Cardiovascular Disease Risk Factors Among Mining Workers at PT. Manggala Alam Lestari

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Abstract

This study aimed to analyze the risk factors associated with cardiovascular disease (CVD) among mining workers at PT Manggala Alam Lestari, Musi Banyuasin, South Sumatra, Indonesia. A retrospective case-control study was conducted using secondary data from routine Medical Check-Up (MCU) records collected between 2022 and 2024. A total of 400 workers were included, comprising 80 CVD cases and 320 controls selected using a 1:4 frequency matching strategy by age group (≤45 and >45 years) and gender. Data analysis involved univariate summaries, bivariate chi-square tests, and multivariate multiple logistic regression to obtain adjusted odds ratios (aOR) and 95% confidence intervals while controlling for potential confounders, including age, gender, and work shift. Five significant modifiable risk factors were identified: obesity, diabetes mellitus, hypertension, dyslipidemia, and smoking. Obesity showed the strongest association with CVD (aOR ≈ 9.4), followed by diabetes mellitus (aOR ≈ 8.4), hypertension (aOR ≈ 7.6), dyslipidemia (aOR ≈ 5.2), and smoking (aOR ≈ 4.0). The final logistic regression model demonstrated good performance, with a Nagelkerke R^2 value of 0.645, indicating that 64.5% of the variation in CVD status could be explained by these five factors, and acceptable model fit on diagnostic testing. In conclusion, obesity and other metabolic and behavioral factors are strongly associated with CVD among mining workers at this site. Targeted occupational health interventions focusing on weight management, early detection and control of metabolic disorders, and comprehensive smoking cessation programs are essential to reduce the burden of CVD in the mining industry.

Keywords: Cardiovascular Disease, Mining Industry, Metabolic Risk Factors, Obesity, Occupational Health.

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of death globally, accounting for more than 17 million deaths each year and over 30% of all-cause mortality (World Health Organization (WHO), 2023). In Indonesia, cardiovascular disease (CVD) continues to pose a substantial public health burden. The 2018 National Basic Health Survey (Riskesdas) reported a hypertension prevalence of 34.1% among adults aged ≥18 years, while the 2023 Indonesian Health Survey (SKI) showed that the prevalence based on blood pressure measurements in the same age group was 30.8%, indicating a persistently high burden despite a slight decline. The 2023 SKI also reported that the prevalence of diabetes mellitus among individuals aged ≥15 years based on a blood glucose examination reached 11.7% (Kemenkes RI, 2018, 2023).

Despite these significant figures, CVD among workers in high-risk occupations, such as mining, remains under-researched, particularly in the Indonesian context.

Mining workers face various occupational hazards that may increase their risk for cardiovascular disorders, including continuous exposure to dust, high noise levels, physical strain, and irregular shift patterns. A longitudinal study conducted among copper-gold miners in Papua, Indonesia, revealed an upward trend in metabolic risk factors, including cholesterol, glucose, blood pressure, and body weight, over a five-year period (Rodriguez-Fernandez et al., 2022). Likewise, a study involving Brazilian mining haul truck operators reported elevated body mass index, blood pressure, and lipid disturbances, with a significant relationship to CVD incidence (Marques et al., 2022). Furthermore, a cross-sectional study among Chinese coal miners demonstrated that long-term dust exposure was significantly associated with arterial stiffness and an increased ten-year ASCVD risk (Huang et al., 2024). Exposure to dust and noise pollution has also been shown to be significantly correlated with cardiovascular health issues in mining environments (Cruz-Ausejo et al., 2024; Milošević et al., 2025; Tabaei et al., 2025).

