ASSOCIATION OF SELECTED WORKER CHARACTERISTICS WITH TOTAL CHOLESTEROL LEVELS AMONG MINING WORKERS

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ABSTRACT

Background: Cardiometabolic disorders such as dyslipidemia and hypertension are increasingly prevalent among workers in high-risk industries, including mining, due to age, nutritional status, and work-related stressors. The purpose of the study was to determine the relation between age, body mass index (BMI), and blood pressure and total cholesterol levels in mining workers in PT Harmoni Panca Utama, Job Site KDA. Methods: The cross-sectional design was used and a multiple linear regression was carried out to determine the relationship between the independent variables and the overall cholesterol levels. Results: The analysis showed that age and BMI were significant in influencing the level of total cholesterol ($p < 0.001$), but the systolic and diastolic blood pressure did not exhibit significant relations. Low-density lipoprotein (LDL) cholesterol was associated with greater LDL and total cholesterol deposition because of age-related changes in lipid metabolism, and the excessive body weight (BMI) was associated with dyslipidemia because of visceral fat deposition and dysfunctional lipoprotein metabolism. Conclusion: These results have highlighted the significance of occupational health-serial of monitoring concerning the age and the nutritional status of workers to avoid cardiometabolism complications.

Keywords: age, body mass index, blood pressure, total cholesterol, mining workers

INTRODUCTION

Mining is a physically demanding segment of the labor market with a high demand, unstable weather patterns, fluctuating rotating shifts, and lack of access to nutritious food (Ramdhani and Soraya, 2024; Wardhana and Tejamaya, 2024). Such work conditions can raise the chances of metabolic diseases like high blood pressure, metabolic changes with age, high body mass index (BMI), and dyslipidemia which are the leading risk factors of cardiovascular diseases (Qin, Jia and Yang, 2023). This is because cardiovascular disease is the leading cause of death in the whole world, and occupational determinants are also becoming significant factors that contribute to the risk (Alhajaji et al., 2025). The prevalence of hypertension, obesity, and dyslipidemia among workers in Indonesia has increased, particularly in high-risk workplaces such as mining activities (Andini and Siregar, 2024; Haldy and Kurniawidjaja, 2024).

The amount of total cholesterol is one of the most important indicators to determine the risk of cardiovascular diseases (Martin et al., 2025). It is indicated by several studies that the high body mass index (BMI) correlates with high levels of total cholesterol, and it becomes so because of the changes in lipid metabolism caused by adipose tissue (Bell et al., 2021a). High blood pressure is also directly associated with vascular dysfunction and lipid metabolic diseases and could accelerate the progress of atherosclerosis (Poznyak et al., 2022; Blagov et al., 2024). Though many studies were carried out in a general population, there is still a lack of scientific data on the simultaneous effect of age, blood pressure, and BMI on the level of total cholesterol of workers employed in open-pit mining [especially those working in the open mines] (Zhao et al., 2024). However, there is very limited similar data among mining workers in Indonesia, especially the workers who are employed in open-pit mining systems like the one available at PT Harmoni Panca Utama, Job Site KDA. In order to develop specific occupational health interventions, a thorough knowledge of the correlation between blood pressure, BMI, and total

cholesterol levels in the mining work place is necessary.

The objective of the study is to analyze the relationship between age, blood pressure and the body mass index (BMI) with the level of total cholesterol levels in mining workers of PT Harmoni Panca Utama, Job Site KDA. It is anticipated that the outcomes of the given research will contribute to the scientific body of knowledge in the area of occupational health in the mining industry and help to design specific monitoring and prevention interventions against metabolic diseases among miners.

METHOD

This study was a cross-sectional study design that utilized quantitative analysis of observations. The data were obtained from secondary sources, namely the summarized Medical Check-Up (MCU) results conducted by PT Hasta Panca Mandiri Utama at the KDA Job Site between June and December 2023. The variables considered in the analysis were age, blood pressure (systolic/diastolic), body mass index (BMI), and total cholesterol. Age was obtained from respondent identity data; blood pressure was measured using a digital sphygmomanometer following standard procedures; BMI was calculated from measured weight and height (kg/m^2); and total cholesterol levels were determined through laboratory examination using an enzymatic assay. The occupational health unit of the company presented all the data in a digital summary form, and anonymized them before they were used in this study.

