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THE RELATIONSHIP BETWEEN AIR POLLUTION AND CORONARY ARTERY DISEASE: A SYSTEMATIC REVIEW

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ABSTRAK

Beberapa studi penelitian sebelumnya menunjukkan bahwa polusi udara memiliki dampak yang luas bagi kesehatan tubuh manusia, salah satunya pada bidang kardiovaskular. Paparan polusi udara yang masuk ke dalam saluran pernapasan dapat memicu terjadinya respon inflamasi dan meningkatkan risiko terjadinya penyakit kardiovaskular seperti *coronary artery disease*. *Systematic review* ini bertujuan untuk mengetahui hubungan polusi udara dengan kejadian *Coronary Artery Disease* (CAD). Penulusuran jurnal dilakukan pada lima *database* elektronik yaitu Pubmed, Science Direct, Europe PMC, Wiley Online Library, dam Cochrane dengan mengikuti metode *Preferred Reporting Items for Systematic Review and Meta-Analyses* (PRISMA). Hasil pencarian mendapatkan enam artikel orisinil yang memenuhi kriteria inklusi dan eksklusi untuk dianalisis. Bedasarkan hasil analisis menunjukkan bahwa adanya hubungan yang signifikan antara polusi udara baik berupa komponen gas atau *particulate matter* dengan kejadian *coronary artery disease.* Tingginya kadar polusi udara pada suatu daerah juga dapat meningkatkan risiko terjadinya CAD lebih tinggi dibandingkan daerah dengan tingkat polusi udara yang lebih rendah.

ABSTRACT

The Relationship Between Air Pollution And Coronary Artery Disease: A Systematic Review. Several previous research studies have shown that air pollution has broad impacts on human health, particularly in the cardiovascular field. Exposure to air pollution entering the respiratory system can trigger inflammatory responses and increase the risk of cardiovascular diseases such as coronary artery disease. This systematic review aim to determine the relationship between air pollution and the occurrence of Coronary Artery Disease (CAD). Journal searches were conducted on five electronic databases, namely Pubmed, Science Direct, Europe PMC, Wiley Online Library, and Cochrane, following the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) method. The search results get six original articles that meet the inclusion and exclusion criteria for analysis. Based on the results of the analysis shows that there is a significant relationship between air pollution in the form of gas components or particulate matter with the incidence of coronary artery disease. High levels of air pollution in an area can also increase the risk of CAD higher than areas with lower levels of air pollution.

INTRODUCTION

Air pollution is a mixture of gas components and Particulate Matter (PM). Gas components include nitrogen dioxide (NO_2), nitric oxide (NO), sulfur dioxide (SO_2), ozone (O_3), and carbon monoxide (CO). Meanwhile, PM has varying compositions depending on its source. PM components consist of carbon particles with absorbed organic chemicals and reactive metals. Common components of PM include nitrate, sulfate, polycyclic aromatic hydrocarbons, endotoxins, and metals such as iron, copper, nickel, zinc, and vanadium.[1] PM can be classified into coarse particles (diameter < 10 μm, ≥ 2.5 μm), fine particles (diameter < 2.5 μm, ≥ 0.1 μm), and ultrafine particles (nano particles, diameter < 0.1 μm). Fine particles with a diameter < 2.5 μm ($PM_{2.5}$) are considered the most dangerous components. $PM_{2.5}$ originates from both combustion and non-combustion sources, including industrial emissions, re-suspended dust from soil, fires, agricultural and biomass burning, as well as coal combustion.[2]

Exposure to air pollution has become a global health issue over the past few decades. According to the Global Burden of Disease 2019, approximately 6.7 million deaths occur annually due to air pollution.[3] Exposure to air pollution is also a significant risk factor for morbidity and mortality in cardiovascular diseases. Literature suggests that 60-80% of cardiovascular disease deaths are linked to air pollution.[4] Cardiovascular diseases are the leading cause of global mortality, accounting for 18.6 million deaths in 2019.[5]