Emerging research has further highlighted the influence of high-altitude mining environments and occupational stressors on cardiovascular outcomes. In Kyrgyzstan, workers in elevated mining locations were found to be more vulnerable to CVD, particularly those with high body mass index and older age (Vinnikov et al., 2024). In addition, the development of predictive models using artificial intelligence has shown promising results in identifying high-risk individuals based on routine health metrics such as blood pressure, BMI, and lipid profiles (Teshale et al., 2024). Collectively, these studies demonstrate that both environmental exposures and metabolic abnormalities contribute to CVD risk among mining workers. However, most evidence comes from non-Indonesian settings or focuses predominantly on either occupational hazards or general metabolic risk, rather than their combined impact in Indonesian mining populations. (Marques et al., 2022).

At PT Manggala Alam Lestari, a mining company located in Musi Banyuasin, South Sumatra, preliminary health screening data from 2024 revealed dyslipidemia and obesity prevalence rates of 43%, hypertension at 17%, and diabetes mellitus at 10% (Octavia Dewi and Jansen Fernando, 2024). These figures exceed the national average and present a pressing concern for occupational health management. Given the high burden of modifiable CVD risk factors among mining workers, there is a critical need for focused research that not only considers occupational exposures but also quantifies the contribution of metabolic and behavioral factors using routinely collected Medical Check-up (MCU) data.

This study therefore aims to identify and analyze the primary metabolic, behavioral, and occupational risk factors associated with CVD among workers at PT Manggala Alam Lestari, based on MCU data collected from 2022 to 2024. The results of this study are expected to support evidence-based policymaking in occupational health and contribute to reducing the prevalence of cardiovascular diseases among mining workers.

METHODS

This study employed a retrospective case–control design to investigate the risk factors associated with cardiovascular disease (CVD) among workers at PT Manggala Alam Lestari, a mining company located in Musi Banyuasin, South Sumatra, Indonesia. The case-control design was considered appropriate because it allows comparison between workers diagnosed with CVD (cases) and those without the condition (controls), thereby facilitating the identification of variables associated with CVD occurrence. The study utilized secondary data obtained from routine Medical Check-Ups (MCUs) conducted by the company's occupational health unit between 2022 and 2024.

The study population comprised all registered employees of PT Manggala Alam Lestari who underwent MCU during the defined study period. A total of 400 workers were included: 80 with a confirmed CVD diagnosis and 320 without. Cases were defined as employees with a documented clinical diagnosis of CVD in the MCU records based on the International Classification of Diseases, 10th Revision (ICD-10) codes, including coronary heart disease (I20–I25), cerebrovascular disease or stroke (I60–I69), peripheral artery disease (I70–I79), and heart failure (I50). All diagnoses were made and recorded by company physicians or collaborating cardiologists as part of routine occupational health services.

Controls were employees who had no documented CVD diagnosis in their MCU records during the same period. Controls were selected in a 1:4 ratio using frequency matching by age group (≤45 years and >45 years) and gender to minimize confounding. Within each age-gender stratum, controls were randomly selected from the MCU database using simple random sampling.

The study analyzed both independent and dependent variables. The dependent variable was the presence of CVD as defined above. Independent variables included age, sex, body mass index (BMI), hypertension status, diabetes mellitus status, dyslipidemia, smoking behavior, shift-work status, and family history of cardiovascular disease.

Data analysis was conducted using univariate, bivariate, and multivariate statistical approaches. Univariate analysis summarized the distribution and frequency of each variable.

Bivariate analysis used the chi-square test to assess associations between each independent variable and CVD status. Variables with $p<0.25$ in the bivariate analysis, together with age, gender, and shift work as a priori confounders, were entered into a multiple logistic regression model. Multivariate logistic regression was used to estimate adjusted odds ratios (ORs) and 95% confidence intervals (CIs), thereby identifying the most influential risk factors after controlling for potential confounders.

This study complied with ethical standards in human subject research. Ethical approval was granted by the Health Research Ethics Committee of Hang Tuah University, Pekanbaru, Indonesia (approval number 133/KEPK/UHTP/III/2025). All data were anonymized, handled confidentially, and used exclusively for academic research purposes.

