and harmonized diagnosis criteria. Hence, we have pooled similar outcomes based on the diagnosis metabolic syndrome among type 2 diabetic patients was 54.56% [95%CI (43.73, 65.38), $I^2=97.0\%$, $P=0.001$]. The effect size of the overall pooled prevalence using NCEP-ATP III diagnosis criteria among type 2 diabetic patients in Ethiopia was presented using a forest plot (Fig. 2).

Subgroup analysis by region

We conducted a **s**ub-group analysis based on the region where the primary articles were located. Hence, the lowest pooled prevalence of metabolic syndrome using the random-effects model was 41.25% [95%CI (36.66, 45.85), $I^2=0.00\%$, $p<0.983$] in the Oromia region, Ethiopia followed by 53.04% [95%CI (32.64, 73.39), $I^2=98.4\%$, $p<0.001$] in South region, Ethiopia. Whereas, whereas, the highest sub-group pooled prevalence of metabolic syndrome was 65.36% [95%CI (58.44, 72.28), $I^2=74.8\%\%$, $p<0.019$] in Amhara region, Ethiopia (Fig. 3).

Prevalence of metabolic syndrome using IDF diagnosis criteria in Ethiopia

In a systematic review and meta-analysis, a total of seven primary articles with IDF diagnosis criteria were appraised and retrieved to pool the overall prevalence of metabolic syndrome among type 2 diabetic patients in Ethiopia. Hence, the prevalence of metabolic syndrome in individual articles ranged from 31.40 to 57.00% in Oromia and Amhara, regions, Ethiopia respectively. The overall pooled prevalence of metabolic syndrome using the IDF diagnosis criteria among type 2 diabetic patients was 48.32% [95%CI (42.1, 54.44), $I^2=97.0\%$, $P=0.001$]. The effect size of the overall pooled prevalence using IDF diagnosis criteria among type 2 diabetic patients in Ethiopia was presented using a forest plot (Fig. 4).

Subgroup analysis by region using IDF diagnosis criteria

We conducted a **s**ub-group analysis based on the region where the primary articles were located. Hence, the lowest pooled prevalence of metabolic syndrome using the asymmetry, which is a potential indicator of bias. To reinforce these findings and assess robustness, we performed a trim-and-fill analysis. This method estimates the number of potentially missing studies due to publication bias and adjusts the pooled effect size accordingly. Our trim-and-fill analysis did not identify any missing studies or alter the pooled estimate, providing further confidence that publication bias did not significantly influence our results.

Additionally, we conducted Begg's test, a rank correlation method that evaluates the relationship between study effect sizes and their variances. This statistical test did not reveal any significant correlation, as indicated by a p-value of 0.675, suggesting the absence of publication bias. Similarly, we applied Egger's test, a regression-based approach that examines the relationship between the standardized effect sizes and their standard errors. With a p-value of 0.755, Egger's test provided no evidence of significant asymmetry in the funnel plot, further supporting the minimal risk of publication bias in our meta-analysis.

Sensitivity analysis

We have conducted a sensitivity analysis to identify whether there is evidence of the influencing effect of one study on the other. The output of leave-one-out sensitivity analysis through the random-effects model revealed that there was no individual study that influenced the overall pooled prevalence of metabolic syndrome among type 2 patients in this particular review. For each single study, the effect size indicated relates to the overall pooled effect size generated from meta-analysis omitted that particular study (Additional Files: Figures 5 and 9).