The relationship between air pollution and cardiovascular diseases has been the subject of research interest in the last two decades. Several studies also suggest that there is a relationship between air pollution exposure and the incidence of coronary artery disease and myocardial infarction.[5] An epidemiological study report that a 10 $\mu g/m^3$ increase in long-term $PM_{2.5}$ exposure raises cardiovascular mortality risk by 11%.[4] Air pollution entering the respiratory system can cause oxidative stress and trigger inflammatory responses, leading to atherosclerosis and increasing the risk of cardiovascular diseases such as Coronary Artery Disease (CAD).[2,6] According to data from the Basic Health Research (Riskesdas) in 2018, there has been an increase in the incidence of heart and vascular diseases annually. Approximately 15 out of every 1,000 individuals, or around 2,784,064 people in Indonesia, have been diagnosed with heart disease.[7] Therefore, the aim of this scientific study is to discuss the relationship between air pollution and the occurrence of Coronary Artery Disease (CAD).

METHOD

This systematic review uses secondary data obtained from relevant scientific journals. The method used in the scientific study is Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA). Journal searches were conducted in electronic databases including PubMed, Science Direct, Europe PMC, Wiley Online Library, and Cochrane. The search utilized keywords such as "air pollution", "particulate matter", "coronary artery disease", and "myocardial infarction", adhering to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Journal published in the last 5 years (2018-2023)
- Journal in the form of quantitative studies
- The journal are fully accessible without payment

Exclusion Criteria

- Journals are original studies, such as review articles, editorials, commentary, correspondence, letters to the editor, and similar types.

Figure 1. shows the PRISMA flow diagram as a procedure for selecting original articles that will be analyzed in this systematic review.