The population of the study involved all the mining workers working as heavy equipment operators in open pit mining locations. The sample size was determined using a total population approach. Out of 463 mining operators who underwent medical check-up (MCU) between June and December 2023, 426 subjects met the inclusion criteria, which required complete records of blood pressure, body mass index (BMI), and total cholesterol levels. The remaining 37 subjects did not meet the inclusion criteria and were excluded from the study. Exclusion criteria were workers whose data were

incomplete or contained invalid values, defined as physiologically implausible measurements (e.g., total cholesterol < 100 mg/dL or > 400 mg/dL), and workers with a known diagnosis of severe medical conditions affecting lipid metabolism (e.g., diabetes mellitus or chronic kidney disease).

Data analysis involved univariate, bivariate, and multivariate. The univariate analysis was conducted to explain the nature of the study participants using frequency distribution and mean values of each variable. The analysis based on the distribution of data to determine the association between blood pressure (systolic and diastolic) and BMI to total cholesterol levels was performed through simple linear regression. After that, a multiple linear regression analysis was used to estimate the input of each independent variable in the overall cholesterol rates after adjusting them simultaneously. Before the multiple regression analysis assumptions that unstandardized residuals were normally distributed, that the regression line was linear, multicollinearity was no longer than 3, and the homoscedasticity was satisfied were tested. All the analyses were done on the basis of IBM SPSS Statistics version 27 where the level of significance was set $p < 0.05$.

RESULTS AND DISCUSSION

Research Subject Description

The aggregate of the medical check-up (MCU) records in June 2023 until December 2023 in PT. Hasta Panca Mandiri Utama that is working at KDA Job Site was 463. During this, 426 records passed through the inclusion criteria and 37 records failed to pass through the inclusion criteria.

The average age of the respondents was 32.9 years (SD = 7.3) with the lowest age of 20 years, and the highest age of 54 years showing that the majority of the respondents were in productive age. BMI ranged from 15.1-45.7 kg/m2 with a mean of 25.4 kg/m2 (SD=4.1), and it belongs to the upper-normal/overweight range of WHO classification (World Health Organization, 2025). The systolic blood pressure mean was 111.4 mmHg (SD = 9.8), and the mean of the diastolic blood pressure was 79.9 mmHg (SD = 5.8).

These two values were normal according to the JNC 8 guidelines, but some of the participants showed systolic pressures of up to 150 mmHg, which is a sign of possible hypertension among a small number of the population (Hernandez-vila, 2015). The total cholesterol was 104-332 mg/dl with a mean of 188.7 mg/dL and SD=38.9. Although the mean value was not below the normal range (<200 mg/dL), the highest mean of 332 mg/dL shows that the participants have substantially high cholesterol levels and this can predispose them to cardiovascular disease. Table 1 proposes detailed characteristics of the study subjects.

Table 1. Characteristics of Study Participants (N = 426)

Variable	Minimum	Maximum	Mean	SD
Age (years)	20	54	32.9	7.3
Body Mass Index (kg/m²)	15.1	45.7	25.4	4.1
Systolic Blood Pressure (mmHg)	70	150	111.4	9.8
Diastolic Blood Pressure (mmHg)	60	90	79.9	5.8
Total Cholesterol (mg/dL)	104	332	188.7	38.9

Statistical Assumption Testing

Before conducting the multiple linear regression analysis, various classical assumption tests such as normality, linearity, multicollinearity, and homoscedasticity tests were performed to check whether the regression model fulfilled the assumptions required.

The normality assumption was evaluated through the Kolmogorov-Smirnov test on the unstandardized residuals. The outcome showed a significance value of (p = 0.462), which is above 0.05, thus implying that the residuals follow a normal distribution.

The Test for Linearity method was utilized to carry out linearity tests on the relationship between the independent and dependent variables. The outcomes pointed out that the correlations between age (p = 0.481), systolic blood pressure (p = 0.130), diastolic blood pressure (p = 0.516), and BMI (p = 0.279) with total cholesterol levels were linear. This was concluded because the significance

values for the Deviation from Linearity for each variable were more than 0.05. Multicollinearity test was performed through the evaluation of the independent variables for the presence of correlations using Tolerance and Variance Inflation Factor (VIF) as the two main indicators. The Tolerance values were 0.966 for age, 0.917 for systolic blood pressure, 0.949 for diastolic blood pressure, and 0.966 for BMI; the corresponding VIF values were 1.035 for age, 1.090 for systolic blood pressure, 1.054 for diastolic blood pressure, and 1.035 for BMI. It was concluded from the analysis that all the Tolerance values were larger than 0.10 and all the VIF values were less than 10, which means that there was no multicollinearity among the predictors in the regression model.

