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Triglyceride to high-density lipoprotein ratio as a predictor for 10-year cardiovascular disease in individuals with diabetes in Thailand

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Abstract

Background Cardiovascular disease (CVD) remains the leading cause of morbidity and mortality worldwide. The triglyceride to high-density lipoprotein cholesterol (TG/HDL) ratio has emerged as a potential marker for CVD risk. However, its predictive value for high 10-year predicted Cardiovascular (CV) risk remains unclear; This study evaluates the predictive value of the TG/HDL-C ratio for 10-year cardiovascular risk using the Framingham Heart Study (FHS) risk prediction model in individuals with Type 2 Diabetes Mellitus (T2DM).

Methods A cross-sectional study was conducted on 61,004 adults from 2014,2015, and 2018 aged 30–74 years with T2DM, without a history of CVD. The FHS model was used to estimate 10-year predicted CV risk, and high CVD risk was defined as ≥ 20%. ROC curve analysis was used to determine the optimal TG/HDL cutoff for high 10-year predicted CV risk in the overall population and age-specific subgroups. Logistic regression was performed to find the association between TG/HDL and high 10-year predicted CV risk, adjusting for potential confounders.

Results The optimal TG/HDL-C cutoff was 2.52 (AUC = 0.618, 95% CI: 0.612–0.624), with 67% sensitivity and 50% specificity. Higher TG/HDL were associated with increased odds of high predicted CVD risk in a dose-dependent manner, with an adjusted odds ratio (AOR) of 5.16 (95% CI: 4.86–5.49) in the highest TG/HDL quartile (> 4.91). Age-stratified analysis identified lower cutoffs for older adults (≥ 60 years: 2.42, AUC = 0.694) than younger individuals (< 60 years: 2.98, AUC = 0.636), indicating stronger predictive performance in older adults.

Conclusions The TG/HDL ratio is significantly associated with 10-year predicted CVD risk in T2DM with age-specific differences in predictive value. The lower cutoff for older adults (2.42) suggests even modest elevations indicate increased risk. These findings support TG/HDL integration into routine CVD risk assessments and highlight the importance of age-specific cutoffs for improved risk stratification.

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Keywords Triglyceride to HDL ratio, TG/HDL, Association, Cardiovascular risk, Diabetes mellitus, Thailand

Introduction

Cardiovascular disease (CVD) is a group of disorders that affect the heart and blood vessels, including coronary artery disease (CAD), stroke, peripheral arterial disease (PAD), and heart failure. It remains a leading cause of global morbidity and mortality, with its impact steadily increasing. From 1990 to 2019, the prevalence of CVD doubled, contributing to a rise in cumulative deaths from 12.1 million to 18.6 million [1, 2]. This growing burden has placed significant strain on healthcare systems, leading to escalating costs and an increased caregiving load [3, 4]. Despite advancements in medical management, early identification and control of Cardiovascular (CV) risk factors remain crucial for reducing disease burden and improving patient outcomes [5].

In Thailand, although a Thai CV risk score has been developed for a particular professional demographic, additional external validation is still required [6]. Numerous tools for assessing cardiovascular risk exist, including the Framingham Heart Study (FHS) model, one of the most widely recognized risk-predicting tools. This model plays a pivotal role in care management, intervention evaluation, and risk stratification [7, 8]. Originally designed for the U.S. population, its application in Asian populations has been validated by two retrospective cohort studies demonstrating its utility in multiethnic settings [9, 10].

The triglyceride-to-high-density lipoprotein cholesterol (TG/HDL) ratio is a widely used clinical marker with applications in various metabolic and cardiovascular contexts. It is recognized as an early indicator of insulin sensitivity, with studies incorporating it into predictive models to enhance the accuracy of insulin resistance estimation [11, 12]. Additionally, the TG/HDL ratio has been identified as a reliable cardiovascular risk marker, correlating with early vascular damage even in younger individuals [13]. Abnormal lipid profiles, characterized by elevated TG and reduced HDL levels, are well-established modifiable risk factors for CVD [14]. While lowering low-density lipoprotein (LDL) cholesterol has proven effective in reducing CV risk, emerging evidence highlights that abnormal TG and HDL levels remain significant contributors to cardiovascular pathology [15–17]. Numerous studies demonstrate an association between higher TG/HDL ratios and cardiovascular disease [15, 18–20]. Both prospective and retrospective cohort studies link a high TG/HDL ratio to an increased risk of major adverse cardiovascular events (MACE) [16, 21]. Furthermore, the TG/HDL ratio has been employed to predict revascularization, coronary artery calcifications, stent stenosis, and future cardiovascular events [22–25].

However, the prognostic capability of the TG/HDL ratio varies across ethnic groups. Studies indicate that TG/HDL is a strong predictor of cardiovascular risk in Caucasian populations [26, 27], while its predictive value appears less consistent in individuals of African ancestry [27]. These differences may arise from genetic variations in lipid metabolism, disparities in adipose tissue distribution affecting triglyceride and HDL levels, and lifestyle factors influencing lipid profiles and cardiovascular risk [28–30]. These ethnic discrepancies underscore the necessity for customized risk evaluation strategies when using TG/HDL as a CV risk marker in heterogeneous populations.

This cross-sectional study aims to evaluate the role of the TG/HDL ratio in predicting 10-year CV risk among individuals with T2DM, utilizing the FHS risk prediction model. By integrating TG/HDL into a validated risk assessment framework, this research seeks to determine its utility as a reliable indicator for cardiovascular risk stratification, particularly within Asian populations.

