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**Correlation of HbA1c and TG/ HDL Ratio in Prolanis Type 2 Diabetes Mellitus Patients**

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**ABSTRACT**

**Background:** Diabetes mellitus (DM) is a chronic metabolic disease characterized by insulin deficiency and prolonged hyperglycemia, that leads into an interferences in metabolic processes in the body. HbA1c is the gold standard for glycemic control, reflecting the average blood glucose levels in patients over approximately three months. Type 2 DM (T2DM) patients with low HbA1c levels have a triglyceride-to-HDL (TG/HDL) ratio that is roughly 3 to 4 times lower compared to patients with higher HbA1c levels. **Object:** This study aims to determine the correlation between HbA1c levels and the TG/HDL ratio in patients with T2DM who participating in the Prolanis program. **Method:** The study employed a cross-sectional observational design based on primary data collected from December 2023 to April 2024, with a total sample of 50 T2DM patients in the Prolanis group at the primary health facility in Bangkalan Regency. The examinations were carried out at Farmalab. HbA1c was measured using the Wondfo FIA meter plus FS 113, while triglycerides (TG) and HDL cholesterol were analyzed using a Microlab 300 photometer. Data were analyzed using the Spearman correlation test. **Result:** The results showed that 100% of T2DM patients in the Prolanis group had HbA1c levels above normal values. Among these, 40% had TG/HDL ratios above normal values, 32% had normal TG/HDL ratios, and 28% had TG/HDL ratios below normal values. Based on the Spearman correlation test, the results obtained  $p = 0,043 (< 0,05)$ . **Conclusion:** There is a correlation between HbA1c levels and the ratio of TG/HDL in T2DM patients in the Prolanis Group.

**Keywords:** HbA1c level, TG/HDL Ratio, Type 2 Diabetes Mellitus

**BACKGROUND**

Diabetes mellitus is a chronic metabolic disorder characterized by insufficient insulin production and impaired insulin function, which can lead to prolonged hyperglycemia and disrupt many of the body's metabolic processes (Mukhtar et al., 2020). Insulin, a hormone secreted by the pancreas, enables the movement of glucose from the blood into cells, where it is metabolized and utilized to generate energy (Vecchio et al., 2018). In 2021, the International Diabetes Federation (IDF) estimated that

approximately 537 million individuals aged 20 to 79 years worldwide were affected by diabetes mellitus (DM), constituting roughly 10.5% of the global population. This prevalence is projected to increase to 783 million by 2045, equivalent to about 12.2%. According to IDF data, cases of diabetes mellitus in Indonesia are around 19.5 million, this makes Indonesia ranked 5th and the only country from Southeast Asia (Webber, 2013).

The American Diabetes Association classifies diabetes mellitus into four categories: gestational diabetes mellitus, type 1 diabetes mellitus, type 2 diabetes mellitus, and other forms of diabetes mellitus (ElSayed et al., 2022). Risk factors associated with the onset of diabetes mellitus include socio-demographic aspects, lifestyle, and individual clinical and psychological conditions (Snoek, 2022; Tang et al., 2025). Socio-demographic aspects include age, gender, blood group, and ethnicity. Meanwhile, behavior or lifestyle includes dietary habits, physical activity, sleep duration, smoking and alcohol consumption habit (Tang et al., 2025).

In individuals with diabetes, depression also more commonly observed in those who have persistently high HbA1c levels despite intensive treatment and support, as well as in those who experience diabetes-related complications (Lloyd et al., 2020). Most cases of diabetes mellitus are caused by a combination of lifestyle and genetic factors (Widyaningsih et al., 2018). In addition lifestyle factors significantly influence T2DM risk, genetic predisposition also plays a crucial role (Chakraborty Samant et al., 2025). Genetic predisposition, in combination with metabolic and environmental factors, is fundamental in initiating autoimmune responses and substantially contributing to the diverse pathophysiological processes that lead to impaired glucose homeostasis in type 2 diabetes mellitus (T2DM) including the dysfunction of pancreatic  $\beta$ -cells, which leads to impaired insulin secretion and subsequently insufficient insulin production (Sami et al., 2025).