Trim and fill analysis

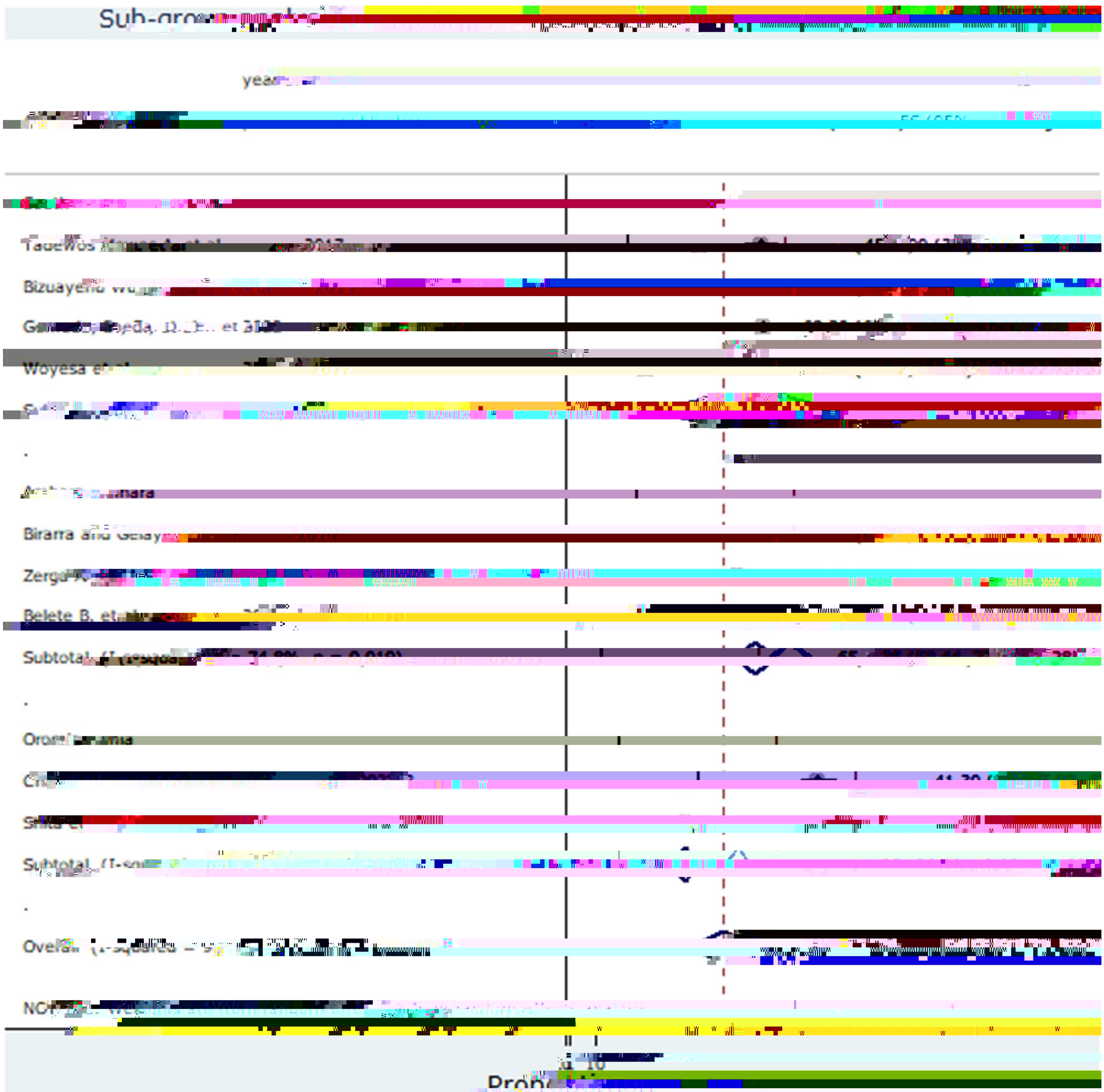

Fig. 3 Forest plot of the subgroup analysis of the regional prevalence of metabolic syndrome using NCEP-ATP III diagnosis criteria among type 2 diabetic patients in Ethiopia

a determinant of Metabolic Syndrome among type 2 diabetic patients. We found sex, alcohol intake, and did not have physical exercise signi cant predictors of metabolic syndrome among type 2 diabetic patients in Ethiopia using IDF as diagnosis criteria. In this regard, seven [22–26, 30, 32] articles reported sex as a determinant were pooled and the pooled e ect size of the analysis revealed that females had 45% lower odds (Adjusted Odds Ratio [AOR] = 0.55, 95% CI: 0.35–0.87) of metabolic syndrome compared to males, after adjusting for other factors in the model. Four studies [17, 19, 20, 26] identi ed alcohol intake as a signi cant predictor, showing that individuals who consumed alcohol had 1.44 times higher odds of developing metabolic syndrome compared to non-drinkers (AOR = 1.44, 95% CI: 1.03–2.01). Additionally, six studies [16–20, 26] reported physical exercise as a predictor, and the pooled e ect size indicated that individuals who did not engage in physical exercise were 1.86 times more likely to develop metabolic syndrome than those who exercised (AOR = 1.86, 95% CI: 1.43–3.55).