The homoscedasticity was tested by means of a scatterplot representing the predicted values against the residuals, where the distribution of the residuals was examined. The non-patterned random distribution implies that the variance of the residuals is constant (Figure 1). Thus, the condition of homoscedasticity was satisfied.

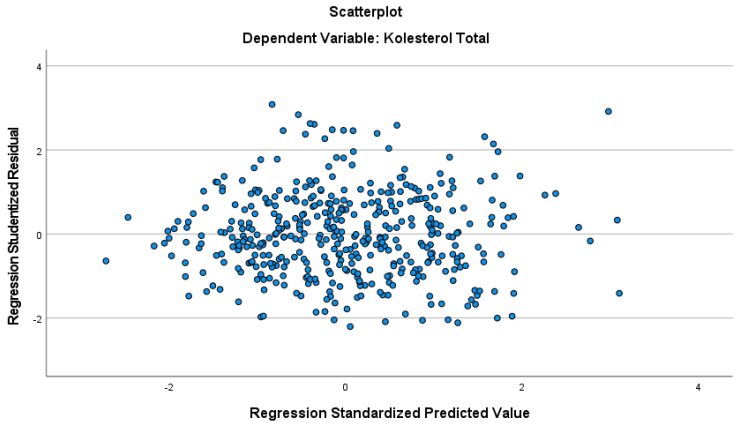

Figure 1. Scatterplot of Predicted Values versus Residuals

From the findings of the four tests, one can conclude that the data satisfies all the classical assumptions and thus, allows for the conduct of multiple linear regression analysis.

Multiple Regression Analysis Results

The multiple linear regression analysis was done to determine the impact of age, BMI, systolic blood pressure, and diastolic blood pressure on total cholesterol levels. Table 2 illustrates the results.

Table 2. Multiple Linear Regression Analysis of Total Cholesterol Levels

Independent Variable	B Coefficient	p-value	95% Confidence Interval for B
Age	1.208	<0.001	0.718 to 1,698
Body Mass Index (BMI)	1.913	<0.001	0.718 to 1.698
Systolic Blood Pressure	0.071	0.707	1.046 to 2.779
Diastolic Blood Pressure	0.423	0.189	-0.301 to 0.444
Constant	58.8	0.059	-0.209 to 1.054

- Dependent Variable: Total Cholesterol
- $F(4, 421) = 13.280$, $p < 0.001$
- Adjusted $R^2 = 0.104$

The regression analysis was statistically significant ($F(4,421) = 13.280$, $p < 0.001$). Age and BMI were significantly associated with total cholesterol levels ($p < 0.001$), with 95% CI indicating that the true effect sizes of these predictors lie within a positive and clinically meaningful range. In contrast, systolic and diastolic blood pressure showed no significant association ($p > 0.05$). The adjusted R^2 of 0.104 indicates that 10.4% of the variation in total cholesterol levels was explained by the four independent variables.

Effect of Age on Total Cholesterol Levels

The results showed that the level of total cholesterol was strongly affected by the age ($p < 0.001$). In line with the literature of the past, an aging process is correlated with a higher risk of dyslipidemia because of the reduction in lipid metabolism, a decline in the activity of lipolytic enzymes, and the reduction in vascular elasticity, which helps accumulate LDL and total cholesterol (Li *et al.*, 2023; Song *et al.*, 2023).

The physical stress, harsh weather conditions, and unregulated shifts are also a more common exposure of older workers in the mining work setting, which may worsen their lipid profiles (Makar *et al.*, 2024). It has been previously demonstrated that employees with the age of 40 years and above have increased total cholesterol, especially when they adopt high-fat diets and low physical activity (Bajada, Xiberras and Muscat Inglott, 2022;

Irma Zuraini *et al.*, 2024). Further evidence is provided by Viana (2022), who noted that an extra year of age was significantly correlated with the level of total cholesterol in heavy industry workers; Zhao *et al.* (2024) found that lipid levels were higher in miners more than 45 years old because of the cumulative effect of oxidative stress and metabolic hormone changes; and even normal blood pressure in older age increased LDL and total cholesterol levels, demonstrating that age is another independent determinant of the lipid level (Feng *et al.*, 2020; Zhang *et al.*, 2020; He *et al.*, 2022).