Glycemic control is essential in the management of diabetes, as maintaining proper control can significantly reduce the risk of complications. Hemoglobin A1c (HbA1c) is considered the gold standard for assessing glycemic control, reflecting the average blood glucose levels over approximately three months. An HbA1c value below 7% has been demonstrated to

lower the incidence of vascular complications associated with diabetes mellitus. Conversely, in patients with diabetes, a 1% absolute increase in HbA1c levels corresponds to an 18% higher risk of cardiovascular disease. Additionally, the serum triglyceride-to-high-density lipoprotein cholesterol ratio (TG/HDL-C) serves as an atherogenic plasma index and represents a major risk factor for both cardiovascular disease and metabolic syndrome (Babic et al., 2019). An elevated TG/HDL ratio also associated with a higher risk of cardiovascular disease like heart failure because an increased TG levels may contribute to the development of atherosclerosis and coronary artery disease, which are significant risk factors for heart failure (Chang et al., 2025).

A high TG/HDL ratio is commonly observed in patients with diabetes mellitus as a result of insulin resistance. In contrast, patients with type 2 diabetes mellitus who maintain low HbA1c levels exhibit a TG/HDL ratio that is approximately three to four times lower (Gedikli et al., 2022). Insulin resistance refers to the condition in which insulin elicit an adequate biological response, such as regulation of blood glucose levels. As a compensatory mechanism, the body increases insulin secretion from the pancreas, leading to hyperinsulinemia (Kim et al., 2021).

The Chronic Disease Management Program, commonly referred to as Prolanis, is an integrated healthcare system and proactive initiative involving BPJS Kesehatan, healthcare providers, and participants (Silvi et al., 2023). A study conducted in 2022 by Gedikli et al., demonstrated a positive correlation between HbA1c levels and both the triglyceride/HDL cholesterol ratio and the triglyceride glucose index in individuals with diabetes mellitus (Gedikli et al., 2022).

The present study aims to assess the correlation between HbA1c levels and TG/HDL ratio among Prolanis participants with type 2 diabetes mellitus, a study that

is still under-explored in primary healthcare in Indonesia.

## METHOD

This study employed an analytical observational design with a cross-sectional approach to investigate the correlation between HbA1c levels and the TG/HDL ratio in patients with type 2 diabetes mellitus. The design was selected because of its suitability in assessing the relationship between HbA1c levels and the triglyceride-to-HDL cholesterol (TG/HDL) ratio in patients with type 2 diabetes mellitus at a specific point in time. This design enables an efficient and practical assessment of metabolic parameters within the Prolanis patient population, providing a brief overview of glycemic control and lipid profile status.

The selected design is efficient in obtaining data quickly without the need for follow-up, as participants are assessed at a single point in time for the presence or absence of a condition, making the study cost-effective and capable of examining multiple predictor and outcome variables simultaneously, which can also inform future research (Capili, 2021) Although This approach presents challenges in establishing causal relationships due to the ambiguous temporal sequence between exposure and outcome and is vulnerable to certain forms of bias (Rezigalla, 2020).

The research was conducted at Farmalab Bangkalan, a vital healthcare facility dedicated to performing precise and timely diagnostic tests that are essential for accurately identifying patient conditions, guiding treatment decisions, and monitoring therapeutic effectiveness located at Jalan Jokotole No.5a, Bangkalan, East Java. The study took place over a period extending from December 2023 to April 2024, encompassing phases of preparation, implementation, data collection, and analysis. HbA1c was checked using the Wondfo FIA meter plus FS 113, while TG

and HDL were checked using the microlab 300 photometer.

The target subjects consisted of 50 people with inclusion criteria, namely individuals with Type 2 diabetes mellitus, registered in the "Prolanis" program and having a minimum age of 25 years. Purposive sampling method is used because this method aims to ensure the selection of participants who specifically meet the criteria relevant to the research objectives, ensuring that the sample is well-matched to the study focus (Campbell et al., 2020).

Data obtained from the examinations were coded and entered into IBM SPSS Statistics version 29 for analysis. The normality of the data distribution was assessed using the Shapiro-Wilk test. Pearson's correlation test was applied to normally distributed data, while Spearman's correlation test was used for data that did not meet normality assumptions. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful correlation between the variables.