Predictor variables associated with metabolic syndrome using the NECP-PAT-III diagnostic criteria in

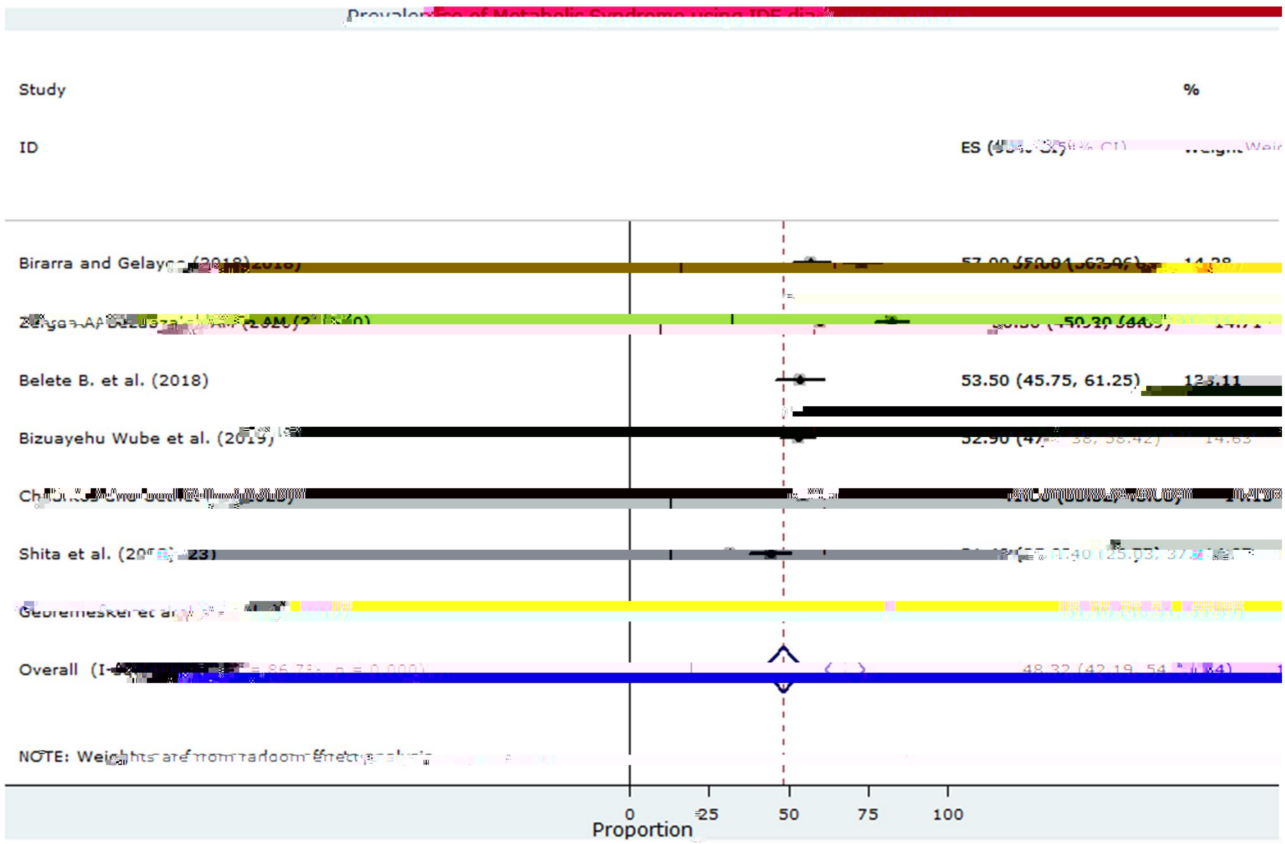

Fig. 4 Forest plot of the pooled prevalence of metabolic syndrome using IDF diagnosis criteria among type 2 diabetic patients in Ethiopia

Ethiopia were also analyzed. Five studies [6, 16–18, 21] were pooled and the e ect size revealed that females had 0.44 times (AOR = 0.44, 95% CI: 0.29–0.68) the odds of metabolic syndrome compared to males. e residency was examined in three studies [16, 21, 22], which found that individuals living in urban areas had 2.12 times higher odds of developing metabolic syndrome compared to those in rural areas (AOR = 2.12, 95% CI: 1.55–2.88). Lastly, three studies [16, 17, 21] examined diabetes duration as a predictor, with a pooled e ect size showing that patients with a diabetes duration of six or more years since diagnosis had 2.94 times higher odds of developing metabolic syndrome compared to those with a shorter duration (AOR = 2.94, 95% CI: 1.17–7.41). (Table 4).