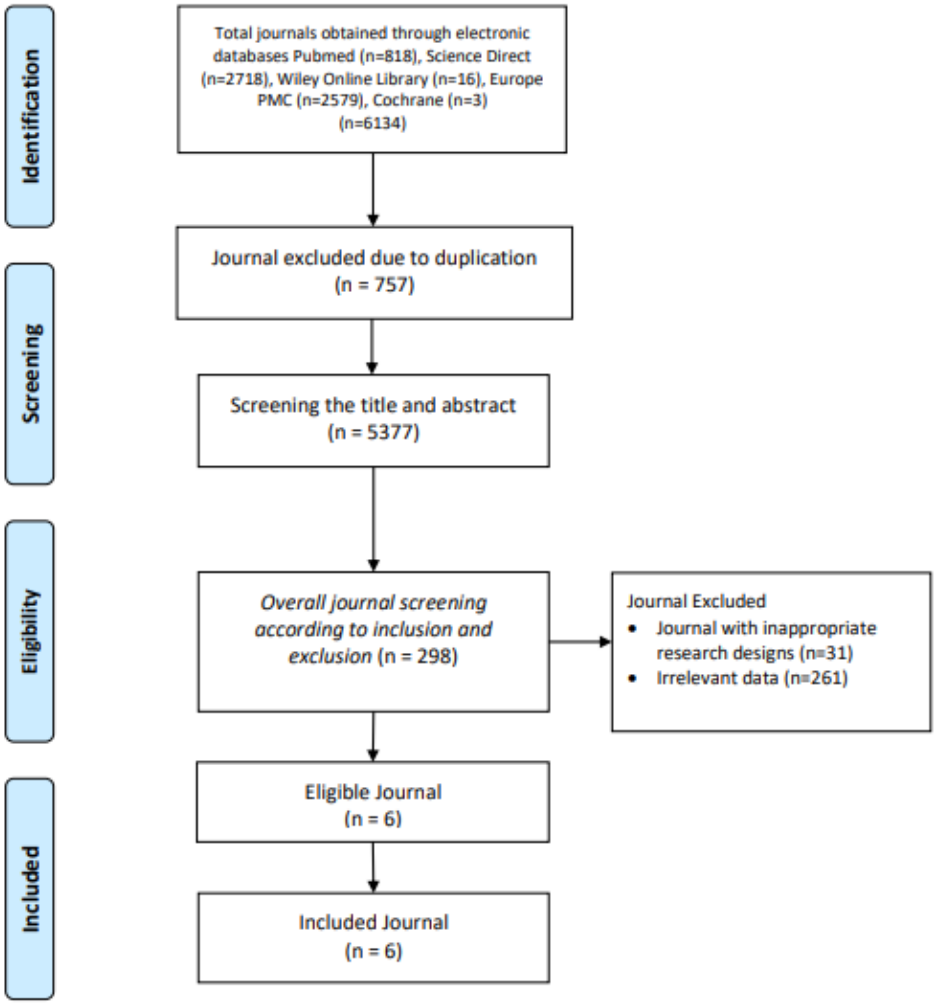

Figure SEQ Figure * ARABIC 1. Flow diagram

RESULT

The results of systematic data searches through various electronic databases obtained 6,134 related literature (Pubmed= 181, Science direct= 2,718, Wiley online library= 16, Europe PMC= 2,579, Cochrane= 3) using predetermined keywords. Based on the screening process, 757 duplicate journals were found. In addition, there were 292 journals that were excluded because they were not original studies, inappropriate research designs, and irrelevant research data. The final results of the search found six journals that met the inclusion and exclusion criteria for analysis in this systematic study. The six selected journals were original articles and used research study designs in

the form of retrospective cohort, case-control and observational retrospective studies. Four of the six selected journals used a retrospective cohort study design.

In Table 1, the results of various studies show significant relationship between exposure to air pollution, both in the form of gas components and PM, and the risk of Coronary Artery Disease (CAD) or Acute Coronary Syndrome (ACS). Research conducted by Li Jinyue, Liang F, Liu F et al. (2022) showed 26% increase in CAD risk with 10 μg/m^3 increase in $PM_{2.5}$ exposure (HR = 1.26, 95% CI: 1.18–1.33).[8] Furthermore, the study noted that individuals with high genetic risk factors had a higher risk of CAD compared to other groups. Two studies conducted in Poland by Kuźma Ł et al. (2021) demonstrated that other gas components such as NO_2, SO_2, or CO could also increase the risk of CAD or ACS.[12] These studies also revealed that industrial areas have higher concentrations of air pollution compared to non-industrial areas.

Table 1. Analysis Results

Researcher, Study Design, Study Location	Title	Number of samples	Result
Li Jinyue, Liang F,Liu F et al[8], Cohort Retrospective Study, China. 2022	Genetic risk modifies the effect of long-term fine particulate matter exposure on coronary artery disease	41.149 samples	● There is a significant association between long-term exposure to $PM_{2.5}$ and an increased risk of CAD. The risk of CAD increases by 26% with every 10 μg/m³ increase in $PM_{2.5}$ exposure (HR = 1.26, 95% CI: 1.18–1.33). ● Samples in the high genetic risk group with the highest $PM_{2.5}$ exposure have the greatest risk of developing CAD (95% CI: 3.13-6.11).
Posadas-Sánchez R, Vargas-Alarcón G, Cardenas A et al[6], Case-control Study, Mexico. 2022	Long-term exposure to ozone and fine particulate matter and risk of premature coronary artery disease: results from genetics of atherosclerotic disease Mexican study	1.615 samples (869 control and 746 patient with premature Coronary Artery Disease (pCAD))	● There is a significant association between the increased risk of pCAD and $PM_{2.5}$ exposure after 5 years of study (OR=2.75; 95%CI: 1.47-5.16). ● There is a significant association between the increased risk of pCAD and ozone exposure in the 1st year of study (OR = 1.10; 95% CI: 1.03–1.18); 2nd year (OR = 1.17; 95% CI: 1.05–1.30); 3rd year (OR = 1.18; 95% CI: 1.05–1.33); and 5th year (OR = 1.13; 95% CI: 1.04–1.23).
Slawsky E, Ward-Caviness C, Neas L et al[9], Cohort Retrospective Study, North Carolina. 2021	Evaluation of $PM_{2.5}$ air pollution sources and cardiovascular health	5.681samples	● There is an association between $PM_{2.5}$ fractions from ammonium bisulfate and ammonium nitrate and an increased prevalence of CAD (OR= 1.20; 95% CI: 1.11, 1.22 and OR=1.18; 95% CI: 1.05, 1.32). ● There is an association between $PM_{2.5}$ fractions from ammonium bisulfate and ammonium nitrate and an increased prevalence of MI (OR= 1.20; 95% CI:

			1.10, 1.29 and OR=1.35; 95% CI: 1.20, 1.53).
Kuźma Ł, Pogorzelski S, Struniawski K et al[10], Cohort Retrospective Study, Poland. 2020	Exposure to air pollution- a trigger for myocardial infraction? A nine-year study in Bialystok- the capital of the Green Lung Poland (BIA-ACS registry)	2.645samples	● There is a significant association between the increase in the number of patients treated for ACS and the increase in NO_2 concentration (OR=1.08, 95% CI: 1.02-1.15, p=0.01). ● No association was found between the concentrations of $PM_{2.5}$, PM_{10}, and SO_2 and the number of patients treated for ACS.
Gestro M, Condemi V, Bardi L et al[11], Observational Retrospective Study, Italy. 2020	Short-term air pollution exposure is a risk factor for acute coronary syndromes in an urban area with low annual pollution rates: Results from a retrospective observational study (2011—2015)	391.689 samples	● There is a significant association between $PM_{2.5}$ exposure and the risk of ACS at all ages, particularly in elderly patients (>75 years) (p<0.01).
Kuźma Ł, Wańha W, Kralisz P et al[12], Cohort Retrospective Study Poland. 2021	Impact of short-term air pollution exposure on acute coronary syndrome in two cohorts of industrial and non-industrial areas: A time series regression with 6,000,000 person-years of follow-up (ACS - Air Pollution Study)	9.046 samples	● The concentrations of $PM_{2.5}$, PM_{10}, SO_2, NO_2, and CO are higher in industrial areas compared to non-industrial areas. ● An increase of 10μg/m³ in NO_2 concentration is associated with an increase in NSTEMI cases (6.2% in industrial areas and 12.6% in non-industrial areas). ● An increase of 10μg/m³ in SO_2 concentration is associated with an increase in STEMI cases in industrial areas (OR = 1.094, 95% CI = 1.030–1.162; P = 0.002). In non-industrial areas, no association was found between air pollution and STEMI cases.

In this systematic review study, the selected journals were also assessed for quality and risk of bias according to the Cochrane Handbook for Systematic Reviews of Interventions (Figure 2). The assessment results indicated an average study quality of 50%, with low bias risk observed in studies by Posadas et al. (2022), Slawsky et al. (2021), and Kuźma Ł et al. (2021). Li Jinyue et al. (2022) and Gestro et al. (2020) showed a 30% bias risk, while a high bias risk of 20% was noted in the study by Kuźma Ł et al. (2020).

