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The Relationship Between High-Density Lipoprotein (HDL) and Glycated Hemoglobin (HbA1C) in Type 2 Diabetes Mellitus Patients: Implications for Cardiovascular Risk

Setyoadi[1]*, Dina Dewi Sartika Lestari Ismail[1], Annisa Wuri Kartika[1], Dewi Purnama Sari[1], Angel Dwi Septian[1], Adelina Stefanie Lallo[1], Rara Kurniasari[1]

1 Faculty of Health Sciences, Brawijaya University, Indonesia

Correspondence
Setyoadi,
Department of Community Nursing, Faculty of Health Sciences, Brawijaya University, Malang, Indonesia, 65233,
email: setyoadi@ub.ac.id

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder marked by hyperglycemia due to insulin resistance or impaired insulin secretion. Dyslipidemia, especially low High-Density Lipoprotein (HDL), contributes significantly to cardiovascular disease risk in T2DM. Glycated hemoglobin (HbA1c) serves as the standard biomarker for long-term glycemic control. Previous studies suggested an inverse relationship between HDL and HbA1c, but results remain inconsistent, and limited evidence exists from Indonesian primary care settings. **Purpose:** This study aimed to examine the association between HDL cholesterol and HbA1c levels in T2DM patients at a primary healthcare center in Batu City, Indonesia. **Methods:** An observational analytic study with a cross-sectional retrospective design was conducted. Secondary data were obtained from medical records of T2DM patients at Puskesmas Sisir, Batu City, in July 2025. A total of 79 patients fulfilling inclusion criteria were included through total sampling. Laboratory results of HDL (mg/dL) and HbA1c (%) were analyzed. Spearman's rank correlation test was used, with significance set at $p \leq 0.05$. **Results:** Among the 79 respondents, most were aged 45–65 years (50.6%) and female (77.2%). The mean HDL level was 45.3 ± 8.2 mg/dL, while the mean HbA1c level was 8.2 ± 1.5%. Correlation analysis indicated a weak negative association between HDL and HbA1c ($r = -0.132$, $p = 0.246$). Although higher HDL levels tended to correspond with lower HbA1c values, the relationship was not statistically significant. **Conclusions:** These findings underscore the critical role of community nurses in integrating routine HbA1c and lipid profile monitoring into T2DM follow-up visits, promoting holistic cardiovascular risk assessment even when individual biomarkers show weak associations.

KEYWORDS

Type 2 diabetes mellitus, High density lipoprotein cholesterol; Glycated hemoglobin, Primary Health Care, Cardiovascular risk

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1. BACKGROUND

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia due to insulin resistance and/or impaired insulin secretion (Gieroba et al., 2025). This condition has become a major global health problem, with prevalence continuously rising over the past decades (Ong et al., 2023). One of the most important complications of T2DM is lipid metabolism disorder, which contributes to an increased risk of cardiovascular disease (Borén et al., 2024). High Density Lipoprotein (HDL) is a lipid fraction known for its protective role against cardiovascular diseases through reverse cholesterol transport, as well as its anti-inflammatory and anti-atherogenic effects (Madaudo et al., 2024). On the other hand, glycated hemoglobin (HbA1c) is a standard biomarker reflecting long-term glycemic control over the preceding two to three months (Shimizu et al., 2019). Several studies have reported a negative association between HDL levels and HbA1c in T2DM patients, indicating that poor glycemic control is often accompanied by lower HDL concentrations (Nnakenyi et al., 2022). However, findings across populations remain inconsistent, highlighting the need for further investigation, particularly in Indonesian populations.