RESULT

A total of 400 mining workers at PT. Manggala Alam Lestari participated in this study, comprising 80 individuals diagnosed with cardiovascular disease (CVD) as the case group and 320 individuals without CVD as the control group. Statistical analyses included univariate, bivariate, and multivariate approaches.

Univariate Analysis

Univariate analysis was conducted to describe the baseline characteristics of the study population and the distribution of cardiovascular risk factors by CVD status. The study included 400 mining workers, comprising 80 individuals with cardiovascular disease (CVD) and 320 controls without CVD. The majority of participants were younger than 45 years, representing 70.0% of cases and 68.7% of controls, and almost all were male (93.3% of cases and 94.7% of controls). Shift work was similarly prevalent in both groups, with 78.8% of cases and 80.3% of controls employed on rotating shifts. In contrast, metabolic risk factors were markedly concentrated among CVD cases: approximately two-thirds of cases had hypertension (70.0%), dyslipidemia (68.8%), diabetes mellitus (67.5%), and obesity (67.5%), whereas only about one-fifth or fewer of controls exhibited each of these conditions. A positive family history of CVD was relatively uncommon overall but more frequent among cases than controls (5.0% vs. 1.3%), suggesting a possible contribution of genetic susceptibility in this worker population. Taken together, these patterns indicate that, despite comparable age, sex, and work-shift distributions, CVD cases were disproportionately burdened by metabolic abnormalities and, to a lesser extent, genetic predisposition.

Table 1. Characteristics of respondents (n = 400)

Characteristics of Respondents	Cardiovascular risk factors by CVD status			
	Cases		Control	
	f	%	f	%
Work Shift				
Shift	63	78.8	257	80.3
Non-shift	17	21.2	63	19.7
Smoking Habit				
Smoker	34	42.5	255	79.7
Non-smoker	46	57.5	65	20.3
Hypertension				
Yes	56	70.0	65	20.3
No	24	30.0	255	79.7
Dyslipidemia				
Yes	55	68.8	73	22.8
No	25	31.2	247	77.2
Diabetes Mellitus				
Yes	54	67.5	64	20.0
No	26	32.5	256	80.0
Obesity				
Obese	54	67.5	56	17.5
Non-obese	26	32.5	264	82.5
Age				
≥ 45 years	24	30.0	100	31.3
< 45 years	56	70.0	220	68.7
Gender				
Male	77	93.3	303	94.7
Female	3	6.7	17	5.3
Genetic History				
Yes	4	1.0	4	1.0
No	76	19.0	316	79.0

Bivariate Analysis

Associations between each independent variable and CVD status were examined using Chi-Square tests based on 2×2 contingency tables (CVD case vs. control and exposed vs. non-exposed). Crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated from these contingency tables.

Analyses were performed using 2×2 contingency tables, with the non-exposed category (e.g., non-smoker, no hypertension, no diabetes) as the reference group. Table 3 shows that smoking (OR = 5.308; 95% CI: 3.155–8.930), hypertension (OR = 9.154; 95% CI: 5.280–15.871), dyslipidemia (OR = 7.444; 95% CI: 4.338–12.775), diabetes mellitus (OR = 8.308; 95% CI: 4.831–14.287), obesity (OR = 9.791; 95% CI: 5.651–16.963), and family history of CVD (OR = 4.158; 95% CI: 1.017–17.002) were each significantly associated with higher odds of CVD. In contrast, age (p = 0.829), gender (p = 0.566), and work shift (p = 0.755) were not significantly associated with CVD, which is consistent with the use of age and gender for

frequency matching between cases and controls. Overall, these results indicate that modifiable metabolic and behavioral factors, particularly obesity, diabetes, hypertension, dyslipidemia, and smoking, together with family history of CVD, are more strongly associated with CVD than demographic or occupational characteristics in this worker population, and they were therefore selected as candidate variables for multivariable modeling.

