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THE CORRELATION BETWEEN BLOOD LEAD (PB) LEVELS AND TOTAL LEUKOCYTE COUNT AMONG SILVER MAN INDIVIDUALS

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ABSTRACT

Lead (Pb) exposure remains an environmental health problem that affects groups with direct exposure, including silver man individuals who coat their bodies with paint. Lead is still found in various paint products due to its use as a pigment and additive, making it a potential major source of environmental lead exposure. Lead is known to affect the immune system through inflammatory mechanisms and oxidative stress, which may result in alterations in total leukocyte count. This study aimed to determine the association between blood lead (Pb) levels and total leukocyte count among silver man individuals. This study employed an analytic observational design with a cross-sectional approach involving 18 silver man individuals who were recruited using an accidental sampling technique among individuals who met the inclusion criteria. Blood Pb levels were measured using Atomic Absorption Spectrophotometry (AAS), while total leukocyte counts were analyzed using a hematology analyzer. The relationship between blood Pb levels and total leukocyte count was assessed using Pearsons correlation test. The results showed that all subjects had elevated blood Pb levels. Statistical analysis indicated no significant association between blood Pb levels and total leukocyte count, with a p-value of 0.420 (p 0.05) and a correlation coefficient (r) of 0.202, indicating a positive but very weak correlation. There was no significant association between blood lead (Pb) levels and total leukocyte count among silver man individuals. These findings highlight the importance of vigilance regarding lead exposure and the need for regular health monitoring among at-risk populations.

Keywords: blood lead levels; leukocytes; silver man

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INTRODUCTION

Lead (Pb) exposure remains a major global public health concern, particularly in developing countries, including Indonesia. Lead is a toxic heavy metal that remains in various paint products, especially decorative and construction paints, where lead compounds are used as pigments, drying agents, and color stabilisers. The presence of lead in paint contributes to environmental exposure through dust, paint deterioration and peeling, and direct contact, thereby increasing health risks to humans (Mologo et al., 2025). Lead has no physiological function in the human body and may cause permanent damage to the hematopoietic system. According to the World Health Organization (WHO, 2021), paint is classified as hazardous if it contains more than 90 parts per million (ppm) of lead. This threshold has been established as an international safety standard because exposure exceeding this level may result in various toxic effects, including neurological disorders, decreased intelligence quotient (IQ), anemia, and kidney damage, particularly among children. The continued use of lead-containing paint remains a significant environmental health issue due to its widespread impact on child development and public health. To minimize these risks, the WHO recommends that all countries implement regulations limiting lead content in paint to below 90 ppm as a health-protective standard (Rosidah & Hadipranoto, 2023).

Lead exposure from paint continues to pose a serious problem in Indonesia. A study by Ismawati et al. (2024) demonstrated that the majority of decorative paints circulating in the market still contain lead concentrations far exceeding the WHO safety threshold. Research conducted by Nexus3–IPEN in 2021 reported that 77% of 120 paint samples contained lead levels above 90 ppm, with 39% exceeding 10,000 ppm. These findings underscore the persistent use of hazardous substances in the paint industry and highlight the potential for long-term health risks among workers and the general population (Ismawati et al., 2024).

One population at particularly high risk of metal paint exposure is manusia silver workers. Manusia silver refers to informal street workers who coat their entire bodies with silver-colored spray paint—often containing lead—without the use of personal protective equipment. This occupation is largely driven by socioeconomic factors, including limited employment opportunities and environmental pressures, placing these workers at high risk of chronic lead exposure through both dermal absorption and inhalation (Novita, 2022).

Chronic lead exposure is known to affect both the hematopoietic and immune systems. One of the principal components of the immune system is leukocytes (white blood cells), which play a crucial role in host defense against foreign substances, infectious agents, and tissue injury through cellular and humoral immune mechanisms. Leukocytes are broadly classified into granulocytes and agranulocytes. Granulocytes include neutrophils, eosinophils, and basophils, which are primarily involved in phagocytosis and inflammatory responses. Agranulocytes consist of lymphocytes and monocytes, which function in specific immunity, clearance of cellular debris, and the formation of immunological memory (Aristoteles & Nanik, 2023).

Total leukocyte count is a commonly used hematological parameter to assess physiological and pathological conditions. Alterations in circulating leukocyte levels may reflect inflammatory responses, infection, or immune system dysfunction. Moreover, leukocytes are highly sensitive to changes in the internal environment, and fluctuations in their numbers may serve as early indicators of biological disturbances resulting from hazardous substance exposure (Bavia et al., 2024). Therefore, total leukocyte count was selected as the primary parameter in this study due to its sensitivity, accessibility through routine hematological examination, and its capacity to reflect early immune responses to heavy metal exposure, including lead.