Globally, the International Diabetes Federation (IDF) reported that in 2021, approximately 537 million adults (aged 20–79 years) were living with diabetes, a number projected to rise to 643 million by 2030 and 783 million by 2045 (IDF, 2021). Indonesia ranks fifth worldwide in the number of people with diabetes, reaching 19.47 million in 2021(Kemenkes RI, 2022). The prevalence of T2DM in Indonesia continues to increase across regions (Wahidin et al., 2024). According to the 2018 Basic Health Research (Riskesdas), the prevalence of diabetes among individuals aged ≥15 years was 2%, with higher rates observed in older adults and women (Kemenkes, 2018). Cardiovascular disease remains the leading cause of mortality among T2DM patients (Siam et al., 2024). Evidence suggests that low HDL levels significantly contribute to the development of atherosclerosis and coronary heart disease in this population (Kjeldsen et al., 2022). Meanwhile, elevated HbA1c levels (>7%) are a strong indicator of poor glycemic control and are associated with higher risks of both microvascular and macrovascular complications (Boye et al., 2022). A significant negative correlation between HbA1c and HDL among Indonesian T2DM patients has been demonstrated (Yuliana, 2024), while no significant relationship was found in Chinese adults, suggesting the influence of ethnicity, lifestyle, and environmental factors (Chen et al., 2025). These findings highlight the importance of integrating the study aim into nurse-led health education, structured screening protocols, and patient counseling strategies to improve early detection and management of complications in T2DM patients.

The interplay between glycemic control and lipid profile in T2DM patients can be explained through pathophysiological mechanisms (Nnakenyi et al., 2022). Chronic hyperglycemia due to insulin resistance induces oxidative stress, systemic inflammation, and protein glycosylation (González et al., 2023). These processes impair lipid metabolism by reducing the activity of lipoprotein lipase and lecithin-cholesterol acyltransferase, enzymes essential for HDL formation (Gluba-Sagr et al., 2025). Consequently, HDL levels and functionality decline, reducing the effectiveness of reverse cholesterol transport (Motte et al., 2020). In addition to metabolic factors, lifestyle factors such as diets high in saturated fats, low fiber intake, and physical inactivity, as well as demographic and hormonal influences, further deteriorate lipid profiles (Martemucci et al., 2024). Postmenopausal women, for example, experience estrogen decline associated with reduced HDL levels and increased cardiometabolic risk (Ryczkowska et al., 2023). Other factors, including disease duration, treatment adherence, and nutritional status, also influence both HbA1c and HDL levels (Mužik et al., 2023). In Indonesia, although routine assessment of lipid profile and HbA1c is recommended for T2DM patients, implementation is often limited by barriers such as restricted healthcare access, low patient awareness, and financial constraints (Alkaff et al., 2021). These limitations result in many patients failing to achieve optimal glycemic and lipid targets, thereby maintaining a high risk of cardiovascular complications (Dakal et al., 2025).

Investigating the relationship between HDL and HbA1c in primary care settings such as community health centers (Puskesmas) is crucial for strengthening local evidence (Firhat et al., 2023). The findings can serve as a reference for comprehensive monitoring strategies by integrating lipid profile and

HbA1c assessments into routine T2DM evaluation, while also promoting multidimensional interventions combining pharmacological therapy with lifestyle education, including balanced diets, increased physical activity, and weight management (Singh et al., 2024). Furthermore, this research can raise patient awareness regarding the interplay between glycemic control and cardiovascular health, emphasizing the importance of maintaining both HbA1c and HDL within normal ranges (Widiarti et al., 2025). Local evidence may also inform preventive policies by healthcare providers and local governments to design individualized cardiovascular risk reduction programs, particularly for patients with high HbA1c and low HDL (Bancks et al., 2024). In addition, the study can provide a basis for longitudinal and multivariate research to identify confounding factors influencing the HbA1c and HDL relationship, such as nutritional status, disease duration, treatment regimen, and complication history.

Based on these considerations, this study aimed to analyze the association between HDL and HbA1c levels among T2DM patients. The results are expected to contribute to scientific evidence supporting promotive and preventive strategies against cardiometabolic complications, as well as to provide a reference for developing more comprehensive and evidence-based management approaches for T2DM.

2. METHODS

This study employed an observational analytic design with a correlational approach in the form of a quantitative study. A cross-sectional retrospective design was applied, in which data collection and analysis were conducted using secondary laboratory records. Data were obtained from medical records of patients with type 2 diabetes mellitus (T2DM) at Puskesmas Sisir, Batu City, in July 2025. This design was chosen because it allows the researchers to examine the association between High Density Lipoprotein (HDL) and glycated hemoglobin (HbA1c) levels in a specific population without direct intervention, while being efficient in terms of time and resources.