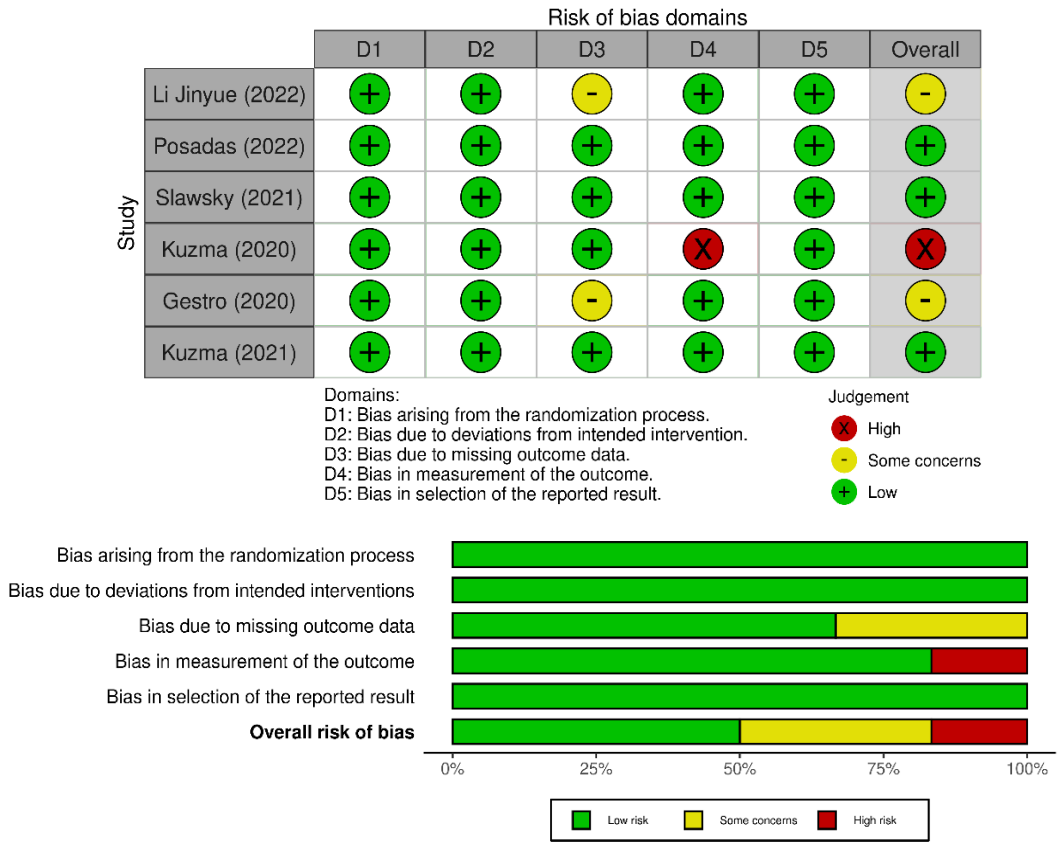

Figure SEQ Gambar * ARABIC 2. Risk of Bias Result

DISCUSSION

The results from the analysis of six selected journals have strengthened the evidence that there is a significant association between air pollution exposure and the incidence of coronary artery disease. This is also same with the multicenter study "Effects of Low-Level Air Pollution: A Study in Europe (ELAPSE)" on a cohort study from six European countries. The results of that study showed a significant association between $PM_{2.5}$ exposure and the incidence of stroke and coronary artery disease.[13]

In the studies conducted by Li Jinyue et al.(2022), Posadas-Sánchez R et al.(2022), and Gestro M et al.(2020), it was mentioned that exposure to air pollution in the form of $PM_{2.5}$ can increase the risk of coronary artery disease or acute coronary syndrome. Inhalation of air pollution can trigger oxidative stress reactions and inflammatory responses in the body. This occurs because gas components or PM entering the respiratory tract activate macrophage cells, dendritic cells, pro-inflammatory cytokines (IL-6 and TNF-α), and other oxidative stress

mediator cells, resulting in local and systemic inflammation. [2,14] Pollutant particles that reach the bloodstream can cause endothelial dysfunction and increase the risk of atherosclerosis. Additionally, exposure to air pollution can alter the composition of blood in the body, thereby increasing the risk of cardiovascular disease. Exposure to PM is known to trigger platelet aggregation and increase fibrinogen levels in the blood, which are key factors in the blood clotting process and major determinants of blood viscosity. Platelet aggregation can subsequently promote thrombosis formation and increase the risk of coronary artery disease. [14–20]

High levels of air pollution in a region can increase the risk of CAD more than in areas with lower levels of air pollution. In a study conducted by Kuźma Ł et al.(2021) [12] the impact of short-term air pollution exposure on ACS in industrial and non-industrial areas was examined. The study showed that an increase of 10 μg/m³ in NO_2 concentration was associated with a 6.2% increase in NSTEMI cases in industrial areas and a 12.6% increase in non-industrial areas. Additionally, the study explained that an increase of 10 μg/m³ in SO_2 concentration was associated with an increase in STEMI cases in industrial areas, while no association was found between increased air pollution and STEMI cases in non-industrial areas. This is also in line with another study conducted in Bialystok, the largest city in northeastern Poland with low air pollution levels. The study by Kuźma Ł et al.(2020)[10] in Bialystok showed no association between the concentrations of $PM_{2.5}$, PM_{10}, and SO_2 and the number of patients treated for ACS.

The limitation of this study is that some of the reviewed research did not explain the risk factors related to the medical history of the samples, which could lead to the risk of bias in the conducted research.

CONCLUSION

The findings from this systematic review conclude that there is a significant association between exposure to air pollution in the form of gas components or Particulate Matter (PM) and the incidence of Coronary Artery Disease (CAD). Areas with high levels of air pollution can further increase the risk of developing CAD or other cardiovascular diseases.

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