Discussion

e prevalence of metabolic syndrome among type2 diabetic patients in Ethiopia found 54.56% [95%CI (43.73, 65.38), $I^2 = 97.0\%$, $P = 0.001$], 48.32% [95%CI (42.1, 54.44), $I^2 = 97.0\%$, $P = 0.001$], 47.0% [95%C (27.00, 66.95), $I^2 = 97.0\%$, $P = 0.001$], and 59.37%[95%CI(47.21, 71.52), $I^2 = 97.0\%$, $P = 0.001$] using NCEP-ATP III, IDF, WHO, and harmonized diagnosis criteria respectively. e subgroup analysis by region revealed signi cant variation in the prevalence of metabolic syndrome among diabetic patients. is might be due to population socio-cultural and health access di erences across the regions of Ethiopia. For instance, the Amhara region has the highest prevalence of unmet health needs of the community as a result of human-made problems such as war. e nding was consistence with the study results of 50.2% and 53.9% in India [33] and 53.1% in Mexico [34] of the study conducted in India using NCEP-ATP III and IDF diagnosis criteria respectively. It was also consistent with study results of 45.8% in India [35] and 43.83 in Ghana [36] using NCEP-ATP III diagnosis criteria. However, the nding was higher than the study results of 35.1% and 29.5% in Brazil [37] using IDF and NCEP-ATP III diagnosis criteria respectively. It was also higher than the study results of 36% and 31% in Mexico [38] using NCEP-ATP III and WHO diagnosis criteria respectively. e possible explanation might be due to socio-demographic and health-related literacy variations among Ethiopia, Brazil and Mexico, which had a lion's share in self-care and risk minimization among diabetic patients. However, the current study result is lower than the study results of 68.6% in Ghana [39] and 58.00% in Ghana [40]. It was also lower than the study results of 73.4%, and 64.9% in Iran [41] using NCEP-ATP III and IDF diagnosis criteria respectively. Moreover, it was lower than the study result 57.7%