The study population consisted of all patients diagnosed with T2DM who underwent lipid profile and HbA1c examinations during July 2025. Samples were selected using a total sampling technique based on secondary laboratory data within the study period. A total of 79

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respondents met the inclusion criteria. Inclusion criteria were patients with a confirmed diagnosis of T2DM and complete laboratory data on both HDL and HbA1c levels, and who were actively registered in healthcare services at Puskesmas Sisir. Exclusion criteria included patients with incomplete laboratory data or the presence of comorbid conditions that could significantly affect lipid and glucose levels, such as severe liver disease or end-stage renal failure. The independent variable in this study was glycated hemoglobin (HbA1c, %), and the dependent variable was High Density Lipoprotein (HDL, mg/dL). Both variables were measured based on laboratory test results recorded in patients' medical records.

The research instrument was an observation sheet specifically designed to collect secondary data from patient records. Data recorded included patient identity (age, religion, gender, education, employment), HDL levels, HbA1c levels, and additional demographic characteristics. Data were collected by reviewing laboratory records of T2DM patients for the examination period of July 2025. Eligible data according to inclusion criteria were documented in the observation sheet. Patient confidentiality was maintained by coding or using initials instead of full names or other personal identifiers. Data were analyzed using SPSS version 26. The association between HDL and HbA1c levels was examined using Spearman's rank correlation test. The results were presented as correlation coefficients (r) and significance values (p), with a significance level set at $\alpha \leq 0.05$.

This study was reviewed and approved by the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Brawijaya. The research protocol was approved under ethical clearance number 25F171111112M and ethical approval letter number 210/UN10.F17.10.4/TU/2025. Ethical approval was valid from July 24, 2025, to July 24, 2026. All research procedures adhered to the ethical principles of the Declaration of Helsinki, including respect for patient privacy and confidentiality.

3. Results

Table 1. General Characteristics of the Patients (n = 79)

Demographic	n	%
Age (years)		
<45	10	12.7%
45-65	40	50.6%
> 65	29	36.7%
Religion		
Islam	65	82.3%
Non islam	14	17.7%
Gender		
Male	18	22.8%
Female	61	77.2%
Education		
No school	5	6.3%
Elementary school	20	25.3%
Middle School	15	19.0%
High school	25	31.6%
College	14	17.7%)
Employment		
Unemployed	22	27.8%
Labor	30	38.0%
Entrepreneur	27	34.2%

Respondent characteristic data shows that total of 79 respondents participated in this study. Based on age distribution, the majority were in the 45–65 years group (n = 40; 50.6%), followed by those aged >65 years (n = 29; 36.7%), and <45 years (n = 10; 12.7%). In terms of religion, most respondents were Islam (n = 65; 82.3%), while a smaller proportion were non-Islam (n = 14; 17.7%). Regarding gender, the majority were female (n = 61; 77.2%), while males (n = 18; 22.8%). For education level, the largest group of respondents had completed high school (n = 25; 31.6%), followed by elementary school (n = 20; 25.3%), middle school (n = 15; 19.0%), college (n = 14; 17.7%), and no formal education (n = 5; 6.3%). Employment status showed that most respondents were laborers (n = 30; 38.0%), followed by entrepreneurs (n = 27; 34.2%) and unemployed individuals (n = 22; 27.8%).

Table 2. Descriptive statistics of HDL cholesterol and HbA1c levels among T2DM patients

Variable	n	Minimum	Maximum	Mean	Standard Deviation
HDL (mg/dL)	79	28.0	63.0	44.8	8.5
HbA1c (%)	79	6.0	12.2	8.3	1.6

Table 2 presents the descriptive statistics of HDL cholesterol and HbA1c levels among T2DM patients (n = 79). The mean HDL cholesterol level was 44.8 mg/dL (SD = 8.5), with values ranging from 28.0 to 63.0 mg/dL, indicating that several patients had HDL levels below the optimal threshold for cardiovascular protection. The mean HbA1c level was 8.3% (SD = 1.6), with a minimum of 6.0% and a maximum of 12.2%. These results suggest that the majority of patients had poor glycemic control, as the average HbA1c exceeded the recommended target of <7%. Collectively, these findings highlight the metabolic risk burden faced by T2DM patients, particularly the coexistence of low HDL cholesterol and elevated HbA1c, which may contribute to an increased risk of cardiovascular and microvascular complications.