Methods

Study design and subjects

The data for this study were obtained from the database titled 'Assessment of Quality of Care among Patients Diagnosed with Type 2 Diabetes and Hypertension Visiting the Ministry of Public Health (MoPH) and Bangkok Metropolitan Administration Hospital in Thailand (Thailand DM/HT) [31]. This serial cross-sectional study was conducted in 2014, 2015, and 2018. Before commencing the study, we obtained the necessary permissions from the National Health Security Office (NHSO) and the Medical Research Network of the Consortium of Thai Medical Schools (MedResNet). The study included Thai adult patients with T2DM or Hypertension (HT) from all MoPH Hospitals, Bangkok Metropolitan Hospitals, and public and private clinics participating in the nationwide NHSO program. A total of 33,288, 32,616, and 36,793 patients with T2DM were recruited in 2014, 2015, and 2018, respectively (Fig. 1). The study included T2DM patients aged 30 to 74. The FHS equation was employed to calculate the predicted 10-year CV risk [32]. Participants with a history of CVD (including coronary death, myocardial infarction, coronary insufficiency, angina, ischemic stroke, hemorrhagic stroke, transient ischemic attack, PAD, and heart failure) or those with unavailable laboratory data necessary for calculating FHS (TG, FBS, HDL, TC) were excluded. Thus, 61,004 participants were included in the study.

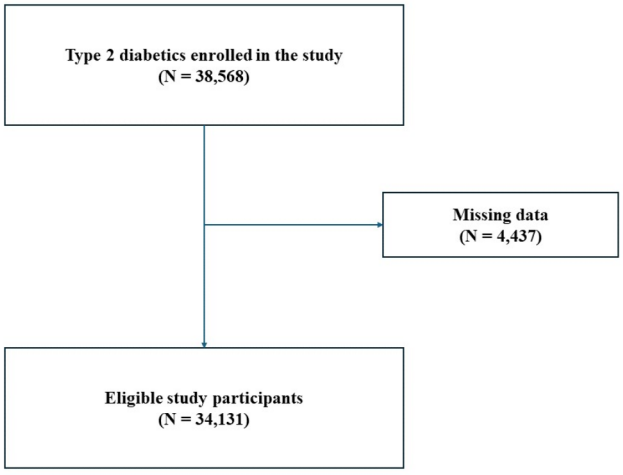

Fig. 1 Flow of enrolled with Type 2 diabetes receiving care in Thailand in 2014, 2015, and 2018

Data collection

We utilized a standardized case report form (CRF) for medical records. This CRF was completed by well-trained registered nurses following a standard protocol. After completion, the forms were sent to the MedResNet central data management unit in Nonthaburi, Thailand. The data collected from the patient's medical records included baseline information, current medications, laboratory testing results, and the status of diabetes complications.

Variables and measurements

For the operationalization of demographic variables. BMI was categorized as ≥25 and <25 kg/m², following the WHO classification for obesity tailored to the Asian population [33]. Age was stratified into two groups: <60 years and ≥60 years. These cutoffs were based on the average age of premature myocardial infarction occurrence (55 years for males and 65 years for females), reflecting age-specific cardiovascular risk patterns [34]. Fasting plasma glucose (FPG) was classified into ≤130 mg/dL and >130 mg/dL, based on the target glycemic control recommended for diabetic patients by established clinical guidelines [35]. Hypertension, SBP, and smoking status were excluded from the model analysis to

Table 1 Baseline characteristics of enrolled diabetic patients from 2014, 2015 and 2018 (*N* = 61,004)

Year	2014	2015	2018	
Characteristics	***n*(%)**	***n*(%)**	***n*(%)**	***p*-value**
No. of participants	17,761	18,551	24,692	
Age (year)				< 0.001
< 60	9,217 (51.9)	9,281 (50)	11,656 (47.2)	
≥ 60	8,544 (48.1)	9,270 (50)	13,036 (52.8)	
Sex				< 0.001
Male	5,211 (29.3)	5,805 (31.3)	8,017 (32.5)	
Female	12,550 (70.7)	12,746 (68.7)	16,675 (67.5)	
Scheme				< 0.001
Universal healthcare coverage	1,4037 (79.2)	14,365 (77.4)	19,432 (78.7)	
Civil servant medical benefit	2,641 (14.9)	3,024 (16.3)	3,807 (15.4)	
Social security	827 (4.7)	804 (4.3)	1,129 (4.6)	
Others	224 (1.3)	358 (1.9)	324 (1.3)	
BMI (kg/m²)				< 0.001
< 25	8,471 (47.7)	8,546 (46.1)	11,283 (45.7)	
≥ 25	9,290 (52.3)	10,005 (53.9)	13,409 (54.3)	
Hypertension	13,080 (73.6)	14,182 (76.4)	18,638 (75.5)	< 0.001
Dyslipidemia	12,524 (70.5)	13,854 (74.7)	17,677 (71.6)	< 0.001
Gout	592 (3.3)	635 (3.4)	1,198 (4.9)	< 0.001
Receiving anti-diabetic drug	17,337 (97.6)	18,022 (97.1)	23,926 (96.9)	< 0.001
FPG (mg/dL)				< 0.001
≤ 130	6,542 (29.3)	6,860 (30.7)	8,920 (40)	
> 130	11,219 (29)	11,691 (30.2)	15,772 (40.8)	
TG/HDL ratio				
median (IQR)	3.3 (2.2–5.1)	3.2 (2.1-5.0)	3.0 (2.0-4.7)	< 0.001
Quartile 1 (< 2.05)	4,080 (23.0)	4,842 (26.1)	7,022 (28.4)	< 0.001
Quartile 2 (2.05–3.16)	4,382 (24.7)	4,495 (24.2)	6,109 (24.7)	
Quartile 3 (3.16–4.91)	4,452 (25.1)	4,443 (24)	5,850 (23.7)	
Quartile 4 (> 4.91)	4,847 (27.3)	4,771 (25.7)	5,711 (23.1)	