Even though the age factor was strong, the adjusted R^2 of the model was low (0.104), which means that age can only explain a minor part of the variation of the total cholesterol levels. It is expected that other factors, including the genetic factors, diet, and physical activity, will contribute significantly to the reported increases in total cholesterol (Schnurr *et al.*, 2020; Hooda, 2023; Bojarczuk *et al.*, 2024; Brittain *et al.*, 2024).

The Impact of BMI on Total Cholesterol Levels

The current research showed that BMI has a great impact on the total cholesterol levels ($p < 0.001$). This result coincides with the available literature that suggests that higher BMI, especially the presence of the excess visceral fat, may increase insulin resistance and lipoprotein metabolism with the disruption and stimulation of LDL production, which increases the total cholesterol levels (Bell *et al.*, 2022; Lu *et al.*, 2022). Mining works have not only an increased risk of dyslipidemia among workers with high BMI but also face the danger of physical fatigue, musculoskeletal issues, and other metabolic complications, which indirectly affect the lipid profiles of the latter (Shahraz *et al.*, 2025; Wang *et al.*, 2025). Abdullah *et al.* (2020) found that the total cholesterol was higher in workers with a BMI ≥25 kg/m 2 than in workers with normal BMI and irrespective of the physical activity level.

This fact is also facilitated by Al-shoaibi *et al.* (2024) who discovered that increasing BMI systematically

elevates the chances of having an abnormal cholesterol level among the adult working groups. Haditya and Waren (2025) noted that there was a positive significant relationship between BMI and total cholesterol in mining workers especially those who are highly active and undergo excessive caloric intake. As Bell *et al.* (2021b) observed, the increase in BMI by 4.8 kg/m² could have led to strong positive changes in LDL and total cholesterol, which proved BMI as an independent metabolic predictor. Moreover, Shahraz *et al.* (2025) have shown that visceral fat and dyslipidemia are correlated with high BMI despite normal blood pressure, which is also in line with the metabolic processes noted in the heavy industry workers.

Nevertheless, not every person who has a high BMI has an increased total cholesterol level (Sinurat and Elon, 2019). The distribution of body fats, genetic predisposition, diets, and the level of physical activity still remain a key factor in the lipid profile of a person (Zheng and Qi, 2014).

Systolic and Diastolic Blood Pressure and Their Association with Total Cholesterol Levels

The obtained results of the analysis suggested that systolic ($p = 0.707$) and diastolic blood pressure ($p = 0.189$) did not significantly influence the level of total cholesterol in the mining workers. The findings are in line with various studies that found that the correlation between the blood pressure and the total cholesterol is relatively low, especially in the active working groups of workers or in younger people (Naue, Doda and Wungouw, 2016). Even though blood pressure does not directly affect the overall cholesterol, hypertension may remain a risk factor of cardiovascular diseases via vascular pathways and atherosclerotic pathways, including enhancing endothelial injury, vascular inflammation, and arterial plaque formation (Devy *et al.*, 2022).

Nevertheless, other researchers have demonstrated that the lipid profiles, including LDL increase and HDL decrease, may be influenced by the chronic long-term hypertension and affect the metabolic risk indirectly, which goes against the statement of

lack of the relationship between the two (Chen and Cheng, 2022). This study did not find a significant association between blood pressure and total cholesterol, possibly due to the cross-sectional design, relatively small variance in blood pressure in the sample, or the absence of measurements of moderating factors such as diet, physical activity, and genetic factors. The low adjusted R^2 (10.4%) indicates that only a small portion of total cholesterol variation can be explained by the analyzed factors. Although blood pressure is not a primary predictor of overall cholesterol among mining employees, periodic monitoring remains necessary to prevent long-term metabolic and cardiovascular risks.

CONCLUSION

The findings of this research paper reveal that the effect of age and body mass index (BMI) significantly influence the total cholesterol levels of mining workers, but the effects of systolic and diastolic blood pressure are not significant. Accumulation of LDL and total cholesterol as a result of heightened age-associated lipid metabolism and physiological changes associated with age and high BMI as a result of visceral fat deposition and poor lipoprotein metabolism lead to dyslipidemia, respectively. These results are crucial in highlighting the consideration of demographic and nutritional status in the management of metabolic risk, and in the necessity of occupational health monitoring and interventions programs that focus on older employees and high BMI workers to prevent cardiometabolic disease.

ACKNOWLEDGEMENTS

This study was facilitated by the fact that the Institute of Research and Community Services (LPPM) of Sebelas Maret University provided financial support to the author via the Research Implementation Assignment Agreement (No. 194.2/UN27.22/PT.01.03/2024, dated March 15, 2024).

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