The bivariate analysis was conducted to examine the relationship between High-Density Lipoprotein (HDL) and glycated hemoglobin (HbA1c) levels among 79 respondents. The Spearman's rank correlation test revealed a negative correlation between the two variables, with a correlation coefficient of $r = -0.132$ and a significance value of $p = 0.246$ ($\alpha \leq 0.05$). This finding indicates a tendency that higher HDL levels are associated with lower HbA1c values. However, the strength of this relationship was weak, and the result was not statistically significant. Therefore, in this study population, increased HDL concentrations did not consistently correspond to meaningful improvements in long-term glycemic control.

Table 3. Results of the Analysis of the Relationship between HDL and HbA1c

Variable	n	α	r	p
HDL HbA1C	79	0.05	-0.132	0.246

4. DISCUSSION

This study explored the relationship between high density lipoprotein (HDL) cholesterol and glycated hemoglobin (HbA1c) among patients with type 2 diabetes mellitus (T2DM). A negative trend was observed, whereby higher HDL levels were associated with lower HbA1c values. However, the correlation was weak and failed to achieve statistical significance, indicating that improved HDL levels may not directly reflect better glycemic control in this population (AlZeer et al., 2025). Potential influences include demographic characteristics, treatment adherence, nutritional status, and unmeasured confounding factors (Sharahili et al., 2023).

The findings are consistent with previous research that reported no significant HDL and HbA1c association among Chinese adults, suggesting possible roles of ethnicity and lifestyle (Xiao et al., 2025). In contrast, a significant negative correlation was documented in Indonesian patients, supporting a meta-analysis that associated higher HDL with improved metabolic outcomes (Lawton et al., 2024). Differences across studies may reflect variations in sample size, methodology, and clinical heterogeneity (Wu et al., 2025).

Pathophysiological mechanisms provide a rationale for an inverse relationship, chronic hyperglycemia due to insulin resistance induces oxidative stress (Iheagwam & Iheagwam, 2025), protein glycosylation (Galicia-Garcia et al., 2020), and systemic inflammation (Iheagwam & Iheagwam, 2025), impairing lipid metabolism through reduced lipoprotein lipase and lecithin cholesterol acyltransferase activity (Gao et al., 2022). Consequently, diminished HDL impairs reverse cholesterol transport, promoting atherosclerosis (Ouimet et al., 2019). Elevated HbA1c further worsens lipid dysfunction (Huang et al., 2025). Although the observed association direction supports these mechanisms, the weak correlation highlights the complexity of HDL and HbA1c regulation. Clinically, these findings underscore the importance of comprehensive risk assessment in T2DM. HDL should not be used in isolation but interpreted alongside HbA1c, full lipid profiles, blood pressure, body mass index, and lifestyle factors (Liao et al., 2025). Patient education should emphasize strict glycemic control through adherence, diet, exercise, and weight management (American Diabetes Association, 2022). Improving HDL remains relevant but should be integrated within broader cardiometabolic risk management strategies (Wang et al., 2023). Routine monitoring of HbA1c and lipid profiles in primary care is essential for early identification of cardiovascular complications (Jalal et al., 2023). Although statistical significance was not achieved, the local evidence supports risk-based interventions for patients with high HbA1c and low HDL levels.

Implications for nursing practice include the need for nurse led health education and counseling to strengthen patient adherence to diet, exercise, and

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medication regimens, while promoting awareness of the dual importance of glycemic control and lipid management. Nurses in primary care can play a pivotal role in implementing routine screening protocols, monitoring both HbA1c and HDL levels, and providing individualized lifestyle modification strategies. Furthermore, integrating culturally sensitive education and community-based interventions may enhance patient engagement and improve long-term cardiometabolic outcomes in T2DM populations.