BMI Body Mass Index, *FPG* fasting plasma glucose, *TG* triglyceride, *HDL* high density lipoprotein,

Table 2 Logistic regression analysis of high 10-year predicted CV risk and TG/HDL ratio

Variables	Total					
	OR	**95%CI**	***p* value**	**AOR[a]**	**95%CI**	***p* value**
TG/HDL ratio	1.14	1.14–1.15	< 0.001	1.22	1.21–1.23	< 0.001
TG/HDL ratio						
Low TG/HDL ratio[b]	Ref	-	-	ref.	-	-
High TG/HDL ratio[b]	2.05	1.98–2.12	< 0.001	2.83	2.72–2.96	< 0.001
TG/HDL ratio (Quartile)						
Quartile 1 (< 2.05)	Ref	-	-	ref.	-	-
Quartile 2 (2.05–3.16)	1.46	1.39–1.53	< 0.001	1.81	1.71–1.92	< 0.001
Quartile 3 (3.16–4.91)	2.04	1.95–2.14	< 0.001	2.88	2.71–3.05	< 0.001
Quartile 4 (> 4.91)	2.97	2.83–3.10	< 0.001	5.16	4.86–5.49	< 0.001

TG Triglyceride, *OR* odds ratio, *AOR* adjusted odds ratio

[a] Adjusted for sex, geographic region, occupation, health scheme, age, BMI, fasting plasma glucose, receiving anti-diabetic drugs, dyslipidemia, gout comorbidity

[b] Low TG/HDL is ≤ 2.52, high TG/HDL is > 2.52

reduce redundancy, as these variables are already integral components of the Framingham 10-year CV risk score. Multicollinearity diagnostics confirmed that all included variables, including TG/HDL ratio and age, were free from multicollinearity with the Framingham score (Variance Inflation Factor, VIF < 5). TG/HDL ratio and age were retained in the model due to their clinical and research relevance. The predicted 10-year CV risk was calculated using the FHS equation. This calculation incorporated variables from laboratory-based data such as age, sex, systolic blood pressure (SBP), history of current smoking, history of diabetes, treatment for hypertension, total cholesterol (TC), and HDL cholesterol. The predicted 10-year CV risk of 10–20% was defined as low