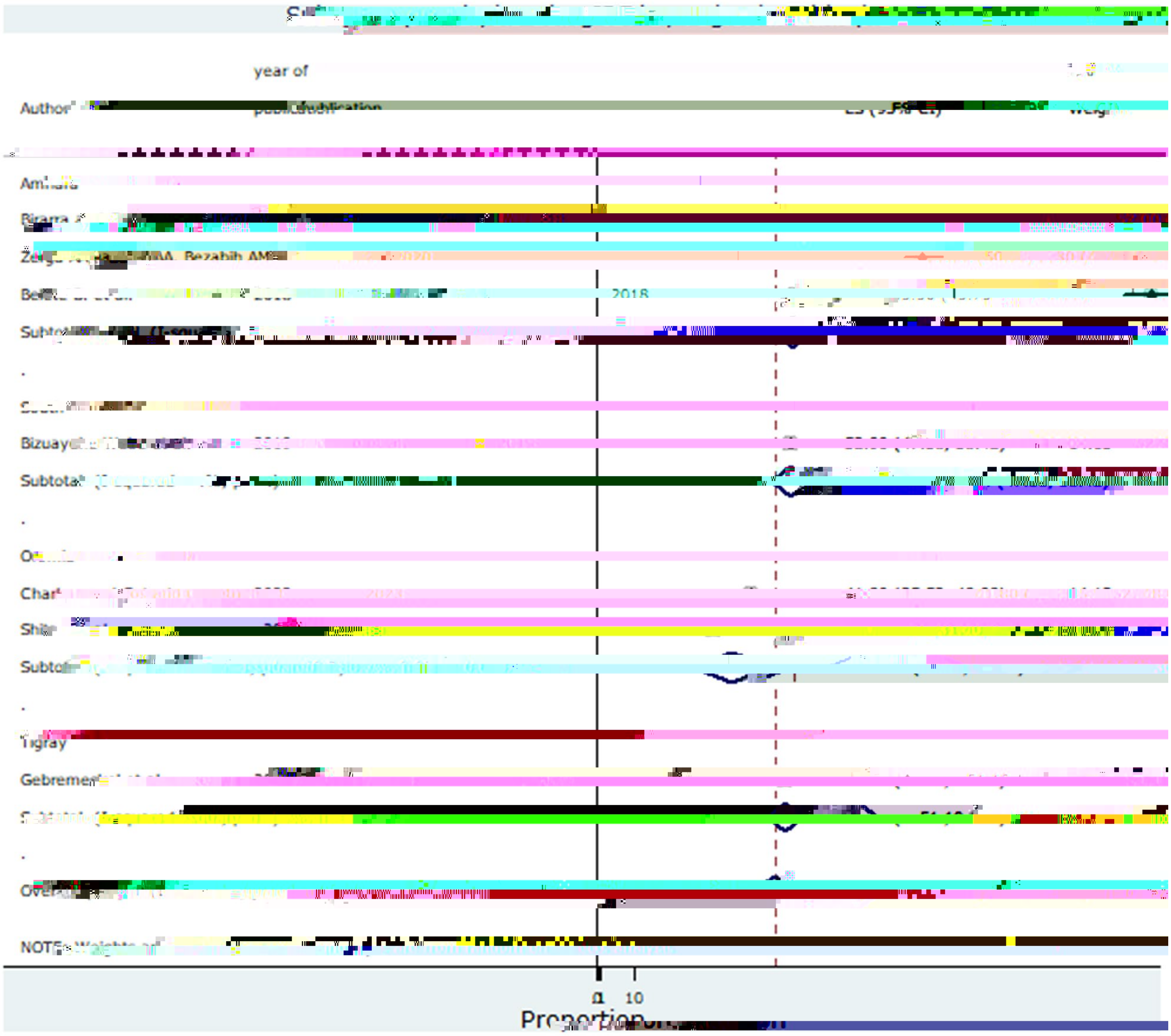

Fig. 5

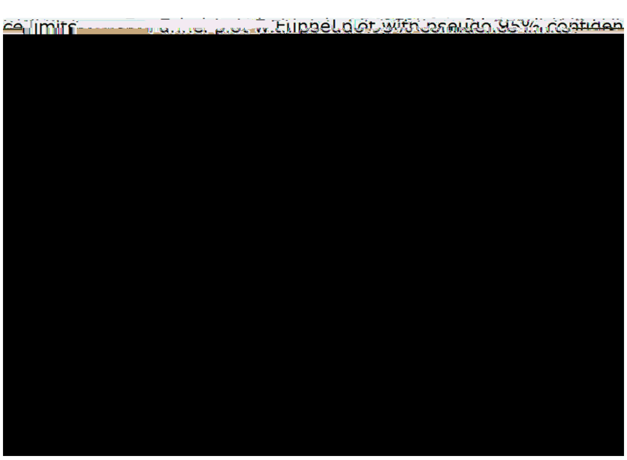

Fig. 6 Funnel plot analysis of the metabolic syndrome using NCEP-ATP III diagnosis criteria among type 2 diabetic patients in Ethiopia

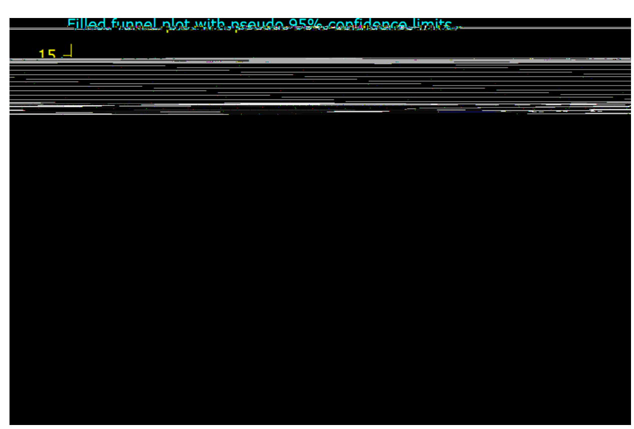

Fig. 7 Sensitivity analysis of included studies for the metabolic syndrome using NCEP-ATP III diagnosis criteria among type 2 diabetic patients in Ethiopia