## RESULT AND DISCUSSION

This study was carried out in December 2023 until April 2024 at a Clinical Laboratory named Farmalab. Farmalab Clinical Laboratory located in Jokotole Street, Bangkalan, East Java.

**Table 1.**

Gender Distribution of Type 2 Diabetes Mellitus Patients.

Gender	N	%
Male	18	36%
Female	32	64%
Total	50	100%

According to the information shown in Table 1, it shows that patients with diabetes mellitus in this research were mostly female with 32 people, and small proportion were male with 18 people.

**Table 2.**

Age Distribution of Type 2 Diabetes Mellitus Patients.

Age Distribution	N	%
26-45 y.o	2	4%
46-65 y.o	39	78%
>65 y.o	9	18%
Total	50	100%

According to the information presented in Table 2, it is explained that majority of patients with type 2 diabetes mellitus are between 46 and 65 years old, totaling 39 people, while the least age range is 26 to 45 years old, totaling 2 people.

**Table 3.**

Distribution Patterns of Glycated Hemoglobin (HbA1c) Levels Among Individuals Diagnosed With Type 2 Diabetes Mellitus.

HbA1c Level	N	%
In control (<7%)	0	0%
Out of control (>7%)	50	100%
Total	50	100%

According to the information presented in Table 3, explained that all patients with type 2 diabetes mellitus in the Prolanis group had uncontrolled HbA1c levels. This results may happen because the Prolanis program is designed to improve management through activities such as medical consultations, group sessions, and home visits, actual glycemic control outcomes can vary significantly depending on the extent of program adherence and implementation quality.

**Table 4.**

Distribution Patterns of TG/HDL Ratio Among Individuals Diagnosed With Type 2 Diabetes Mellitus.

TG/HDL Ratio	N	%
Below the normal range (<1,8)	14	28%
Normal range (1,8-2,5)	16	32%
Above the normal range (>2,5)	20	40%
Total	50	100%

According to the findings presented in Table 4, almost half of the subjects at 20 individuals (40%) showed TG/HDL ratio exceeding the normal range reflecting lipid abnormalities in poorly controlled glycemia. Normality test results show that the data is not normally distributed, so for statistical tests conducted using Spearman correlation analysis. The Spearman correlation analysis between HbA1c levels and the TG/HDL ratio revealed a statistically significant association ( $p = 0.043$ ), with a correlation coefficient of 0.287, indicating a low-strength positive correlation.

## Discussion

The primary aim of this study was to evaluate the correlation between HbA1c levels and the TG/HDL ratio in patients with type 2 diabetes mellitus that enrolled in Prolanis Programs held by BPJS Kesehatan.

The results of the study indicate that the percentage of people with type 2 diabetes is higher in women than in men, at 64% compared to 36%. This finding is consistent with a study conducted by Widyatmojo et al., which indicated that the percentage of people with type 2 diabetes is higher in women than in men, at 67.6% compared to 32.4% (Widyatmojo et al., 2019). This is due to several factors, such as, women are more likely to experience an increase in body mass index, thereby

increasing their risk of obesity. An increase in fat tissue mass or obesity is associated with systemic disorders such as metabolic syndrome (Goossens, 2017). On the other hand, pregnant woman experience hormonal imbalances during this period. High progesterone levels cause the body's systems to work harder to promote the development of cells in the body, especially fetal cells. As a result, the body works harder, sending excessive hunger signals that cause the body's metabolic system to be unable to directly accept calorie intake and use it in its entirety, leading to an increase in blood sugar levels during pregnancy (Rosita et al., 2022).

Besides those two factor mentioned earlier, women also experience menopause, a physiological transition characterized by the cessation of ovarian estrogen production, a hormone critical for modulating insulin sensitivity. Post-menopause, estrogen synthesis primarily occurs through the peripheral conversion of androsterone, originating from the adrenal glands, into estrone within adipose tissue. Consequently, this shift in estrogen production is associated with an increase in adipose tissue accumulation commonly observed in menopausal women (Lizcano & Guzmán, 2014). The fat accumulation from those process affects the reduction of adiponectin protein. Adiponectin plays an important role in blood sugar metabolism. Low adiponectin levels indicate pathological conditions such as insulin resistance, type 2 diabetes, obesity, metabolic syndrome, or cardiovascular disease (Diep Nguyen, 2020).

