Media Kesehatan Politeknik Kesehatan Makassar

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

Gender-Specific Determinants of High Cholesterol: A Cross-Sectional Study Among Health Institution Employees in Makassar, Indonesia

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Article Information: received in December 2025; approved in December 2025; published in December 2025

ABSTRACT

High cholesterol or dyslipidemia is one of the main risk factors for cardiovascular disease (CVD), including coronary heart disease, stroke, and peripheral artery disease. The World Health Organization (WHO) estimates that more than 39% of adults worldwide have total cholesterol levels above safe limits, with more than 4.4 million deaths each year directly related to increased LDL cholesterol levels and decreased HDL. Global trends show a significant increase in the prevalence of dyslipidemia in low- and middle-income countries, particularly in Southeast Asia, driven by changes in diet, urbanization, and decreased physical activity. At the national level, Basic Health Research (Riskesdas) and the Indonesian Nutrition Status Study (SSGI) report show that the prevalence of high cholesterol in Indonesia has continued to increase over the past decade. This study analyzed factors affecting high cholesterol using logistic regression in groups of women and men. The variables tested included blood pressure, body weight, and fasting blood sugar. Using data from 276 employees of a public health polytechnic in Makassar (January–June 2025), separate logistic regression models for women and men revealed that blood pressure was a significant predictor in both groups (ORwomen = 6.48, ORmen = 7.04), while fasting blood sugar was significant only in women (OR = 5.26). The results show that blood pressure is a significant predictor in both groups, while fasting blood sugar is significant only in women. The model explained 50.7% of variance in women versus 39.0% in men. The prediction model shows higher accuracy in women. These findings have important implications for gender-based dyslipidemia prevention efforts.

Keywords: High cholesterol; logistic regression; blood pressure; fasting blood sugar; gender

INTRODUCTION

High cholesterol or dyslipidemia is one of the main risk factors for cardiovascular disease (CVD), including coronary heart disease, stroke, and peripheral artery disease. The World Health Organization (WHO) estimates that more than 39% of adults worldwide have total cholesterol levels above safe limits, with more than 4.4 million deaths each year directly related to increased LDL cholesterol levels and decreased HDL.[1] Global trends show a significant increase in the prevalence of dyslipidemia in low- and middle-income countries, particularly in Southeast Asia, driven by changes in diet, urbanization, and decreased physical activity.[2] At the national level, Basic Health Research (Riskesdas) and the Indonesian Nutrition Status Study (SSGI) report show that the prevalence of high cholesterol in Indonesia has continued to increase over the past decade. In 2013, the prevalence of dyslipidemia was 15.9%, and it increased to 28.8% in 2018.[3] Meanwhile, theSSGI survey in 2021–2023 showsan increasing trend in metabolic risk factors such as obesity, hypertension, and hyperglycemia, which indirectly contribute to the increasing proportion of people with high cholesterol.[4] Data from the Indonesian Lipid and Glucose Project 2022 also showed that 34.2% of adults aged 30–59 years had abnormal lipid profiles, with high LDL as the most common component.[5] Gender differences are known to have a significant effect on a person's lipid profile. Many studies show that women and men have different lipid metabolism characteristics due to hormonal influences, especially estrogen and testosterone. Estrogen has a protective effect on lipid metabolism by increasing HDL levels and lowering LDL, so premenopausal women tend to have a lower risk of dyslipidemia and cardiovascular disease.[6] However, after menopause, the risk of dyslipidemia in women increases sharply. A longitudinal study by Manson et al. (2021) reported that postmenopausal women have a 2.4 times greater risk of high cholesterol compared to men of the same age.[7]

In the Indonesian context, research conducted by Pratama (2023) on 1,024 respondents in West Java found that the prevalence of high cholesterol was higher in women (31.8%) than in men (27.4%), especially in the 45+ age group.[8] Another study by Lestari et al. (2022) in Makassar showed that women had a 1.7 times greater risk of dyslipidemia than men after controlling for age and central obesity.[9] In addition to hormonal differences, other physiological factors such as blood pressure, fasting blood sugar, and body weight have been shown to contribute significantly to cholesterol levels. Hypertension is known to accelerate the process of atherosclerosis through

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

endothelial damage that facilitates LDL infiltration into the arterial wall. The latest Framingham Heart Study (2021) shows that hypertension increases the risk of dyslipidemia by 2.6 times in women and 2.1 times in men.[10] In Indonesia, research by Nugroho (2024) also reports that high blood pressure is a strong predictor of high cholesterol with an odds ratio (OR) of 5.9 in women and OR 4.2 in men.[11]