Table 2. Bivariate associations between CVD and cardiovascular risk factors

Characteristics of Respondents	Cardiovascular risk factors by CVD status					
	Cases		Control		p-value	OR
	f	%	f	%		
Work Shift						
Shift	63	78.8	257	80.3	0.755	1,101
Non-shift	17	21.2	63	19.7		(0,603–2,011)
Smoking Habit						
Smoker	34	42.5	255	79.7	0.001	5,308
Non-smoker	46	57.5	65	20.3		(3,155-8,930)
Hypertension						
Yes	56	70.0	65	20.3	0.001	9,154
No	24	30.0	255	79.7		(5,280–15,871)
Dyslipidemia						
Yes	55	68.8	73	22.8	0.001	7,444
No	25	31.2	247	77.2		(4,338-12,775)
Diabetes Mellitus						
Yes	54	67.5	64	20.0	0.001	8,380
No	26	32.5	256	80.0		(4,831–14,287)
Obesity						
Obese	54	67.5	56	17.5	0.001	9,791
Non-obese	26	32.5	264	82.5		(5,651–16,963)
Age						
≥ 45 years	24	30.0	100	31.3	0.829	1,061
< 45 years	56	70.0	220	68.7		(0,622–1,808)
Gender						
Male	77	93.3	303	94.7	0.566	0,566
Female	3	6.7	17	5.3		(0,198–2,430)
Genetic History						
Yes	4	1.0	4	1.0	0.0320	4,158
No	76	19.0	316	79.0		(1,017–17,002)

Multivariate Analysis

To identify the dominant risk factors for CVD among mining workers, a multivariate logistic regression model was constructed using variables that were significant in the bivariate analysis ($p < 0.25$) and a priori confounders. The initial model included smoking, hypertension, dyslipidemia, diabetes, obesity, family history of CVD, age group, gender, and work shift. Variance inflation factors (VIFs) were examined, and all were <5, indicating no problematic multicollinearity among predictors.

In the final model, five variables remained significantly associated with CVD: smoking, hypertension, dyslipidemia, diabetes, and obesity (Table 4). Family history of CVD was

removed from the final model because, after adjustment for metabolic factors, it became statistically non-significant and produced very wide confidence intervals due to the small number of participants with a positive family history. Age, gender, and work shift were also excluded from the final model because they were not significant and did not materially change the estimates of the main predictors.

In the multivariable logistic regression model, smoking, hypertension, dyslipidemia, diabetes, and obesity remained independently associated with CVD after adjustment for other variables (Table 4). The table reports B, SE, adjusted ORs (Exp(B)), 95% CIs, and p-values for each predictor.

Table 3 Reference category for each predictor is the absence of the risk factor (non-smoker, no hypertension, no dyslipidemia, no diabetes, non-obese). Variables entered on step 1: work shift, smoking, hypertension, dyslipidemia, diabetes, obesity, age, gender, and family history of CVD.

Table 3. Logistic Regression Results

Variables	B	SE	Wald	df	p-value	Adjusted OR (Exp(B))	95% CI for Exp(B)
Smoking	1.375	0.390	12.419	1	< 0.001	3.956	1.841–8.501
Hypertension	2.033	0.392	26.884	1	< 0.001	7.636	3.541–16.468
Dyslipidemia	1.646	0.382	18.547	1	< 0.001	5.184	2.451–10.963
Diabetes mellitus	2.133	0.393	29.391	1	< 0.001	8.439	3.903–18.247
Obesity	2.239	0.390	32.915	1	< 0.001	9.388	4.368–20.174
Constant	−5.300	0.517	105.084	1	< 0.001	0.005	–

The Omnibus Test of Model Coefficients indicated that inclusion of the five predictors significantly improved the model's ability to classify CVD status (Chi-Square = 209.511, df = 5, $p < 0.001$). The Hosmer-Lemeshow goodness-of-fit test showed no evidence of poor fit ($p > 0.05$). The Nagelkerke R^2 value of 0.645 suggests that approximately 64.5% of the variance in CVD status is explained by the predictors in the model. The ROC analysis demonstrated good discrimination between cases and controls, with an AUC of 0.86 (95% CI: 0.81–0.91).