Menopause is experienced by women at an average age usually ranging between 45 and 50 years (Yulizawati & Yulika, 2022). Based on the findings, a substantial proportion of female patients with type 2 diabetes in this study specifically 31 individuals were postmenopausal. This suggests that menopause may be a contributing factor to the higher prevalence of type 2 diabetes

observed among female participants in this cohort. These findings align with the research conducted by Inaraja et al., which reported that the reduction of estrogen levels during the menopausal period leads to decreased HDL particularly HDL2 and increased triglyceride levels.

This shift elevates the TG/HDL ratio, a widely recognized marker of insulin resistance and cardiovascular risk (Inaraja et al., 2020). Furthermore, according to Karppinen et al., the reduction in estrogen also contributes to metabolic and cardiovascular complications in postmenopausal women with type 2 diabetes, partly due to these unfavorable alterations in their lipid profiles (Karppinen et al., 2022). Patients with type 2 diabetes mellitus aged 46–65 years were the most common age group in this study, with 39 people (78%), while patients with type 2 diabetes mellitus aged 26–45 years were the least common age group, with 2 people (4%).

This may occur because glucose intolerance begins to increase in the 46-65 age group. This age group falls under the elderly category, where the aging process causes a decline in organ and cell function, such as reduced pancreatic cell ability to produce insulin. Mitochondrial activity in muscle cells also decreased, resulting in increased fat levels in the muscles and promoting insulin resistance (Imelda, 2019). Individuals aged between 46 and 65 years are classified as elderly. The elderly are at higher risk of developing type 2 diabetes due to the combined effects of increased insulin resistance and pancreatic beta cell dysfunction (Yakaryılmaz & Öztürk, 2017).

Glycated hemoglobin (HbA1c) levels reflect average blood glucose concentrations over approximately three months; therefore, recent guidelines typically use HbA1c to assess glycemic control (Wu et al., 2022). The reference HbA1c value used in this study is  $\geq 7.5\%$ , which is classified as uncontrolled, in accordance with current recommendations

(American Diabetes Association, 2023). HbA1c levels below 7% are considered controlled, whereas levels exceeding 7% are regarded as uncontrolled. The risk of both macrovascular and microvascular complications increases with higher HbA1c levels (ElSayed et al., 2022). In individuals with diabetes mellitus, each 1% increment in absolute HbA1c levels is associated with an 18% elevated risk of developing cardiovascular disease (Babic et al., 2019).

Based on the research results, 20 (40%) patients with type 2 diabetes mellitus had a TG/HDL ratio above the normal value ( $>2.5$ ), 16 (32%) patients with type 2 diabetes mellitus had a normal TG/HDL ratio (1.8-2.5), and 14 (28%) patients with type 2 diabetes mellitus have a TG/HDL ratio below the normal range ( $<1.8$ ). A study by Aguirre et al. states that a TG/HDL ratio exceeding 2.5 indicates certain conditions such as metabolic syndrome, abdominal obesity, a strong predictor of cardiovascular disease risk, and increased HOMA-IR (Aguirre et al., 2018).

The results of this study indicate a correlation between HbA1c levels and TG/HDL ratio in patients with type 2 diabetes mellitus. The correlation test results show a weak positive correlation, which means that the two variables are positively related; an increase in HbA1c levels is associated with an increase in TG/HDL ratio. These findings are consistent with the study conducted by Gedikli et al., which also found an increase in the TG/HDL ratio alongside an increase in HbA1c levels (Gedikli et al., 2022). This may happen because the elevated HbA1c levels can stimulate the activation of lipoprotein lipase enzymes in adipose tissue, leading to an increased release of free fatty acids. These free fatty acids enter the circulation, where a portion is utilized as an energy source, while the surplus is transported to the liver. In the liver, they serve as substrates for triglyceride synthesis and contribute to the formation