This study has limitations: its retrospective cross-sectional design precludes causal inference; the predominance of elderly female respondents limits generalizability; and important confounders, including disease duration, treatment regimens, and lifestyle variables, were uncontrolled. The relatively small sample size may also have reduced statistical power.

Future studies with longitudinal designs, larger cohorts, and multivariable analyses are warranted to clarify the HDL and HbA1c relationship and strengthen the evidence for cardiovascular risk prevention in T2DM.

5. CONCLUSION

In conclusion, this study identified a weak but inverse relationship between HDL cholesterol and HbA1c levels among T2DM patients in a primary care setting, although the association did not reach statistical significance. These findings suggest that HDL alone is not a reliable indicator of glycemic control and highlight the multifactorial regulation of both lipid and glucose metabolism. Comprehensive patient management integrating HbA1c, lipid profiles, cardiovascular risk factors, and lifestyle behaviors remains essential. Future longitudinal studies with larger, more diverse cohorts and rigorous control of confounding factors are needed to clarify the clinical significance of the HDL and HbA1c relationship and to guide more effective cardiometabolic risk reduction strategies in T2DM populations.

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AUTHOR CONTRIBUTIONS

Setyoadi (STO), Dina Dewi Sartika Lestari Ismail (DDSLI), Annisa Wuri Kartika (AWK), Dewi Purnama Sari (DPS), Angel Dwi

Septian (ADS), Adelina Stefanie Lallo (ASL) Rara Kurniasari (RK). STO contributed to the conception and design of the study, data collection, and manuscript writing. DDSLI, AWK, and DPS was involved in data collection, analysis, and manuscript writing. ADS, ASL, and RK contributed to data collection, and manuscript writing. STO was responsible for manuscript revisions and final approval of the version to be published. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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DATA AVAILABILITY

Supplemental data will be provided upon request.

REFERENCES

Alkaff, F. F., Illavi, F., Salamah, S., Setiyawati, W., Ramadhani, R., Purwantini, E., & Tahapary, D. L. (2021). The Impact of the Indonesian Chronic Disease Management Program (PROLANIS) on Metabolic Control and Renal Function of Type 2 Diabetes Mellitus Patients in Primary Care Setting. Journal of Primary Care and Community Health, 12. https://doi.org/10.1177/2150132720984409

AlZeer, I., AlBassam, A. M., AlFeraih, A., AlMutairi, A., AlAskar, B., Aljasser, D., AlRashed, F., Alotaibi, N., AlGhamdi, S., & AlRashed, Z. (2025). Correlation Between Glycated Hemoglobin (HbA1c) Levels and Lipid Profile in Patients With Type 2 Diabetes Mellitus at a Tertiary Hospital in Saudi Arabia. Cureus, 17(3), 1–10. https://doi.org/10.7759/cureus.80736

American Diabetes Association. (2022). Standards of Medical Care in Diabetes—2022 Abridged for Primary Care Providers. Clinical Diabetes, 40(1), 10–38. https://doi.org/10.2337/cd22-as01

Bancks, M. P., Pilla, S. J., Balasubramanyam, A., Yeh, H. C., Johnson, K. C., Rigdon, J., Wagenknecht, L. E., & Espeland, M. A. (2024). Association of Lifestyle Intervention with Risk for Cardiovascular Events Differs by Level of Glycated Hemoglobin. Journal of Clinical Endocrinology and

Metabolism, 109(3), e1012–e1019. https://doi.org/10.1210/clinem/dgad674

Borén, J., Öörni, K., & Catapano, A. L. (2024). The link between diabetes and cardiovascular disease. Atherosclerosis, 394(May). https://doi.org/10.1016/j.atherosclerosis.2024.117607

Boye, K. S., Thieu, V. T., Lage, M. J., Miller, H., & Paczkowski, R. (2022). The Association Between Sustained HbA1c Control and Long-Term Complications Among Individuals with Type 2 Diabetes: A Retrospective Study. Advances in Therapy, 39(5), 2208–2221. https://doi.org/10.1007/s12325-022-02106-4