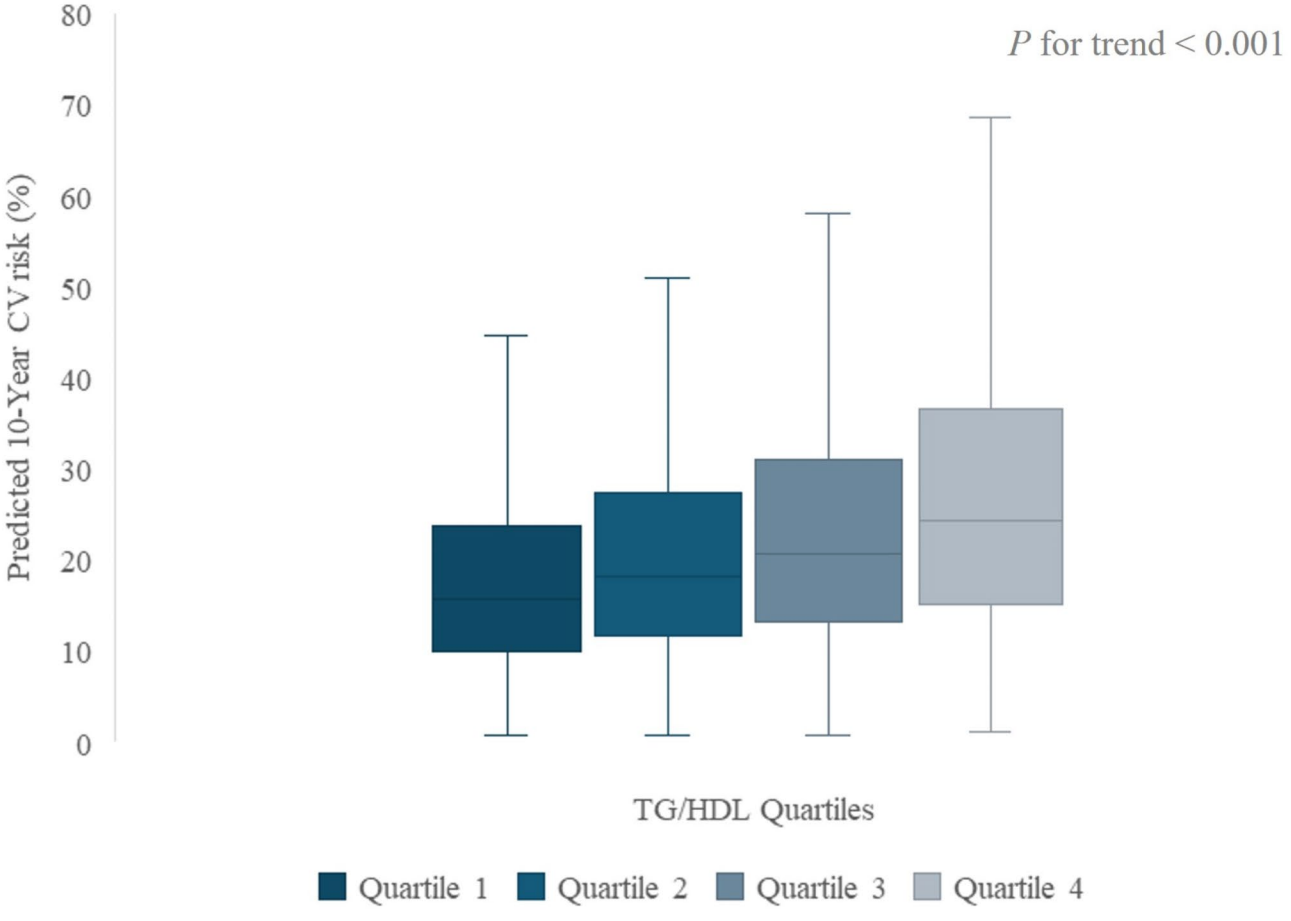

Fig. 2 Boxplot of Predicted 10-year CV risk and TG/HDL ratio quartiles

to intermediate risk, while a risk ≥ 20% was categorized as high [32]. The TG/HDL ratio was calculated using the formula TG divided by HDL.

Statistical analysis

Data analysis in this study was performed using IBM SPSS version 29. Categorical data are presented as numbers and percentages. Continuous variables are shown as means and standard deviations (SD) for normally distributed data and as medians and interquartile ranges (IQR) for non-normally distributed data. Logistic regression was conducted to assess whether TG/HDL-C was independently associated with a higher likelihood of high predicted CV risk (≥ 20%). Univariable logistic regression was performed to identify potential confounders. Multicollinearity diagnostics were conducted on all demographic and clinical variables included in the analysis. VIF values were calculated for all variables, and those with VIF < 5 were considered free of multicollinearity. The TG/HDL ratio identified confounders were incorporated into the final multivariable logistic regression model, with results expressed as adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Receiver Operating Characteristic (ROC) curve analysis was conducted to assess the discriminative performance of the TG/HDL ratio for predicting high 10-year CV risk. The optimal cutoff value was determined using Youden's J statistic, with sensitivity and specificity reported for the overall population and specific subgroups. Interaction tests were performed to identify potential effect modification by key demographic and clinical variables. Subgroup analyses were subsequently performed for variables demonstrating significant interaction effects. Sensitivity analyses were conducted to confirm the robustness of findings, particularly for subgroups with strong associations or significant interactions. All statistical tests were two-sided, with p-values < 0.05 considered statistically significant.

Results

Characteristics of study participants

Table 1 demonstrates the baseline demographic and laboratory characteristics of study participants. A total of 61,004 diabetic patients were enrolled in this study. There were 17,761, 18,551, and 24,692 from the database in 2014, 2015 and 2018, respectively. Over the years, there was a significant increase in the proportion of participants aged ≥ 60 years (from 48.1% in 2014 to 52.8% in 2018, $p < 0.001$). The majority of participants were female, with a notable upward trend in representation from 67.5% in 2014 to 70.7% in 2018 ($p < 0.001$).

In terms of clinical characteristics, the prevalence of hypertension and dyslipidemia remained consistently high across all three time points. The proportion of individuals with BMI ≥ 25 kg/m² increased from 52.3% in 2014 to 54.3% in 2018 ($p < 0.001$), while the percentage of participants with FPG ≥ 130 mg/dL also showed an increasing trend ($p < 0.001$). Similarly, the proportion of participants with FPG > 130 mg/dL increased over time ($p < 0.001$). Median TG/HDL-C ratios showed a declining trend from 3.3 (IQR: 2.2–5.1) in 2014 to 3.0 (IQR: 2.0–4.7) in 2018 ($p < 0.001$), suggesting potential changes in lipid profiles among participants over time. Baseline characteristics, including geographic location, hospital level, occupation, smoking status and SBP were shown in Supplementary Table.

Table 3 Age-specific, FPG-specific logistic regression analysis of high FHS-CV risk and TG/HDL ratio

Variables	AOR	95%CI	*p* value
Age < 60 years[a]			
TG/HDL ratio			
Low TG/HDL ratio[c]	Ref	-	
High TG/HDL ratio[c]	3.09	2.88–3.31	< 0.001
TG/HDL ratio (Quartile)			
Quartile 1 (< 2.05)	Ref	-	
Quartile 2 (2.05–3.16)	1.97	1.78–2.7	< 0.001
Quartile 3 (3.16–4.91)	3.15	2.86–3.46	< 0.001
Quartile 4 (> 4.91)	5.36	4.88–5.88	< 0.001
Age ≥ 60 years[a]			
TG/HDL ratio			
Low TG/HDL ratio[c]	Ref	-	
High TG/HDL ratio[c]	2.73	2.58–2.89	< 0.001
TG/HDL ratio (Quartile)			
Quartile 1 (< 2.05)	Ref	-	
Quartile 2 (2.05–3.16)	1.79	1.66–1.93	< 0.001
Quartile 3 (3.16–4.91)	2.81	2.60–3.04	< 0.001
Quartile 4 (> 4.91)	5.29	4.85–5.77	< 0.001
FPG < 130[b]			
TG/HDL ratio			
Low TG/HDL ratio[c]	Ref	-	
High TG/HDL ratio[c]	2.86	2.67–3.07	< 0.001
TG/HDL ratio (Quartile)			
Quartile 1 (< 2.05)	Ref	-	
Quartile 2 (2.05–3.16)	1.85	1.69–2.03	< 0.001
Quartile 3 (3.16–4.91)	2.91	2.64–3.19	< 0.001
Quartile 4 (> 4.91)	5.53	4.99–6.12	< 0.001
FPG ≥ 130[b]			
TG/HDL ratio			
Low TG/HDL ratio[c]	Ref	-	
High TG/HDL ratio[c]	2.82	2.67–2.98	< 0.001
TG/HDL ratio (Quartile)			
Quartile 1 (< 2.05)	Ref	-	
Quartile 2 (2.05–3.16)	1.78	1.65–1.92	< 0.001
Quartile 3 (3.16–4.91)	2.86	2.65–3.08	< 0.001
Quartile 4 (> 4.91)	4.99	4.62–5.40	< 0.001