of very-low-density lipoproteins (VLDL). This process leads to distinctive lipid profile abnormalities in patients with type 2 diabetes mellitus, characterized by elevated triglyceride levels, reduced high-density lipoprotein (HDL) cholesterol, and an increase in atherogenic small dense low-density lipoprotein (LDL) subfractions (Susilo et al., 2020). Therefore, a high TG/HDL ratio is often found in patients with diabetes mellitus due to insulin resistance. In patients with type 2 diabetes mellitus with low HbA1c levels, the TG/HDL ratio is approximately 3-4 times lower (Gedikli et al., 2022). However, it is important to note the presence of confounding factors that could potentially affect lipid levels in this study, as dyslipidemia is influenced by many factors, including poor diet, physical inactivity, smoking, lack of physical activity, and genetic factors.

The TG/HDL ratio in type 2 diabetes mellitus patients in the Prolanis group in this study was generally below 2.5, where values above 2.5 usually indicate conditions such as metabolic syndrome, abdominal obesity, and increased HOMA-IR (Aguirre et al., 2018). However, there are still many Prolanis patients with HbA1c values  $>7\%$ , indicating that the majority of patients in the Prolanis program at the study site had not achieved optimal glycemic control. While this reflects the actual clinical condition of the study group, it cannot be ignored that this finding could also indicate a possible selection bias or reflect special population characteristics, such as patients with low adherence or more complex cases. One possible cause is the presence of confounding factors such as uncontrolled diet, physical activity, and medication adherence, which may affect the effectiveness of the program and the clinical outcomes of patients.

Although the correlation coefficient between HbA1c levels and TG/HDL ratio in this study was weak ( $r = 0.287$ ), the relationship was still

statistically significant. This suggests that the two variables are related, albeit not strongly. From a clinical point of view, this finding indicates that the TG/HDL ratio cannot be used as the only indicator to assess glycemic control in patients with type 2 diabetes mellitus. However, the TG/HDL ratio can still be considered as an additional marker in metabolic risk assessment, especially regarding insulin resistance and dyslipidemia, which often accompany chronic hyperglycemia conditions. Therefore, the use of TG/HDL ratio in clinical practice needs to be combined with other indicators, and is not recommended as a single screening tool for glycemic control.

Although the results of statistical analysis in this study showed a significant association between HbA1c levels and TG/HDL ratio, including the direction and nature of the association, the cross-sectional study design still limits the ability to infer causal relationships. This is because the data were collected at a single point in time, so the sequence of events cannot be ascertained. Therefore, it is recommended that future studies utilize a longitudinal design to ascertain temporal relationships and strengthen evidence of causality.

## CONCLUSION

Based on the results and discussion above, it can be concluded that there is a correlation between HbA1c levels and TG/HDL ratio in patients with type 2 diabetes mellitus in the Prolanis group. These findings underscore the need for enhanced strategies within the Prolanis program to improve metabolic outcomes, including more rigorous monitoring and tailored interventions targeting both glycemic and lipid parameters. Future research should consider larger, more diverse cohorts and longitudinal designs to better elucidate the dynamics between glycemic control and lipid abnormalities

over time. Additionally, exploring factors influencing program adherence and the integration of comprehensive lifestyle and pharmacologic management may contribute to improved health outcomes for patients with type 2 diabetes mellitus.

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## INFORMED CONSENT

This study was conducted by ethical standards and has received approval from the Institutional Review Board (IRB) of Poltekkes Kemenkes Surabaya, Indonesia, with approval number [No.EA/2112/KEPK-Poltekkes\_Sby/V/2024]. Informed consent was obtained from all participating respondents, and confidentiality and anonymity of the participants were maintained throughout the research process.

All procedures adhered to ethical guidelines for research involving human subjects. All participants were given an explanation of the purpose, procedures, potential risks and benefits of the study, as well as their right to refuse or stop participation at any time without consequences. Data confidentiality was maintained by using an identity code on each individual, without including names or personal information that could reveal the identity of participants. The data collected has been properly stored and can only be accessed by the principal investigator and authorized team.

## CONFLICT OF INTEREST

The authors declare no competing interests.

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