Chen, Y.-E., Onthoni, D. D., Chuang, S.-Y., Li, G.-H., Zhuang, Y.-S., Chiou, H.-Y., Sheu, W. H.-H., & Chung, R.-H. (2025). Predictive Models for Type 2 Diabetes Mellitus in Han Chinese with Insights into Cross-Population Applicability and Demographic Specific Risk Factors. Diabetes & Metabolism Journal. https://doi.org/10.4093/dmj.2024.0319

Dakal, T. C., Xiao, F., Bhusal, C. K., Sabapathy, P. C., Segal, R., Chen, J., & Bai, X. (2025). Lipids dysregulation in diseases: core concepts, targets and treatment strategies. Lipids in Health and Disease, 24(1), 1–21. https://doi.org/10.1186/s12944-024-02425-1

Firhat E., Fitriani, F., & Nur, M. (2023). Hubungan HbA1c dengan Kadar HDL pada Penderita Diabetes Mellitus Tipe 2 di Puskesmas Simpur Bandar Lampung. Jurnal Ilmu Kedokteran Dan Kesehatan, 10(8), 2508–2515.

Galicia-Garcia, U., Benito-Vicente, A., Jebari, S., Larrea-Sebal, A., Siddiqi, H., Uribe, K. B., Ostolaza, H., & Martín, C. (2020). Pathophysiology of type 2 diabetes mellitus. International Journal of Molecular Sciences, 21(17), 1–34. https://doi.org/10.3390/ijms21176275

Gao, H., Wu, J., Sun, Z., Zhang, F., Shi, T., Lu, K., Qian, D., Yin, Z., Zhao, Y., Qin, J., & Xue, B. (2022). Influence of lecithin cholesterol acyltransferase alteration during different pathophysiologic conditions: A 45 years bibliometrics analysis. Frontiers in Pharmacology, 13(December), 1–19. https://doi.org/10.3389/fphar.2022.1062249

Gieroba, B., Kryska, A., & Sroka-Bartnicka, A. (2025). Type 2 diabetes mellitus –

conventional therapies and future perspectives in innovative treatment. Biochemistry and Biophysics Reports, 42(March), 102037. https://doi.org/10.1016/j.bbrep.2025.102037

Gluba-Sagr, A., Olszewski, R., Franczyk, B., Młynarska, E., Rysz-Górzyńska, M., Rysz, J., Surma, S., Sohum, S., Banach, M., & Toth, P. P. (2025). High-density lipoproteins. Part 2. Impact of disease states on functionality. American Journal of Preventive Cardiology, 23 (March). https://doi.org/10.1016/j.ajpc.2025.101073

González, P., Lozano, P., Ros, G., & Solano, F. (2023). Hyperglycemia and Oxidative Stress: An Integral, Updated and Critical Overview of Their Metabolic Interconnections. International Journal of Molecular Sciences, 24(11). https://doi.org/10.3390/ijms24119352

Huang, C., You, H., Zhang, Y., Fan, L., Feng, X., & Shao, N. (2025). Association between the hemoglobin A1c/High-density lipoprotein cholesterol ratio and stroke incidence: a prospective nationwide cohort study in China. Lipids in Health and Disease, 24(1). https://doi.org/10.1186/s12944-025-02438-4

IDF. (2021). International Diabetes Federation (Vol. 102, Issue 2). https://diabetesatlas.org/atlas/tenth-edition/

Iheagwam, F. N., & Iheagwam, O. T. (2025). Diabetes mellitus: The pathophysiology as a canvas for management elucidation and strategies. Medicine in Novel Technology and Devices, 25 (December 2024), 100351. https://doi.org/10.1016/j.medntd.2025.100351

Jalal, D. A., Vásárhelyi, B., Blaha, B., Tóth, Z., Szabó, T. G., & Gyarmati, B. (2023). Interrelationship of hemoglobin A1c level lipid profile, uric acid, C-reactive protein levels and age in a large hospital database. Molecular and Cellular Probes, 72(August). https://doi.org/10.1016/j.mcp.2023.101933