TG Triglyceride, *AOR* adjusted odds ratio

[b] Adjusted for age, sex, geographic region, occupation, health scheme, BMI, receiving anti-diabetic drugs, dyslipidemia, gout comorbidity

[c] Low TG/HDL is ≤ 2.52, high TG/HDL is > 2.52

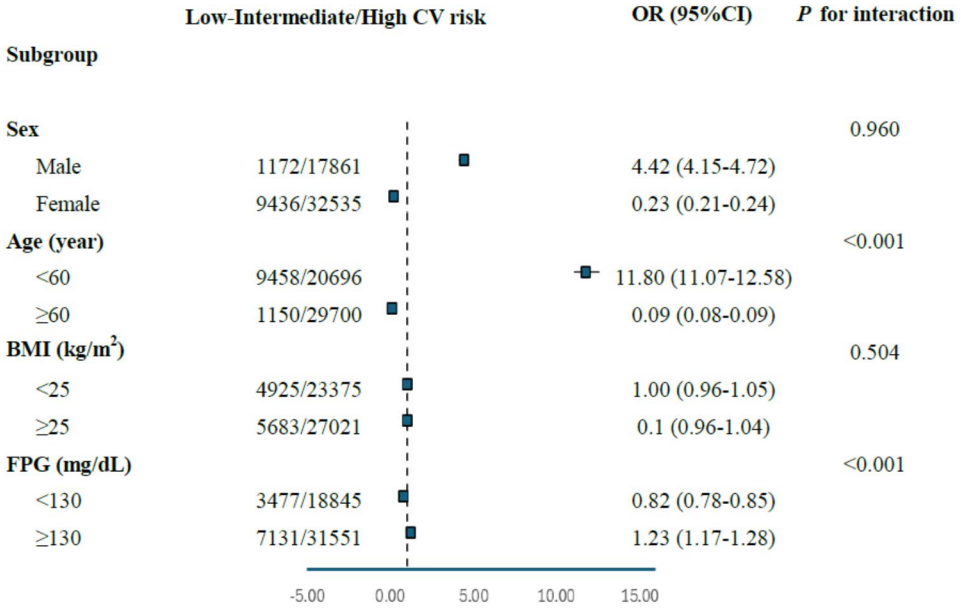

Fig. 3 Interaction test assessing effect modification of the association between TG/HDL ratio and high predicted 10-year CVD risk across selected variables

Logistic regression analysis for the relationship between TG/HDL and high predicted 10-year CV risk

Table 2 displays a logistic regression analysis of the high predicted 10-year CV risk and TG/HDL ratio, adjusting for potential confounders, for every one-unit increase in the TG/HDL-C ratio, the odds of having a high predicted CVD risk increased by 22% (AOR: 1.22, 95% CI: 1.21–1.23, $p < 0.001$). After using ROC analysis to determine the cut-point for high predicted CV risk (TG/HDL ≥ 2.52). Participants with TG/HDL-C ≥ 2.52 had a nearly 2.83-fold higher risk of high predicted CVD risk compared to those with TG/HDL-C < 2.52 with an AOR of 2.83 (95% CI: 2.72–2.96, $p < 0.001$). When analyzed by quartiles, a dose-response relationship was observed (Fig. 2), with higher TG/HDL-C quartiles showing greater odds of high predicted CVD risk. Participants in the second quartile (TG/HDL 2.05–3.06) had 1.88 times higher odds (AOR: 1.88, 95% CI: 1.77–2.00, $p < 0.001$) compared to the reference group (TG/HDL < 2.05). The highest quartile (TG/HDL > 4.91) demonstrated the strongest association, with participants having 5.16 times higher odds of high predicted CV risk (AOR: 5.16, 95% CI: 4.86–5.49, $p < 0.001$).

Table 4 Sensitivity analysis

Variables	AOR	95%CI	*p* value
Age < 60 years[a]			
TG/HDL ratio			
Low TG/HDL ratio[b]	Ref	-	
High TG/HDL ratio[b]	2.94	2.76–3.13	< 0.001
Age ≥ 60 years[a]			
TG/HDL ratio			
Low TG/HDL ratio[c]	Ref	-	
High TG/HDL ratio[c]	2.74	2.59–2.91	< 0.001

[a] Adjusted for sex, geographic region, occupation, health scheme, BMI, fasting plasma glucose, receiving anti-diabetic drugs, dyslipidemia, gout comorbidity

[b] Low TG/HDL is ≤ 2.98, high TG/HDL is > 2.98

[c] Low TG/HDL is ≤ 2.42, high TG/HDL is > 2.42

Subgroup analysis

To assess potential effect modification, interaction testing was performed for sex, age, BMI, and FPG (Fig. 3). Significant effect modification was observed for age and FPG in the association between TG/HDL ratio and cardiovascular risk (p for interaction < 0.001 for both). Conversely, no evidence of effect modification was found for sex or BMI. The result led to further subgroup analyses as shown in Table 3. Stratified analysis by age demonstrated that the association between TG/HDL-C and high predicted CVD risk was more pronounced in individuals aged < 60 years (AOR = 3.09, 95% CI: 2.88–3.31, $p < 0.001$) compared to those aged ≥ 60 years (AOR = 2.73, 95% CI: 2.58–2.89, $p < 0.001$). Stratification by FPG levels (< 130 mg/dL vs. ≥130 mg/dL) showed a consistent association across both groups. Among those with FPG < 130 mg/dL, a TG/HDL-C ratio > 2.52 was associated with a 2.86-fold higher CVD risk (AOR: 2.86. 95% CI: 2.67–3.07, $p < 0.001$). Similarly, in participants with FPG ≥ 130 mg/dL, the risk was 2.82 times higher (AOR: 2.82, 95% CI: 2.67–2.98, $p < 0.001$).