Model performance was evaluated using the Omnibus Test of Model Coefficients, the Hosmer-Lemeshow goodness-of-fit test, and Nagelkerke R^2. Discrimination of the final model was assessed by calculating the area under the receiver operating characteristic (ROC) curve (AUC).

Table 4. Omnibus Test of Model Coefficients and Nagelkerke R-Square

Chi-Square	df	p-value	Nagelkerke R Square
209.511	5	< 0.001	0.645

DISCUSSION

This study identified smoking, hypertension, dyslipidaemia, diabetes, and obesity as the dominant risk factors associated with cardiovascular disease (CVD) among mining workers at PT Manggala Alam Lestari. These findings emphasize that, within this high-risk occupational group, CVD burden is driven mainly by modifiable metabolic and behavioral factors rather than by non-modifiable characteristics such as age and sex. Obesity emerged as the most influential factor, with obese workers having nearly a 9.4-fold higher odds of CVD compared with non-obese workers, consistent with evidence that excess adiposity promotes metabolic dysfunction, insulin resistance, and chronic low-grade inflammation, all of which increase cardiovascular risk (Kasim et al., 2023).

Hypertension (OR = 7.636) was also a strong predictor of CVD in this workforce, in line with studies that highlight its role in accelerating atherosclerosis and other cardiovascular complications (Khasanah, 2022; Wang & Lloyd-Jones, 2021). Smoking further amplified CVD risk, which is biologically plausible because tobacco exposure damages endothelial cells, elevates blood pressure, and accelerates plaque formation in the arteries (Higashi, 2023; Jia et al., 2024). These results suggest that, even in physically demanding jobs such as mining, traditional cardiovascular risk factors retain a powerful influence on disease occurrence and may offset any potential benefits of occupational physical activity.

The strong independent associations for diabetes (OR = 8.439) and dyslipidemia (OR = 5.184) are consistent with the broader literature. Mazur et al. reported that dietary strategies targeting glucose and lipid control are central to CVD prevention (Mazur et al., 2024), while Kim et al. showed that longer diabetes duration and elevated cholesterol levels are associated with higher CVD risk (Kim et al., 2024). Azagew et al. found a high prevalence of diabetic dyslipidemia in Ethiopia, particularly among women with low physical activity and uncontrolled blood glucose (Azagew et al., 2024), and Zhang et al. demonstrated that the triglyceride–glucose index is more strongly associated with ischaemic heart disease and mortality in diabetic than in non-diabetic individuals (Zhang et al., 2025). Together with our findings, these studies support the interpretation that clustering of diabetes and lipid abnormalities in this mining population contributes substantially to the observed CVD burden.

Our results are broadly consistent with research in other mining settings. Rodriguez-Fernandez et al. observed unfavorable trends in cholesterol, glucose, blood pressure, and body weight over time among mining workers in Papua, Indonesia (Rodriguez-Fernandez et al., 2022), while Marques et al. reported high levels of body mass index, blood pressure, and lipid disturbances among Brazilian haul-truck operators working

rotational schedules (Marques et al., 2022). Studies in Chinese coal miners and other industrial populations have also linked occupational exposures such as dust and noise to arterial stiffness and increased CVD risk (Huang et al., 2024; Cruz-Ausejo et al., 2024; Milošević et al., 2025; Tabaei et al., 2025). Compared with these studies, the present analysis contributes by quantifying the relative magnitude of several metabolic and behavioral risk factors in a single multivariable model using routine medical check-up data from an Indonesian mining company, with good model fit and discrimination (Nagelkerke $R^2 = 0.645$).

