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Effects of Air Pollution on the Immune Response of Residents Around Benda Sub-District, Tangerang

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Abstract – **Air pollution around Benda Sub-district, Tangerang has become a critical environmental issue due to the high intensity of traffic transportation and industrial activities that contribute to the emission of harmful gases. Prolonged exposure to air pollutants poses significant health risks, including adverse effects on the human immune system, particularly for communities residing. This study aims to examine the immune response—specifically leukocyte differentials (neutrophils, eosinophils, monocytes, basophils, lymphocytes) and C-Reactive Protein in individuals aged 25–35 years living in densely populated settlements. A cross-sectional approach was employed involving 24 volunteer participants, accompanied by air quality measurements at the sampling location, including TSP, SO_2, NO_2, Pb, CO, Ox, NMHC, PM_{10}, and $PM_{2.5}$. The results highlighted the high MCV levels in all participants could causing the basic inflammatory response in the body. Furthermore, this study revealed that air pollution exposure indirectly affects the immune system**.

Abstrak – **Pencemaran udara di sekitar Kecamatan Benda, Tangerang, telah menjadi permasalahan lingkungan yang serius akibat tingginya intensitas transportasi lalu lintas dan aktivitas industri yang berkontribusi terhadap emisi berbagai gas berbahaya. Paparan polutan udara dalam jangka panjang dapat menimbulkan risiko kesehatan yang signifikan, termasuk gangguan pada sistem imun manusia, terutama bagi masyarakat yang tinggal di kawasan tersebut. Penelitian ini bertujuan untuk mengkaji respons imun, khususnya diferensial leukosit (neutrofil, eosinofil, monosit, basofil, dan limfosit) serta kadar C-Reactive Protein (CRP), pada individu berusia 25–35 tahun yang tinggal di permukiman padat penduduk. Penelitian menggunakan pendekatan potong lintang (*cross-sectional*) dengan melibatkan 24 partisipan sukarela. Selain itu, dilakukan pengukuran kualitas udara di lokasi pengambilan sampel yang meliputi Total Suspended Particulate (TSP), SO_2, NO_2, Pb, CO, Ox, NMHC, PM_{10}, dan $PM_{2.5}$. Hasil penelitian menunjukkan bahwa seluruh partisipan memiliki nilai Mean Corpuscular Volume (MCV) yang tinggi, yang berpotensi memicu respons inflamasi dasar dalam tubuh. Lebih lanjut, penelitian ini mengungkapkan bahwa paparan pencemaran udara secara tidak langsung memengaruhi sistem imun manusia**.

Keywords *- Air Pollution, Air Quality, Community Residents, Immune Response*

INTRODUCTION

Environmental pollution has become a global issue that threatens public health. Various sources of pollution, such as industrial activities, transportation, and human-related activities, release hazardous substances that degrade air quality. In Asian countries, air pollution has been known to cause serious health problems, particularly respiratory diseases such as acute respiratory infections (ARI) [1]. Air pollution is also associated with disorders of the circulatory system, including cardiovascular diseases [2], and is one of the contributing factors to health complications and mortality [3]. According to the World Health Organization (WHO), air pollution causes 7 million deaths annually. The most affected diseases include chronic obstructive pulmonary disease (COPD), lung

cancer, respiratory tract infections such as pneumonia, stroke, and heart disease. Approximately nine out of ten people worldwide are exposed to contaminated air containing harmful compounds that can penetrate deep into the lungs and spread to the cardiovascular system [4].

Benda Sub-district is strategically located in Tangerang City, which is known for its economic growth exceeding the average of other cities and regencies in Banten Province. This economic development leads to increasing population density [5]. The area is contributed to air pollution through traffic, vehicular emissions, and industrial activities [6,7]. Studies have shown that air pollution sources at Airport around Benda Sub-district include aircraft emissions such as nitrogen oxides (NOx) and fine particulate matter ($PM_{2.5}$ and PM_{10}) [8,9]. Moreover, energy consumption and the use of fossil fuels in airport operations significantly contribute to increased carbon emissions, including CO, SO_2, Ox, and Pb [10–12]. Industrial activities around area also play a role, such as plastic waste burning by a local factory that was stopped by the Air Pollution Control Task Force of the Ministry of Environment and Forestry (KLHK) in 2023 [13]. These activities can increase levels of Total Suspended Particulates (TSP) [14] and Non- Methane Hydrocarbons (NMHC) [15], worsening the environmental condition around.

The immune system plays a crucial role in protecting the human body from pathogens and harmful substances. Exposure to pollutants can induce Reactive Oxygen Species (ROS) and increase pro-inflammatory cytokines, triggering additional inflammatory responses [16]. A study conducted in Beijing, China, involving men aged 22–45 years, revealed that air pollution exposure significantly increased neutrophil, lymphocyte, and monocyte counts, while decreasing eosinophil and basophil counts [17]. In vitro studies have also confirmed that air pollutants affect leukocyte differentiation and C-Reactive Protein (CRP) levels [18,19]. Allergic reactions may be exacerbated by immune responses to pollution [20], worsening asthma symptoms [21], and increasing morbidity and mortality associated with various health conditions, including allergies [22].

METHODS

This study aims to investigate the impact of air pollution on immune responses, specifically the immune system of residents living in Benda Subdistrict, Tangerang. A quantitative approach using a cross-sectional design will be employed. This study will be conducted through several detailed steps:

Research Preparation

Determination of the study site, targeting the densely residential areas in Benda Sub-District, Tangerang. Then, conducting the preparation of required tools and materials.