Receiver operational characteristic curve analysis of TG/HDL ratio for predicting high predicted 10-year CV risk

Figure 4A. illustrates an ROC curve with an optimal cut point of 2.52 (Sensitivity 67%, Specificity 50%) for the TG/HDL ratio to predict high predicted 10-year CV

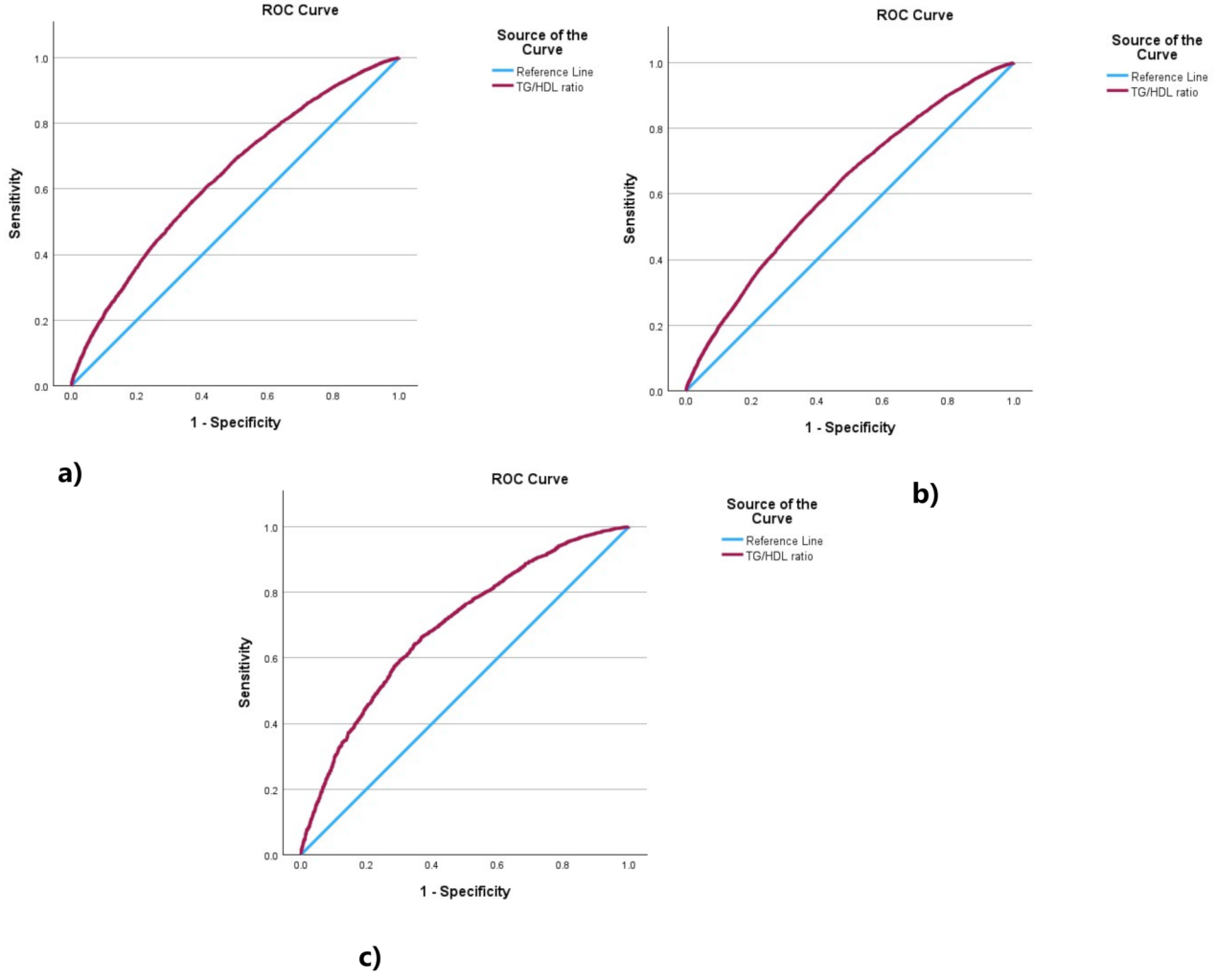

Fig. 4 ROC curve of TG/HDL ratio for predicting high predicted 10-year CV risk. (**A**) Overall participants (**B**) age < 60 and (**C**) age ≥ 60

risk, and AUC of 0.618 (95% CI: 0.612–0.624). Given the observed interaction between TG/HDL ratio and age, an age-stratified ROC analysis was conducted to assess whether distinct cutoff values could improve predictive performance in different age groups. Figure 4B illustrates an ROC curve with an optimal cut point of 2.98, with an AUC of 0.636 (95% CI: 0.629–0.643). The sensitivity and specificity at this threshold were 61% and 42%, respectively for Participants aged < 60 years. Figure 4C exhibits a higher AUC of 0.694 (95% CI: 0.678–0.709) for Participants aged ≥ 60 years. Sensitivity was 66%, while specificity was 37%. The TG/HDL ratio cutoff was lower at 2.42.