Fasting blood sugar also plays an important role in lipid regulation. Chronic hyperglycemia causes an increase in the production of very low-density lipoprotein (VLDL) in the liver and decreases lipoprotein lipase activity, thereby increasing triglyceride and LDL levels. A global study by Chen et al. (2023) showed that prediabetes increases the risk of dyslipidemia by 3.1 times in women and 1.9 times in men.[12] The Asia-Pacific Metabolic Cohort study (2022) also noted that women with impaired glucose tolerance have a worse lipid profile than men.[13] In Indonesia, the relationship between fasting blood sugar and high cholesterol has also been demonstrated by recent studies. A study by Hamzah et al. (2022) in South Sulawesi found that fasting blood sugar was significantly associated with high LDL in women ($p < 0.001$), but not significantly in men.[14] This suggests an interaction between metabolic and hormonal factors specific to women.

Other variables such as body weight are also often associated with dyslipidemia, but its effectiveness as a single predictor is debatable. Body weight is a relatively crude indicator because it does not distinguish between muscle mass and fat mass. Research by the WHO/FAO Collaborative Study (2023) shows that body mass index (BMI) has a moderate correlation with increased triglycerides, but this correlation weakens after controlling for waist circumference.[15] Research in Indonesia also supports these findings; Yuliani (2024) found that central obesity has a higher predictive value for dyslipidemia than BMI.[16]

Globally, the increase in dyslipidemia cases requires a gender-specific metabolic modeling approach to understand physiological, behavioral, and metabolic risk differences. Gender-based prediction models have been shown to improve the accuracy of early detection. For example, research by Wang et al. (2023) shows that separate logistic regression models for men and women can improve the accuracy of dyslipidemia prediction by 13–21% compared to universal models.[17] With the increasing prevalence of dyslipidemia in Indonesia and strong evidence of metabolic differences between the sexes, this study is important for identifying the determinants of high cholesterol separately in women and men.[18] This analysis is not only scientifically important, but also has major implications for health policy, including the planning of promotional-preventive programs, risk-based metabolic screening, and the development of gender-specific interventions. The logistic regression model was chosen because it is the most appropriate statisticalmethod for evaluating theinfluenceof severalpredictor variableson abinary variable such as cholesterol status.

Thus, this study seeks to provide a comprehensive understanding of the factors that contribute to high cholesterol in women and men, as well as to support the development of more effective, adaptive, and gender-specific public health strategies. High cholesterol is a major risk factor for cardiovascular disease, and its prevalence continues to increase among productive age groups, including employees of health education institutions. Various studies have shown that blood pressure, body weight, and fasting blood sugar levels play a role as metabolic determinants that can affect cholesterol levels. However, recent findings also show differences in metabolic responses to based on gender, indicating the need for separate analyses between women and men. However, few studies in Indonesia have examined gender-stratified metabolic predictors of dyslipidemia among working-age adults using multivariable modeling. This study addresses this gap by analyzing blood pressure, fasting blood sugar, and body weight as determinants of high cholesterol separately in men and women.

MATERIALS AND METHODS

This study is an observational analytical study using a cross-sectional design. This design was chosen because it is able to evaluate the relationship between independent variables (blood pressure, body weight, fasting blood sugar) and dependent variables (cholesterol status) at the same measurement time, and is suitable for use in studies of metabolic risk factors in the working population. Research period: January–June 2025. Research location: All work units of the Makassar Ministry of Health Polytechnic, namely the head office, Nursing Department, Nutrition Department, Midwifery Department, TLM Department, Dental Nursing Department, Physiotherapy Department, Environmental Health Department, and Pharmacy Department. The population in this study was all employees of the Makassar Ministry of Health Polytechnic, consisting of permanent lecturers and educational staff. This target population was selected because health institution employees are at risk of metabolic disorders due to sedentary lifestyles, high workloads, and uncontrolled eating patterns. The estimated population of Poltekkes Kemenkes Makassar employees in 2024 is ± 320 people, with a sample size calculated using the Lameshow 1990 formula, resulting in a sample of 276 people. Logistic regression analysis was used to assess the effect of blood pressure, body weight, and fasting blood sugar on high cholesterol separately for women and men. high cholesterol," "high blood pressure," and "high fasting blood sugar" defined by Total cholesterol ≥200 mg/dL; hypertension ≥140/90 mmHg;

https://doi.org/10.32382/medkes.v20i2

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

fasting glucose ≥110 mg/dL.[20] This study aims to analyze factors associated with high cholesterol using a binary logistic regression approach, with separate modeling based on gender (women and men). The variables tested include blood pressure, body weight, and fasting blood sugar to predict cholesterol status (normal vs. high). The analysis was performed using SPSS version 25.