The ethical clearance was obtained from Research Ethics Commission of Universitas Islam Negeri Syarif Hidayatullah Jakarta with the number of Un.01/F.10/KP.01.1/KE.SP/07.08.024/2025 on July 30, 2025.

Air Pollution Data Collection

The Air quality measurements will be conducted at a location of Benda Sub-district using air monitoring instruments. PM_{10}, $PM_{2.5}$, TSP, and Pb will be measured using the gravimetric method; SO_2, NO_2, CO, and Ox will be measured using electrochemical sensors; and NMHC will be analyzed using gas chromatography.

Immune Response Data Collection

Blood samples and survey interviews will be collected from residents living in densely populated area, specifically in RT 03 RW 02, Belendung Village, Benda Sub-district, Tangerang City, Tangerang City. Volunteers will be those who have consented to participate in the study. Blood samples will be collected from 24 participants (12 males and 12 females), selected through purposive sampling (criteria: age 25–35 years, non-smokers, and no history of specific diseases).

Immune responses will be assessed by analyzing immune biomarkers in blood samples, including leukocyte differentiation counts (neutrophils, eosinophils, monocytes, basophils, and lymphocytes), C-Reactive Protein (CRP), hematology (total leukocytes, hemoglobin, erythrocytes, hematocrit, and platelets), and Mean Corpuscular (MC) values (Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC); and Erythrocyte Sedimentation Rate (ESR). Laboratory analyses will involve complete blood count examinations, focusing on leukocyte differentiation and CRP levels. Health data and pollution exposure history will be collected through interviews, including the length of residence in the area, daily outdoor exposure duration, history of respiratory symptoms, activity patterns, and dietary habits.

Data Analysis

Analysis of immune response data in relation to air pollution exposure. The collected data will be statistically analyzed using SPSS or R software. Correlation tests will be performed to identify associations between air pollution exposure and immune response indicators.

RESULTS AND DISCUSSION

The results of this study indicate that air pollution originating from emissions has a measurable impact on the immune system of residents living in areas with high traffic density. Environmental monitoring data showed that the concentrations of several air pollutants, including Total Suspended Particulates (TSP), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), carbon monoxide (CO), oxidants (Ox), Non-Methane Hydrocarbons (NMHC), PM_{10}, and $PM_{2.5}$, were present at varying levels. Although all air quality parameters observed are within normal range, the data from Air Quality Index (AQI) from nearest station (Tangerang Benteng Betawi, Tanah Tinggi AQI Station) showed otherwise. PM_{10} on the first and second day of observation were exceeding the threshold. This pollutant is recognized as significant contributor to oxidative stress and inflammatory responses in the human body.

The basophils, eosinophils, rod neutrophils, and CRP are within normal limits. This indicating that air pollution did not triggering the significant inflammatory or allergic response. However, this could initiate a mild immune response as a result of chronic pollutants exposure.

This study revealed that several participants were experienced in above normal erythrocytes and leukocytes levels. This indicated that pollutant exposure in long terms could affects the hematology components. PM2.5 or PM10 exposure were resulting in oxidative stresses. This finding suggests that chronic exposure to fine particulate matter can trigger systemic inflammation, which may compromise immune regulation and increase susceptibility to disease.

The study highlighting the MCV level that below normal in all participants. Long-term exposure to the pollutants is correlated with anemia, therefore reducing the MCV level. This condition also could reduce the erythrocyte size (microcytosis), resulting in suboptimal oxygen transport activity in blood. This indicates that prolonged exposure to these pollutants may suppress immune defense mechanisms, reducing the body's capacity to respond effectively to pathogens.

Furthermore, all participants were experienced a higher ESR levels. Although this indicates a non-specific inflammation, this is still correlated with biological response to the environmental pollutants. The increased in ESR are in line with leukocytes level increase as an inflammatory process that resulting in oxidative stress. PM2.5, SO2, NO2 may contributing in leukocytes increase. However, the combined effect of multiple pollutants creates a synergistic burden on the immune system, increasing the risk of long-term health complications.

Overall, in the observed study, air pollution did not directly affect the immune systems among residents within the aged 25 to 35. Nevertheless, human naturally has a basic immune response that could activated the inflammation and oxidative stress. This reflected in reduced MCV levels among respondents. Continuously inflammatory stimulation caused by pollutant exposure may contribute to immune imbalance, promoting abnormal immune activation. The observed immunological alterations support existing evidence regarding the effects of environmental pollution to immune response.

Based on study findings, these results are highlighting the urgent need for improving air quality management in high-traffic residential areas. Reducing vehicle emissions through environmental regulations, intensive greening program around the area, and increasing public awareness regarding pollution exposure prevention are recommended to mitigate adverse health outcomes.

CONCLUSION

Long-term of air pollution (TSP, SO_2, NO_2, Pb, CO, Ox, NMHC, PM_{10}, and $PM_{2.5}$) in the densely populated settlements are potentially increased the risks of reduced hematology components, particularly are anemia. These findings highlighted the observed lower MCV levels in all respondents, causing the basic inflammatory response in the body. Therefore, the air pollution exposure indirectly affects the immune system. The findings are expected to provide recommendation for policymakers and stakeholders to develop effective strategies for mitigating air pollution impacts and improving public health in densely populated areas.

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