Sensitivity analysis

Figure 5 illustrates the prevalence of high predicted 10-year CV risk across TG/HDL ratio quartiles, stratified by age groups (< 60 and ≥ 60 years). The prevalence increases progressively across TG/HDL quartiles in both age groups, with a higher prevalence observed in participants aged ≥ 60 years compared to those < 60 years for each quartile (*P* for trend < 0.001).

Table 4 presents the results of the sensitivity analysis conducted to evaluate the association between TG/HDL ratio and high predicted CV risk stratified by age groups. Among participants aged < 60 years, a high TG/HDL ratio (≥ 2.98) was associated with a significantly higher likelihood of high predicted CV risk, with an adjusted odds ratio (AOR) of 2.94 (95% CI: 2.76–3.13, $p < 0.001$), compared to those with a low TG/HDL ratio (< 2.98). Similarly, in participants aged ≥ 60 years, a high TG/HDL ratio (≥ 2.42) was significantly associated with high predicted CV risk, with an AOR of 2.74 (95% CI: 2.59–2.91, $p < 0.001$), compared to the low TG/HDL group (< 2.42).

Discussion

This study investigated the association between the TG/HDL ratio and 10-year predicted CV risk in a large cohort of individuals with T2DM. The baseline

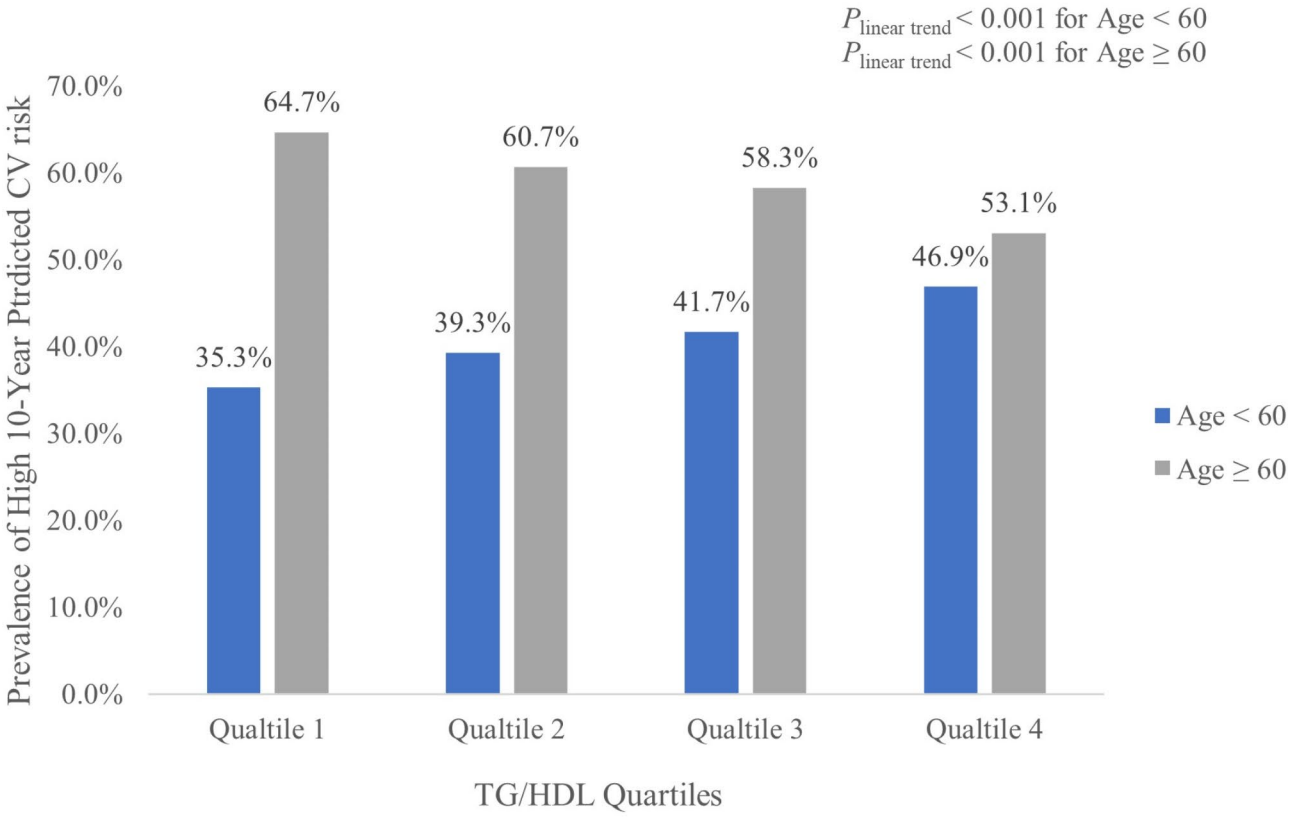

Fig. 5 Prevalence of high predicted 10-year CV risk and TG/HDL quartiles stratified by age

characteristics highlight a significant burden of cardiovascular risk factors in this cohort, including high prevalence rates of overweight and obesity, hypertension, and dyslipidemia. The TG/HDL ratio serves as a novel lipid marker providing insights beyond its HDL component, while age remains a well-established predictor of cardiovascular outcomes.