The findings have important implications for workplace health policy. Targeted workplace programs that address obesity, diabetes, hypertension, dyslipidemia, and smoking could substantially reduce CVD prevalence in the mining sector. Interventions promoting regular physical activity, healthy eating, and weight management may help control key drivers such as obesity and hypertension, while smoking-cessation services and routine screenings for blood pressure, lipids, and glucose are essential for early detection and effective management. Health education campaigns that raise awareness of smoking risks, poor nutrition, and sedentary lifestyles are also recommended. These strategies are in line with guidance from the American Heart Association, the Centers for Disease Control and Prevention, and the World Health Organization regarding the effectiveness of workplace health programs for cardiovascular risk reduction (Carnethon et al., 2009; Centers for Disease Control and Prevention, 2022; WHO, 2023). At PT Manggala Alam Lestari, previous community-oriented initiatives focusing on basic life support and metabolic syndrome prevention provide a useful platform on which to integrate more systematic CVD-risk management (Octavia Dewi & Jansen Fernando, 2024).

At a broader level, collaboration between company occupational health units and local health services is needed to ensure continuity of care for workers with chronic cardiometabolic conditions. Shared care pathways could include agreed-upon targets for blood pressure, lipid levels, and glycaemic control, regular follow-up using MCU data, and clear referral mechanisms. Emerging approaches such as artificial-intelligence-based risk prediction tools may further enhance identification of high-risk individuals using routinely collected indicators (Teshale et al., 2024; Kasim et al., 2023). In addition, attention to occupational safety factors such as dust exposure, noise, and work at high altitude remains important, as these have been linked to CVD outcomes in other mining contexts (Huang et al., 2024; Vinnikov et al., 2024; Milošević et al., 2025).

This study also has several limitations. The retrospective case–control design based on cross-sectional MCU data does not allow causal relationships between risk factors and CVD to

be established; the associations observed represent snapshots over the study period rather than temporal sequences. Future research should employ longitudinal designs to explore long-term effects and clarify causal pathways. Furthermore, the study was conducted in a single mining company, which may limit the generalizability of the findings to other mining operations or industries with different workforce characteristics and exposure profiles. Multi-site research across diverse mining settings in Indonesia is needed to confirm and extend these results (Rodriguez-Fernandez et al., 2022; Milošević et al., 2025).

Residual confounding is also possible. Important variables such as detailed dietary intake, leisure-time physical activity, psychosocial stress, sleep patterns, and objective measures of dust and noise exposure were not available in the MCU dataset and therefore could not be incorporated into the analysis. Family history of CVD, although significantly associated with CVD in bivariate analysis, became non-significant in the multivariable model and had very wide confidence intervals, likely reflecting small numbers and potential misclassification. Finally, because odds ratios from a case–control design may overestimate relative risk when outcomes are common, caution is required when comparing these estimates directly with risk ratios from cohort studies.

Despite these limitations, the study enhances understanding of CVD risk patterns among mining workers and demonstrates the value of routinely collected occupational-health data for risk stratification. The strong and independent associations observed for obesity, diabetes, hypertension, dyslipidemia, and smoking highlight clear targets for intervention and provide a robust empirical basis for developing and scaling up workplace health strategies aimed at reducing CVD burden and improving worker health and productivity in the mining industry (Carnethon et al., 2009; Centers for Disease Control and Prevention, 2022; WHO, 2023).

CONCLUSION

This study showed that obesity, diabetes mellitus, hypertension, dyslipidemia, and smoking are strongly associated with cardiovascular disease (CVD) among mining workers, with obesity emerging as the most influential predictor. These findings highlight the urgent need for targeted workplace health interventions that address these modifiable risk factors to help reduce CVD occurrence in this high-risk occupational group.

To improve cardiovascular health in the workplace, several strategies are recommended. Comprehensive health programs that focus on weight management, regular physical activity, and healthy eating should be implemented to reduce obesity and

hypertension. Smoking cessation programs need to be prioritized, with adequate counseling and support to assist workers in quitting. Routine health screenings for early detection and management of hypertension, diabetes, and dyslipidemia, accompanied by health education campaigns on smoking risks, poor nutrition, and the importance of an active lifestyle, are also essential. Collaboration between the company and healthcare providers should be strengthened to ensure appropriate treatment and follow-up for workers with chronic conditions.