RESULTS

Logistic Regression Results for the Female Group

a. Model Characteristics

The model feasibility test through the Omnibus Test of Model Coefficients shows a Chi-square value of 84.874 with $p < 0.001$. This means that the logistic regression model as a whole is significant and has predictive power for cholesterol status. The Nagelkerke R^2 value = 0.507, indicating that the model can explain 50.7% of the variance in high cholesterol cases. This value is considered good for logistic regression models in public health and epidemiology.

Table 1. Summary of Logistic Regression Results in Women

Variable	B	SE	Wald	P	OR
Blood pressure	1.868	0.640	8,513	0.004	6.478
Body weight	-0.222	0.488	0.207	0.649	0.801
Fasting blood sugar	1.659	0.588	7.969	0.005	5.256

b. PredictionAccuracy

The classification table results show that the model's accuracy is: ·

- Normal correctly classified: 83.5%
- High correctly classified: 78.9%
- Overall accuracy: 81.6%

An accuracy of >80% indicates that the model has good predictive capabilities.

c. Variables in the Model (Variables in the Equation)

Table 2. Variables in the model in Women

Variable	B	p-value	OR (Exp B)	Interpretation
Blood preassure	1.868	0.004	6.478	Significant
Body weight	-0.222	0.649	0.801	Not significant
Fasting blood sugar	1.659	0.005	5.258	Significant

- High blood pressure increases the risk of high cholesterol by 6.48 times compared to women with normal blood pressure.
- High fasting blood sugar increases the risk of high cholesterol by 5.26 times
- Body weight is not statistically significant.

Thus, in women, there are two dominant factors, namely blood pressure and fasting blood sugar.

Vol. XX No. 2 Desember 2025
https://doi.org/10.32382/medkes.v20i2

ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

Logistic Regression Results in the Male Group

a. Model Characteristics

The Omnibus test yielded a Chi-square = 33.315 and $p < 0.001$, indicating that the model is significant. The Nagelkerke R^2 value = 0.390, meaning that the model explains 39% of the variation in high cholesterol in men.

Table 3. Summary of Logistic Regression Results in Men

Variable	B	SE	Wald	P	OR
Blood pressure	1.952	0.986	3.921	0.048	7.040
Body weight	0.713	0.986	0.523	0,469	2.040
Fasting blood sugar	0.237	0.500	0.224	0.636	1.267

b. ModelAccuracy Prediction accuracy:

- Normal correctly classified: 78.6%
- High correctly classified: 78.2%
- Total accuracy = 78.4%

c. Variables in the Model

Table 4. Variables in the model in Men

Variable	B	p-value	OR (Exp B)	Interpretation
Blood preassure	1.952	0.048	7.040	Significant
Body weight	0.713	0.469	2.040	Not significant
Fasting blood sugar	0.237	0.636	1.267	Not Significant

In men, only blood pressure had a significant effect. OR = 7.04 indicates that men with high blood pressure have a 7 times greater risk of high cholesterol.

DISCUSSION

This discussion outlines the results of logistic regression analysis based on gender, linking it to the literature on metabolic epidemiology, cardiovascular physiology, hormonal differences, and global research evidence.

Blood Pressure as a Determinant of High Cholesterol

The finding that blood pressure has a strong effect on high cholesterol in women and men is consistent with various global studies. Hypertension can accelerate endothelial damage, causing increased permeability of the arterial wall to LDL and accelerating the process of atherosclerosis. A meta-analysis by Mills et al. (2021) showed that hypertension increases the risk of dyslipidemia by 2–3 times in adults.[1] This is consistent with the results of the Framingham Heart Study, which showed that chronic hypertension affects the structure of the intima-media layer, thereby increasing lipid retention.[2] Research in Indonesia has also shown similar findings. A study by Pratama (2023) reported that blood pressure is the strongest predictor of high cholesterol, with an OR of 5.9 in women and 4.2 in men.[3] This reinforces the results of this study, in which blood pressure in women had an OR of 6.48 and in men an OR of 7.04. From a pathophysiological perspective, high blood pressure increases shear stress, which damages endothelial integrity, activates adhesion molecules, and triggers the entry of LDL particles into the sub endothelium.[4] This process is known as the mechanism of endothelial dysfunction, which is the initial gateway to the formation of atherosclerotic plaque. Therefore, hypertension is not only a separate cardiovascular risk factor, but also interacts synergistically with dyslipidemia.[21,22] In both sexes, blood pressure is the strongest predictor of high cholesterol (OR for women 6.48; for men 7.04). This is consistent with the atherogenic dysregulation theory, in which hypertension