Our findings demonstrate that a higher TG/HDL ratio is significantly associated with increased likelihood of high predicted CV risk in individuals with T2DM. This result is consistent with prior research showing that elevated TG/HDL ratios predict cardiovascular risk. For instance, an 8-year follow-up in the Copenhagen Male Study reported that a high TG-low HDL profile is as strong a predictor of ischemic heart disease as isolated high LDL levels [15]. Additionally, the dose-response relationship observed across TG/HDL quartiles in our study supports its utility in identifying individuals at elevated CVD risk, consistent with prior studies reporting a significant upward trend in cardiovascular risk across increasing TG/HDL quartiles [26].

ROC curve analysis identified an optimal TG/HDL cutoff of 2.52 for predicting high 10-year CV risk, with an AUC of 0.618 (95% CI: 0.612–0.624), sensitivity of 67%, and specificity of 50%. We did not perform sex-specific cutoffs due to the absence of significant interaction between TG/HDL and sex. However, our cutoff differs from those reported in other populations. For example, Silva et al. identified cutoffs of 3.26 for men and 2.72 for women [18], while studies in Argentina reported cutoffs of 3.5 for men and 2.5 for women [19]. Similarly, research in Iran reported thresholds of 4.42 for men, 3.76 for women, and 3.68 for the overall population [20]. These variations likely reflect differences in geographic regions, race/ethnicity, age distribution, and cardiovascular risk assessment tools [29, 36]. Our study provides a population-specific cutoff tailored to Asian individuals with T2DM, reinforcing the importance of contextual factors in risk stratification.

Interaction testing and subgroup analyses revealed that the association between TG/HDL ratio and high predicted CV risk varied by age group. The association between the TG/HDL and high predicted CVD risk remained significant across all age groups, but a stronger association was observed in younger individuals. ROC analysis showed greater predictive value of TG/HDL in older adults, with a lower cutoff of 2.42 and an AUC of 0.694, compared to a higher cutoff of 2.98 and an AUC of 0.636 in younger adults. These findings suggest age-related differences in lipid metabolism and cumulative cardiovascular burden may influence TG/HDL's predictive utility [37–39]. Younger individuals may require

higher thresholds to identify those at elevated risk, reflecting differences in baseline cardiovascular risk and lipid physiology [40].

The clinical implications of this study are notable. The TG/HDL ratio may serve as an accessible, cost-effective marker for early risk detection in high-risk patients. Age-specific cutoffs could enhance predictive accuracy, particularly for older individuals, ensuring better identification of those at risk. Additionally, these findings highlight the importance of triglyceride-lowering strategies, especially in individuals with elevated TG/HDL ratios and other risk factors. Interventions such as lifestyle modifications and pharmacologic therapy targeting triglycerides could play a key role in reducing cardiovascular risk.

Limitations

This study provides robust evidence from a large, nationally representative dataset of T2DM patients and the use of ROC analysis to define optimal TG/HDL cutoffs and stratified analyses to account for effect modification by age strengthens the clinical applicability of these results. However, several limitations should be considered. Firstly, due to the cross-sectional nature of this study, it does not establish causality between TG/HDL and CV risk but rather identifies the predictive relationship. Future longitudinal studies are needed to determine whether TG/HDL changes over time influence actual CVD outcomes. Additionally, a total of 23,598 participants (28.9% of the initial sample) were excluded due to incomplete data, which may have implications for statistical power. Furthermore, the use of the FHS model for risk prediction introduces a degree of interdependence, as HDL is a component of both the TG/HDL ratio and the FHS score. Although multicollinearity diagnostics confirmed no significant issues, this overlap could potentially influence the results and requires the need of careful interpretation. Finally, geographic and ethnic differences in TG/HDL cutoffs highlight the need for population-specific validation.

Conclusion

This study highlights the TG/HDL ratio as a significant predictor of high 10-year predicted CV risk in individuals with T2DM, demonstrating a strong dose-response relationship and age-specific differences in predictive value. The ROC-defined cutoff of 2.52 provides a clinically relevant threshold for CVD risk stratification, with lower cutoffs (2.42) recommended for older adults to enhance predictive performance. These findings underscore the potential utility of the TG/HDL ratio as a simple, cost-effective tool for screening high-risk individuals, supporting age-adjusted risk assessment strategies in clinical practice.

Abbreviations

FHS	Framingham heart study
TG	Triglyceride
HDL	High density lipoprotein
TG/HDL	Triglyceride to high density lipoprotein
CVD	Cardiovascular disease
T2DM	Type 2 diabetes mellitus
FPG	Fasting plasma glucose
BMI	Body mass index
CI	Confidence interval
SD	Standard deviation
IQR	Interquartile range
OR	Odds ratio
AOR	Adjusted odds ratio

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-025-00835-0.

Supplementary Material 1

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Author contributions

MP, SL, CK, MM, RR, WK, and PS developed the study concept. RR collected the data, MP and SL analyzed the data, and wrote the first draft. PS oversee all the study protocols. All authors contributed to and approved the final version.

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Data availability

Data cannot be shared publicly because the dataset contains identifying information.Additionally, the data belong to the Thailand DM/HT study of the MedResNet. Thus, ethicsrestrictions exist on the data set. Data are available from the Thai NHSO, Bangkok, Thailand(contact Sirikorn Khunsri via sirikorn@nhso.go.th) for researchers meeting the criteria to access confidential data.

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Review Board, Royal Thai Army (Approved No. Q004h/67), in accordant with international guidelines including the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines, and the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use - Good Clinical Practice (ICH-GCP). Due to using secondary data, a waiver of documentation of informed consent was utilized, and the waiver for informed consent was granted by the Institutional Review Board, RTA Medical Department.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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