If effectively implemented, these interventions have the potential to lower CVD risk, improve overall health, enhance productivity, and reduce long-term healthcare costs. Overall, the findings of this study provide a strong foundation for developing and scaling up workplace health strategies aimed at reducing CVD burden and improving the well-being of mining workers.

REFERENCES

Azagew, A. W., Abate, H. K., Mekonnen, C. K., Mekonnen, H. S., Tezera, Z. B., & Jember, G. (2024). Diabetic dyslipidemia and its predictors among people with diabetes in Ethiopia: systematic review and meta-analysis. *Systematic Reviews*, *13*(1), 1–13. https://doi.org/10.1186/s13643-024-02593-2

Carnethon, M., Whitsel, L. P., Franklin, B. A., Kris-Etherton, P., Milani, R., Pratt, C. A., & Wagner, G. R. (2009). Worksite wellness programs for cardiovascular disease prevention: A policy statement from the american heart association. *Circulation*, *120*(17), 1725–1741. https://doi.org/10.1161/CIRCULATIONAHA.109.192653

Centers for Disease Control and Prevention. (2022). *How to Promote Heart Disease and Stroke Prevention in the Workplace*. *May*.

Cruz-Ausejo, L., Cama-Ttito, N. A., Solano, P. F., Copez-Lonzoy, A., & Vera-Ponce, V. J. (2024). Occupational accidents in mining workers: scoping review of studies published in the last 13 years. *BMJ Open*, *14*(10), e080572. https://doi.org/10.1136/bmjopen-2023-080572

Higashi, Y. (2023). Smoking cessation and vascular endothelial function. *Hypertension Research*, *46*(12), 2670–2678. https://doi.org/10.1038/s41440-023-01455-z

Huang, X., Mu, M., Wang, B., Zhang, H., Liu, Y., Yu, L., Zhou, M., Ma, J., Wang, D., & Chen, W. (2024). Associations of coal mine dust exposure with arterial stiffness and atherosclerotic cardiovascular disease risk in chinese coal miners. *International Archives of Occupational and Environmental Health*, *97*(4), 473–484. https://doi.org/10.1007/s00420-024-02062-2

Jia, X., Zhang, P., Meng, L., Tang, W., & Peng, F. (2024). The association between smoking exposure and endothelial function evaluated using flow-mediated dilation values: a meta-analysis. *BMC Cardiovascular Disorders*, *24*(1), 1–9. https://doi.org/10.1186/s12872-024-03915-x

Kasim, S. S., Ibrahim, N., Malek, S., Ibrahim, K. S., Aziz, M. F., Song, C., Chia, Y. C., Ramli, A. S., Negishi, K., & Mat Nasir, N. (2023). Validation of the general Framingham Risk Score (FRS), SCORE2, revised PCE and WHO CVD risk scores in an Asian population. *The Lancet Regional Health - Western Pacific*, *35*, 1–13. https://doi.org/10.1016/j.lanwpc.2023.100742

Kemenkes RI. (2018). Rencana strategis Kementrian Kesehatan tahun 2015-2019 revisi 1 - th. 2017. In *Kementerian Kesehatan RI*.

Kemenkes RI. (2023). *Survei Kesehatan Indonesia 2023 [Indonesian Health Survey 2023]*.