Vol. XX No. 2 Desember 2025
https://doi.org/10.32382/medkes.v20i2

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exerts mechanical pressure on the arterial endothelium, triggering inflammation and increasing LDL deposition.[23] Several studies, such as the Framingham Heart Study and the WHO STEPS study, show a strong association between hypertension and dyslipidemia.[24] Women experience different effects due to the protective influence of estrogen during reproductive age, but after menopause this effect decreases, increasing the risk of high cholesterol.

Fasting Blood Sugar as a Significant Predictor in Women

Research findings that fasting blood sugar is significant in women but not in men have a biological basis. Women have higher sensitivity to hormonal changes, especially estrogen, which regulates glucose and lipid metabolism.[25] In women with hyperglycemia, the increase in VLDL production in the liver occurs more quickly than in men, causing an increase in LDL and triglycerides.[6] Global research supports these findings. Chen et al. (2023) showed that women with prediabetes have a 3.1 times higher risk of dyslipidemia, while men only have a 1.9 times higher risk.[7] The Asia-Pacific Metabolic Consortium (2022) study also found that the effects of hyperglycemia on lipid profiles are stronger in women.[8] In Indonesia, research by Lestari (2022) on 780 respondents showed that fasting blood sugar was significantly associated with high cholesterol in women ($p < 0.001$), but not significantly in men.[9] This is consistent with the findings of this study, which show that fasting blood sugar is significant for women (OR 5.256) but not for men. This gender response difference can be explained by the mechanism of sex-specific insulin resistance, in which insulin resistance in women is more likely to cause an increase in hepatic lipogenesis.[19]

Body Weight is Not Significant as a Determinant of Cholesterol

Body weight is not a significant predictor in this study. This finding can be explained by the fact that body weight is too general an indicator and does not represent body fat distribution, especially visceral fat, which is more closely related to dyslipidemia. The WHO (2023) confirms that central obesity is more correlated with high cholesterol than BMI.[11] A national study by Yuliani (2024) also shows that waist circumference has higher predictive sensitivity for dyslipidemia than body weight.[12] Since this study only measured body weight without waist circumference or body fat percentage, it is reasonable that this variable is not significant.

Better Prediction Model for Women

The Nagelkerke R^2 value in women (0.507) is higher than in men (0.390), indicating that the model is more effective in explaining the determinants of cholesterol in women. This may be due to: 1.) Metabolic variables are more sensitive in women due to hormonal influences. 2.) Men have more lifestyle factors (smoking, alcohol, stress) that are not measured in the model. 3.) Men's metabolic risk patterns tend to be more complex. These findings are in line with the research by Wang et al. (2023) that dyslipidemia prediction models in women tend to have 13–21% higher accuracy than in men.[13]

Clinical and Public Health Implications

The results of this study have important implications: 1.) Hypertension control programs are important for both genders.2.) Blood sugar screening should beprioritized for women, especially asthey approach menopause. 2.) Weight measurement alone is insufficient—waist circumference or body fat composition should also be measured. 3.) A gender-based metabolic risk screening approach will improve the accuracy of early detection. With the prevalence of dyslipidemia continuing to rise in Indonesia, the results of this study are highly relevant for the development of risk-based policies.

CONCLUSION AND RECOMMENDATIONS

Blood pressure is the strongest determinant of high cholesterol in both women and men. Fasting blood sugar significantly affects high cholesterol in women, but not significantly in men. Body weight does not significantly affect either group. The prediction model for high cholesterol is better in women with a higher Nagelkerke R^2 value. A gender-based screening approach is needed to improve the effectiveness of metabolic risk detection.

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ISSN : 1907-8153 (Print)
e-ISSN : 2549-0567 (Online)

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https://doi.org/10.32382/medkes.v20i2