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Exploring the Relationship Between HbA1c and Lipid Profile Parameters in Type 2 Diabetes Mellitus: Evidence from Indonesian Community-Based Chronic Disease Program

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is a global health issue linked to insulin resistance and lifestyle factors. In Indonesia, it has prompted the Chronic Disease Management Program (Prolanis) to monitor glycemic control (HbA1c) and lipid levels, addressing the risk of cardiovascular complications. Our objective was to evaluate the correlation between glycemic control and lipid profiles in patients with T2DM enrolled in the Prolanis program. We carried out a retrospective analysis of secondary data derived from laboratory results of patients diagnosed with T2DM and enrolled in the Prolanis program 2024 in Padang, Indonesia. The data collected comprised HbA1c levels and lipid profiles. We categorized the HbA1c levels into two groups: non-diabetic and diabetic. Furthermore, we classified the components of the lipid profile as follows: total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides. A correlation analysis was conducted to examine the relationship between HbA1c levels and each lipid profile component using the chi-square test in STATA Ver.16. A total of 17 patients (60.76 ± 7.25 years) with type 2 diabetes enrolled in the Prolanis program in 2024 were analyzed for their HbA1c and lipid profiles. Chi-square analysis showed no significant associations between HbA1c levels and any lipid profile component, including total cholesterol ($p = 0.909$, OR = 1.125), HDL (all patients were normal), LDL ($p = 0.778$, OR = 0.75), and triglycerides ($p = 0.767$, OR = 1.5). This study highlighted the need for continued investigation into the complex factors influencing lipid profiles in type 2 diabetes, as no significant relationship was found between glycemic control and lipid abnormalities in this study.

Keywords: cardiovascular risk, dyslipidemia, high-density lipoprotein, low-density lipoprotein, non-insulin-dependent diabetes mellitus, total cholesterol, triglycerides

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder and a significant global health concern. It is characterized by insulin resistance and a relative deficiency of insulin, which collectively lead to persistently elevated blood glucose levels

and various metabolic disturbances. The global prevalence of T2DM among adults has been steadily increasing, with approximately 537 million cases recorded in 2021. Projections suggest that this number may rise to 783 million by 2045 [1]. In Southeast Asian countries, including Indonesia, T2DM represents a major public health burden, consistently ranking among the top ten causes of death and disability-adjusted life years (DALYs) [2].

In response to this growing burden, the Indonesian government implemented the Program Pengelolaan Penyakit Kronis (Prolanis), a chronic disease management program designed to improve health outcomes for individuals with T2DM and hypertension. This initiative includes regular clinical monitoring, patient education, and routine biochemical assessments—such as hemoglobin A1c (HbA1c) and lipid profiles—aimed at preventing complications, particularly cardiovascular disease and diabetic nephropathy [3].

HbA1c serves as a crucial biomarker for long-term glycemic control, reflecting average blood glucose levels over the previous two to three months. Elevated HbA1c levels have been associated with an increased risk of dyslipidemia, as well as the development of both microvascular and macrovascular complications [4]. Dyslipidemia in individuals with T2DM is typically characterized by elevated triglyceride levels, reduced high-density lipoprotein cholesterol (HDL-C), and increased low-density lipoprotein cholesterol (LDL-C), all of which significantly contribute to atherogenesis [5]. Furthermore, renal biomarkers—including urea, creatinine, and microalbuminuria—offer valuable insights into the severity of diabetic nephropathy and assist in cardiovascular risk stratification among T2DM patients [6, 7]. Therefore, this study aimed to investigate the relationship between glycemic control, as indicated by HbA1c levels, and various biochemical parameters in patients with T2DM, including total cholesterol, HDL, LDL, and triglyceride levels. By examining these associations, we seek to contribute to the development of more comprehensive monitoring strategies within the Prolanis framework, ultimately aiming to improve the quality of life and reduce the risk of complications among individuals living with diabetes in Indonesia.

MATERIALS & METHODS

We conducted a thorough cross-sectional secondary data analysis involving 17 adults diagnosed with type 2 diabetes mellitus (T2DM), all of whom were actively participating in the Prolanis program at Klinik Nomor Satu in Padang, West Sumatra, Indonesia. The laboratory test results for these patients were carefully extracted from a comprehensive dataset comprising 2024 individual records.