Khasanah, D. N. (2022). the Risk Factors of Hypertension in Indonesia (Data Study of Indonesian Family Life Survey 5). *Journal of Public Health Research and Community Health Development*, *5*(2), 80. https://doi.org/10.20473/jphrecode.v5i2.27923

Kim, M. K., Lee, K. N., Han, K., & Lee, S. H. (2024). Diabetes Duration, Cholesterol Levels, and Risk of Cardiovascular Diseases in Individuals With Type 2 Diabetes. *Journal of Clinical Endocrinology and Metabolism*, *109*(12), e2317–e2323. https://doi.org/10.1210/clinem/dgae092

Marques, R. A. M., Camargo, P. P., Souza, G. G. L., Gouvea, G. D. R., Fajardo, V. C., Neto, R. M. D. N., Silva, A. L., & de Oliveira, F. L. P. (2022). Cardiovascular Risk Factors in Haul Truck Operators of the Mining Sector Working a Rotational Schedule. *International Journal of Cardiovascular Sciences*, *35*(3), 400–409. https://doi.org/10.36660/ijcs.20210111

Mazur, M., Przytuła, A., Szymańska, M., & Popiołek-Kalisz, J. (2024). Dietary strategies for cardiovascular disease risk factors prevention. *Current Problems in Cardiology*, *49*(9). https://doi.org/10.1016/j.cpcardiol.2024.102746

Milošević, I., Stojanović, A., Nikolić, Đ., Mihajlović, I., Brkić, A., Perišić, M., & Spasojević-Brkić, V. (2025). Occupational health and safety performance in a changing mining environment: Identification of critical factors. *Safety Science*, *184*, 106745. https://doi.org/10.1016/j.ssci.2024.106745

Octavia dewi; Jansen fernando. (2024). Improving Employee Preparedness in the Face of Sudden Death: Basic Life Support Training and Metabolic Syndrome Prevention at PT Manggala Alam Lestari. *Jurnal Pengabdian Kesehatan Komunitas*, *04*(3), 20–31. https://doi.org/https://doi.org/10.25311/jpkk.Vol4.Iss3.2123

Rodriguez-Fernandez, R., Rahajeng, E., Viliani, F., Kushadiwijaya, H., Amiya, R. M., & Bangs, M. J. (2022). Non-communicable disease risk factor patterns among Mining industry workers in Papua, Indonesia: Longitudinal findings from the Cardiovascular Outcomes in a Papuan Population and Estimation of Risk (COPPER) Study. *Occupational and Environmental Medicine*, *72*(10), 728–735. https://doi.org/10.1136/oemed-2014-102664

Tabaei, S., Ghalenoo, S. R., Panahandeh, M., Bagheri, G., & Tabaee, S. S. (2025). The relationship between noise pollution and cardiovascular diseases : an umbrella review on meta-analyses. *BMC Cardiovascular Disorders*, *25*(1), 1–15. /https://doi.org/10.1186/s12872-025-04864-9

Teshale, A. B., Htun, H. L., Vered, M., Owen, A. J., Ryan, J., Tonkin, A., & Freak-Poli, R. (2024). Artificial intelligence improves risk prediction in cardiovascular disease. *GeroScience*. https://doi.org/10.1007/s11357-024-01438-z

Vinnikov, D., Saktapov, A., Romanova, Z., Ualiyeva, A., & Krasotski, V. (2024). Work at high altitude and non-fatal cardiovascular disease associated with unfitness to work: Prospective cohort observation. *PLOS ONE*, *19*(7), e0306046. https://doi.org/10.1371/journal.pone.0306046

Wang, M. C., & Lloyd-Jones, D. M. (2021). Cardiovascular Risk Assessment in Hypertensive Patients. *American Journal of Hypertension*, *34*(6), 569–577. https://doi.org/10.1093/ajh/hpab021

World Health Organization (WHO). (2023). *World Heart Report 2023*.

Zhang, J., Zhan, Q., Deng, Z., Lin, L., Feng, Z., He, H., Zhang, D., Zhao, H., Gu, X., Yin, X., Yu, P., & Liu, X. (2025). Does diabetes modify the triglyceride–glucose index associated with cardiovascular events and mortality? A meta-analysis of 50 cohorts involving 7,239,790 participants. *Cardiovascular Diabetology*, *24*(1). https://doi.org/10.1186/s12933-025-02585-z