Kemenkes. (2018). Laporan Riskesdas 2018 Nasional.pdf. https://kesmas.kemkes.go.id/assets/upload/dir_519d41d8cd98f00/files/Hasil-riskesdas-2018_1274.pdf

Kemenkes RI. (2022). Infodatin Kemenkes 2022. 13(1), 104–116. https://kemkes.go.id/app_asset/file_c ontent_download/17029583366581150 08345c5.53299420.pdf

Kjeldsen, E. W., Thomassen, J. Q., & Frikke-Schmidt, R. (2022). HDL cholesterol concentrations and risk of atherosclerotic cardiovascular disease – Insights from randomized clinical trials and human genetics. Biochimica et Biophysica Acta - Molecular and Cell Biology of Lipids, 1867(1), 159063. https://doi.org/10.1016/j.bbalip.2021.159063

Lawton, R., Frankenberg, E., Seeman, T., Karlamangla, A., Sumantri, C., & Thomas, D. (2024). Explaining adverse cholesterol levels and distinct gender patterns in an Indonesian population compared with the U.S. Economics and Human Biology, 54(March 2023), 101403. https://doi.org/10.1016/j.ehb.2024.101403

Liao, Y., Han, Y., Cao, C., Song, H., & Hu, H. (2025). Association between atherogenic index of plasma and risk of type 2 diabetes mellitus and the mediating effect of BMI: a comparative analysis in Chinese and Japanese populations. Diabetology and Metabolic Syndrome , 17(1), 1–25. https://doi.org/10.1186/s13098-025-01907-1

Madaudo, C., Bono, G., Ortello, A., Astuti, G., Mingoia, G., Galassi, A. R., & Sucato, V. (2024). Dysfunctional High-Density Lipoprotein Cholesterol and Coronary Artery Disease: A Narrative Review. Journal of Personalized Medicine, 14(9). https://doi.org/10.3390/jpm14090996

Martemucci, G., Khalil, M., Di Luca, A., Abdallah, H., & D'Alessandro, A. (2024). Estrategias integrales para el síndrome metabólico: cómo la nutrición, los polifenoles dietéticos, la actividad física y las modificaciones del estilo de vida abordan la diabesidad, las enfermedades cardiovasculares y las afecciones neurodegenerativas. Metabolites, 14(6). https://doi.org/10.3390/metabo14060327

Motte, A., Gall, J., Salem, J. E., Dasque, E., Lebot, M., Frisdal, E., Galier, S., Villard, E. F., Bouaziz-Amar, E., Lacorte, J. M., Charbit, B., Le Goff, W., Lesnik, P., & Guerin, M. (2020). Reduced reverse cholesterol transport efficacy in healthy men with undesirable postprandial triglyceride response.

Biomolecules, 10(5), 1–18. https://doi.org/10.3390/biom10050810

Mužik, R., Knapčoková, V., Saal, B., & Tkáč, I. (2023). Effect of a Disease Management Program on the Adherence to Guideline-Recommended HbA1c Monitoring in Patients with Diabetes in Slovakia. Diabetes Therapy, 14(10), 1685–1694. https://doi.org/10.1007/s13300-023-01447-9

Nnakenyi, I. D., Nnakenyi, E. F., Parker, E. J., Uchendu, N. O., Anaduaka, E. G., & Ezeanyika, L. U. (2022). Relationship between glycaemic control and lipid profile in type 2 diabetes mellitus patients in a low-resource setting. Pan African Medical Journal, 41. https://doi.org/10.11604/pamj.2022.41.281.33802

Ong, K. L., Stafford, L. K., McLaughlin, S. A., Boyko, E. J., Vollset, S. E., Smith, A. E., Dalton, B. E., Duprey, J., Cruz, J. A., Hagins, H., Lindstedt, P. A., Aali, A., Abate, Y. H., Abate, M. D., Abbasian, M., Abbasi-Kangevari, Z., Abbasi-Kangevari, M., ElHafeez, S. A., Abd-Rabu, R., … Vos, T. (2023). Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet, 402(10397), 203–234. https://doi.org/10.1016/S0140-6736(23)01301-6