To evaluate glycemic control, we categorized HbA1c levels into three distinct groups: normal (<5.7%), indicating effective glucose management; prediabetes (5.7% to 6.4%), suggesting an elevated risk of developing diabetes; and diabetes (≥6.5%), which reflects inadequate glycemic control.

Other biochemical parameters were classified based on established clinical thresholds, providing valuable insights into the patients' overall health. The lipid profile components were organized as follows:

- Total cholesterol: classified as normal if below 240 mg/dL; levels at or above this threshold are considered high.
- High-density lipoprotein (HDL): regarded as normal at levels of 40 mg/dL or higher, with levels below this indicating low HDL, a potential risk factor for cardiovascular disease.
- Low-density lipoprotein (LDL): classified as normal if below 160 mg/dL; levels at or above this point are deemed elevated.
- Triglycerides: considered normal when below 200 mg/dL, with levels at or exceeding this threshold indicating high triglyceride levels.

This analysis offered valuable insights into the metabolic profiles of the participants and underscores opportunities for potential intervention and enhancement of their health management.

Statistical analysis was performed using STATA Version 16, a robust software for data analysis. Descriptive statistics were used to effectively illustrate means and percentages, providing insight into the data distribution. The Chi-square test was employed to investigate the relationships between HbA1c categories and various categorical variables, revealing any significant associations. Furthermore, one-way ANOVA was utilized to assess differences in mean HbA1c values among different categories of biochemical parameters, enhancing our understanding of the interactions among these factors.

STATISTICAL ANALYSIS

Statistical analysis was performed using STATA Version 16, a robust software for data analysis. Descriptive statistics were used to effectively illustrate means and percentages, providing insight into the data distribution. The Chi-square test was employed to investigate the relationships between HbA1c categories and various categorical variables, revealing any significant associations. Furthermore, one-way ANOVA was utilized to assess differences in mean HbA1c values among different categories of biochemical parameters, enhancing our understanding of the interactions among these factors.

RESULT

Table 1 summarizes the characteristics of the 17 participants included in this study. A majority of the patients (52.94%) exhibited HbA1c levels within the diabetic range (≥6.5%), indicating that poor glycemic control was prevalent among the sample. Notably, all participants demonstrated low levels of high-density lipoprotein cholesterol (HDL-C), which may reflect a common underlying risk factor for cardiovascular disease in this population.

However, statistical analysis revealed no significant associations between HbA1c levels and key components of the lipid profile. Specifically, no meaningful correlations were observed with total cholesterol ($p = 0.711$), low-density lipoprotein cholesterol (LDL-C) ($p = 0.524$), or triglyceride levels ($p = 0.633$). These findings suggest that glycemic control, as indicated by HbA1c, was not significantly related to lipid abnormalities in this cohort.

Table 1. Participant characteristics by HbA1c and lipid profile categories. HbA1c and lipid parameters were classified based on clinical thresholds. Most participants had poor glycemic control (HbA1c ≥6.5%) and low HDL levels. Values are shown as frequencies and percentages.

Characteristic		Frequency
Sex		
	Male	9 (52.94%)
	Female	8 (47.06%)
HbA1C		
	Normal	3 (17.65%)
	Prediabetes	5 (29.41%)
	Diabetes	9 (52.94%)
Cholesterol		
	Normal	3 (17.65%)
	Borderline	4 (23.53%)
	High	10 (58.82%)
HDL		
	Normal	17 (100%)
LDL		
	Normal	8 (47.06%)
	High	9 (52.94%)
Trigliseride		
	Normal	11 (64.71%)
	Borderline	2 (17.65%)
	High	3 (17.65%)

Table 2 presents a further analysis of the association between HbA1c categories and cholesterol levels. Although participants with HbA1c values in the diabetic range appeared more likely to exhibit elevated cholesterol levels, the relationship was not statistically significant ($p = 0.669$). This implies that the observed trend may have occurred by chance or may have been influenced by other unmeasured variables.