in India [35] using IDF diagnosis criteria. The possible explanation might be the study in Ghana was only among both type 1 and type 2 diabetic patients living in two big districts, but the present study is the pooled prevalence results of four different regions. The current Systematic review and meta-analysis result is also lower than the study result of 70.4 in Iran [41] and 72.7% in India [33] using harmonized diagnosis criteria. Moreover, it was lower than the study results of 80% and 85% in Saudi [42] using WHO and NCEP-ATP III diagnosis criteria respectively. Furthermore, the finding of the current result is lower than the study results of 60.4% and 71.7% in South Africa [43] using NCEP-ATP III and IDF diagnosis criteria. Besides, the findings of a current systematic review and meta-analysis are lower than the results of 63.58% and 69.1% in Ghana [36] using WHO and NCEP-ATP III respectively. The variation might be socio-demographic, socio-economic, healthcare access and lifestyle factors; for instance, growing urbanization in South Africa and Ghana may have higher levels of urbanization compared to Ethiopia. Urban lifestyles are often associated with physical inactivity, unhealthy diets, and increased stress, all of which contribute to higher Mets prevalence. The study results of 66.2% and 58.4% in Nepal [44] using IDF and NCEP-ATP III diagnosis criteria were higher than the current. The possible explanation might be socio-demographic and lifestyle-related variations between patients in Nepal and Ethiopia. For example; Nepal may have higher rates of urbanization and associated sedentary lifestyles, compared to Ethiopia's largely rural population. Urban lifestyles often lead to reduced physical activity and higher rates of obesity and Mets. Besides, the Nepalese diets may include more processed foods, high-calorie diets, or sugary foods, contributing to Mets risk. In contrast, Ethiopia's traditional diet, which includes high consumption of whole grains and less processed

Table 4 Determinants of metabolic syndrome among Type2 diabetic patients using IDF and NECP-ATP III diagnosis criteria in Ethiopia

Determinants of Metabolic Syndrome among Type2 diabetic patients using IDF					
Variables	**No of the Articles pooled**	**Pooled OR (95%CI)**	**Egger's test**	**I^2 (%)**	**P-values**
Sex(Female)	Seven[22–26, 30, 32]	**0.55(0.35, 0.87)***	0.895	81.1	0.001
Age(≥ 65 year)	Five [22–25, 32]	0.48(0.17, 1.36)	0.067	82.6	0.001
Residency(Urban)	Five[22, 23, 25, 26, 30]	0.65(0.36, 1.15)	0.620	80.4	0.001
Duration of DM (≥ 6 years)	Five[22, 23, 25, 26, 32]	0.48(0.23, 1.00)	0.169	75.3	0.003
Alcohol intake(Yes)	Four[23, 25, 26, 32]	**1.44(1.03, 2.01)**	0.991	0.00	0.476
BMI ≥ 25 kg/m^2					

food, may lower Mets prevalence. This is evidenced by studies conducted in the USA [45], Brazil [46] and China [47].

It is also supported by the study conducted in Ghana [48] in which a sedentary lifestyle such as smoking, weight gain, and physical inactivity were significant predictors of metabolic syndrome among type 2 diabetic patients.

Being female was identified as a significant predictor of metabolic syndrome (Mets) among T2DM patients in Ethiopia. Females had lower odds of developing metabolic syndrome compared to males, with odds of having metabolic syndrome decreased by 45% and 56% based on the IDF and NCEP-ATP III criteria, respectively. This finding aligns with studies conducted in Nepal and Ghana [44

22. Birarra MK, Gelayee DA. Metabolic syndrome among type 2 diabetic patients in Ethiopia: a cross-sectional study. BMC Cardiovasc Disord. 2018;18(1):149.
23. Bizuayehu Wube T, Mohammed Nuru M, Tesfaye Anbese A. A Comparative Prevalence Of Metabolic Syndrome Among Type 2 Diabetes Mellitus Patients In Hawassa University Comprehensive Specialized Hospital Using Four Di□erent Diagnostic Criteria. 2019;(12): 1877–1887.
24. Zerga AA, Bezabih AM. Metabolic syndrome and lifestyle factors among type 2 diabetes mellitus patients in Dessie Referral Hospital, Amhara region, Ethiopia. PLoS ONE. 2020;15(11):e0241432.
25. Shita A, et al. Metabolic syndrome and its associated factors among type 2 diabetic patients in Mizan-Tepi University Teaching Hospital, Southwest Ethiopia Region. J Diabetes Res. 2023;4:1234674.
26. Gebremeskel GG, et al. 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 Res Notes. 2019;12(1):603.
27. Agete Tadewos H. WĂΣĞ