Ouimet, M., Barrett, T. J., & Fisher, E. A. (2019). HDL and reverse cholesterol transport: Basic mechanisms and their roles in vascular health and disease. Circulation Research, 124(10), 1505–1518. https://doi.org/10.1161/CIRCRESAHA.119.312617

Ryczkowska, K., Adach, W., Janikowski, K., Banach, M., & Bielecka-Dabrowa, A. (2023). Menopause and women's cardiovascular health: is it really an obvious relationship? Archives of Medical Science, 19(2), 458–466. https://doi.org/10.5114/aoms/157308

Sharahili, A. Y., Mir, S. A., ALDosari, S., Manzar, M. D., Alshehri, B., Al Othaim, A., Alghofaili, F., Madkhali, Y., Albenasy, K. S., & Alotaibi, J. S. (2023). Correlation of HbA1c Level with Lipid Profile in Type 2 Diabetes Mellitus Patients Visiting a Primary Healthcare Center in Jeddah City, Saudi Arabia: A Retrospective Cross-Sectional Study. Diseases, 11(4), 1–14. https://doi.org/10.3390/diseases11040154

Shimizu, I., Kohzuma, T., & Koga, M. (2019). A proposed glycemic control marker for the future: glycated albumin. Journal of Laboratory and Precision Medicine, 4(June). https://doi.org/10.21037/jlpm.2019.05.01

Siam, N. H., Snigdha, N. N., Tabasumma, N., & Parvin, I. (2024). Diabetes Mellitus and Cardiovascular Disease: Exploring Epidemiology, Pathophysiology, and Treatment Strategies. Reviews in Cardiovascular Medicine, 25(12). https://doi.org/10.31083/j.rcm2512436

Singh, S., Kriti, M., K.S., A., Sarma, D. K., Verma, V., Nagpal, R., Mohania, D., Tiwari, R., & Kumar, M. (2024). Deciphering the complex interplay of risk factors in type 2 diabetes mellitus: A comprehensive review. Metabolism Open, 22(March), 100287. https://doi.org/10.1016/j.metop.2024.100287

Wahidin, M., Achadi, A., Besral, B., Kosen, S., Nadjib, M., Nurwahyuni, A., Ronoatmodjo, S., Rahajeng, E., Pane, M., & Kusuma, D. (2024). Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. Scientific Reports, 14(1), 1–17. https://doi.org/10.1038/s41598-024-54563-2

Wang, W., Liu, Y., Li, Y., Luo, B., Lin, Z., Chen, K., & Liu, Y. (2023). Dietary patterns and cardiometabolic health: Clinical evidence and mechanism. MedComm, 4(1), 1–30. https://doi.org/10.1002/mco2.212

Widiarti, W., Saputra, P. B. T., Savitri, C. G., Putranto, J. N. E., & Alkaff, F. F. (2025). The impact of cardiovascular drugs on hyperglycemia and diabetes: a review of 'unspoken" side effects.' Hellenic Journal of Cardiology, 83(October 2024), 71–77. https://doi.org/10.1016/j.hjc.2024.09.007

Wu, Q. Y., Mo, L. R., Nan, J., Huang, W. Z., Wu, Q., & Su, Q. (2025). The Association Between the Hemoglobin Glycation Index and Cardiometabolic Diseases: A Mini-Review. Journal of Clinical Hypertension, 27(7), 1–14. https://doi.org/10.1111/jch.70092

Xiao, Y., Hong, X., Neelagar, R., & Mo, H. (2025). Association between glycated hemoglobin A1c levels, control status, and cognitive function in type 2 diabetes: a prospective cohort study. Scientific Reports, 15(1), 1–14.

https://doi.org/10.1038/s41598-025-89374-6

Yuliana, N. (2024). There is No Relationship Between HbA1C and HDL in Type 2 Diabetes Mellitus Patients. Journal of Medical Case Reports and Reviews, 07(September), 410–417. https://doi.org/10.52845/JMCRR2024/7-10-1