Table 2. Association between HbA1c categories and lipid profile parameters. This table shows the distribution of lipid abnormalities across HbA1c categories. No statistically significant associations were found between glycemic control and total cholesterol, LDL, HDL, or triglyceride levels ($p > 0.05$).

HbA1c	Cholesterol			P-value
	Normal	Borderline	High	
Normal	0	1	2	0.669
Prediabetes	1	2	2	
Diabetes	2	1	6	

In summary, the results indicates that poor glycemic control was not significantly associated with total cholesterol, LDL-C, or triglyceride levels among the participants in this study. These findings highlight the need for further investigation using larger sample sizes to better understand the potential interplay between glycemic status and lipid metabolism in individuals with Type 2 Diabetes Mellitus.

DISCUSSION

This study examined the relationship between glycemic control and lipid profile parameters in 17 individuals with type 2 diabetes mellitus (T2DM) who were enrolled in the Program Pengelolaan Penyakit Kronis (Prolanis). The participants had a mean age of 60.76 ± 7.25 years. Statistical analysis revealed no significant associations between HbA1c levels and any of the lipid profile components, including total cholesterol ($p = 0.909$), low-density lipoprotein cholesterol (LDL-C) ($p = 0.778$), and triglycerides ($p = 0.767$). Interestingly, all participants had HDL-C levels classified within the normal range, which limited further interpretation of this parameter.

These findings are consistent with those of previous studies that reported weak or non-significant correlations between glycemic control and lipid abnormalities in individuals with T2DM. For example, Alzahrani, S. H. noted that although dyslipidemia is frequently observed in patients with T2DM, the direct association between HbA1c levels and lipid markers does not always reach statistical significance, particularly in studies with smaller sample sizes or cross-sectional designs [8]. Similarly, research by Julianto E et al. suggested that HbA1c alone may not serve as a dependable predictor of dyslipidemia across diverse populations [9].

While glycemic status is biologically connected to lipid metabolism—primarily through mechanisms involving insulin resistance and impaired lipoprotein lipase activity—lipid profile regulation is influenced by multiple additional factors. These may include individual dietary habits, levels of physical activity, genetic predisposition, concurrent use of lipid-lowering agents, and overall adherence to diabetes care regimens [10]. Furthermore, although insulin resistance in T2DM can disrupt normal lipoprotein processing, the extent and manifestation of this impairment are highly variable among patients [11].

In this study, the odds ratios for LDL-C (OR = 0.75) and triglycerides (OR = 1.5) did not achieve statistical significance, indicating potential trends that require further investigation. The uniformity of HDL-C levels among participants also constrained the ability to explore its association with glycemic control. It is important to recognize that this finding may not be representative of the broader T2DM population, as low HDL-C is commonly reported in individuals with diabetes [12].

Several limitations must be acknowledged. First, the small sample size (n = 17) inherently limits statistical power, reducing the ability to detect subtle or moderate associations. Second, the cross-sectional nature of the study precludes causal inference and only allows for the identification of associations at a single time point. Third, this study relied on secondary data from clinical records, which may be affected by unmeasured confounders, including medication use (such as statins or antidiabetic agents), diet, physical activity,

and comorbid conditions—all of which can independently influence both glycemic and lipid parameters. Additionally, the uniformity in HDL values, which were all categorized as normal, may reflect limitations in the sample's representativeness or potential data inconsistencies. Lastly, the use of a single-site dataset (Klinik Nomor Satu in Padang) may limit the generalizability of findings to broader populations.

Despite these limitations, the study provides a preliminary exploration of the interplay between glycemic control and lipid profiles in a community-based diabetes management program, and it highlights the need for further, more comprehensive investigations with larger and more diverse cohorts.

CONCLUSION

This study found no significant associations between glycemic control, as measured by HbA1c, and lipid profile parameters among participants with type 2 diabetes mellitus enrolled in the Prolanis program. While dyslipidemia and poor glycemic control were prevalent, their relationship was not statistically evident in this sample. These findings highlight the complex and multifactorial nature of lipid metabolism in T2DM and underscore the need for larger, longitudinal studies to better understand these interactions and inform targeted interventions within community-based diabetes management programs.

Declaration by Authors

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