Previous studies have examined lead exposure among informal workers, including manusia silver. Azzahra et al. (2025) investigated the association between blood lead levels and the occurrence of basophilic stippling. However, the impact of lead exposure on other hematological parameters—particularly those related to immune responses—has not been a primary focus of prior research. Consequently, this study was conducted to analyze the relationship between blood lead levels and total leukocyte count.

Lead exposure among manusia silver workers may occur through the application of metallic paint directly to the skin surface, which can subsequently be absorbed into the bloodstream and affect various physiological systems. Absorbed lead has been shown to interact with cellular blood components, induce oxidative stress, and alter hematological parameters, including immune cells (Rosidah & Hadipranoto, 2023). In line with this, contemporary toxicological studies report that elevated blood lead levels are associated with changes in hematological biomarkers, immune system dysfunction, and impairment of other organ systems (Gonzalez-Villalva et al., 2025; He et al., 2024).

This study aims to analyze the relationship between blood lead (Pb) levels and total leukocyte count among manusia silver workers. Lead exposure in this population occurs primarily through direct contact with metallic paint used in daily occupational activities. The novelty of this research lies in its focus on informal sector workers—who are frequently overlooked in environmental toxicology studies—and in the use of a simple hematological parameter, total leukocyte count, as an early biomarker of lead toxicity in the human body. The findings of this study are expected to provide scientific evidence regarding the potential effects of lead exposure on changes in white blood cell counts and to serve as a preliminary basis for developing occupational safety policies and preventive strategies aimed at reducing heavy metal exposure in the informal sector.

METHOD

This study employed an analytic observational design with a cross-sectional approach. Total leukocyte counts were measured using a Hematology Analyzer at the Clinical Pathology Laboratory of the D4 Medical Laboratory Technology Program, Universitas Muhammadiyah Purwokerto. Blood lead (Pb) levels were analyzed using Atomic Absorption Spectrophotometry (AAS) at the Pharmaceutical Biology Laboratory, Universitas Muhammadiyah Purwokerto, as previously described by Azzahra et al. (2025).

The study population comprised all manusia silver workers in Purwokerto City and Purbalingga Regency, Indonesia. A total of 18 respondents were recruited using an accidental sampling technique. Data collection began with the withdrawal of 3 mL of venous blood using a sterile needle. The blood samples were placed into EDTA tubes and stored in a cool box during transportation to maintain sample stability (Chang et al., 2025).

Blood lead (Pb) concentrations were determined using the Atomic Absorption Spectrophotometry (AAS) method. Standard solutions were prepared at concentrations of 10, 5, 4, 3, 2, 1, 0.5, 0.1, 0.05, and 0.01 ppm to construct a calibration curve for Pb determination prior to sample analysis. A 1 mL blood sample was transferred into an Erlenmeyer flask, followed by the addition of concentrated HNO_3 and HCl in a 1:5 ratio. The mixture was homogenized and heated gradually to boiling until fumes appeared. The solution was then diluted with distilled water as required and filtered using Whatman filter paper into a 50 mL volumetric flask. The prepared sample solution was analyzed using AAS at a wavelength of 283.3 nm, and the results were expressed in ppm (Azzahra et al., 2025).

Subsequently, total leukocyte counts were examined in vitro using a Hematology Analyzer (Aminuddin & Soda, 2025). Data were first assessed for normality using the Shapiro–Wilk test to determine distribution characteristics. Pearson's correlation test was then performed to evaluate the relationship between blood lead (Pb) levels and total leukocyte count. This study received ethical approval from the Health Research Ethics Committee of Universitas Muhammadiyah Purwokerto (Registration Number: KEPK/UMP/70/II/2025).

RESULT

Table 1.
Descriptive statistics of blood lead levels (ppm), total leukocyte count, and duration of employment

Variables	Mean	Median	Min	Max	SD
Blood lead (Pb) level (ppm)	0,49	0,44	0,29	0,99	0,18
Total leukocyte count (cells/µL)	9.635	9.500	5.220	18.010	3.199
Duration of employment (years)	2	1	1	5	1.372

Table 1 shows that the mean blood lead (Pb) level among *manusia silver* workers was 0.49 ± 0.18 ppm, with the lowest level recorded at 0.29 ppm and the highest at 0.99 ppm. These findings indicate that all respondents had blood lead levels exceeding the exposure threshold established by the Ministry of Health of the Republic of Indonesia, as stipulated in Ministerial Decree No. 1406/MENKES/SK/IX/2002, which sets the permissible range at 0.10–0.25 ppm.

The mean total leukocyte count was 9,635 cells/µL, which remains within the normal reference range according to Regulation of the Minister of Health of the Republic of Indonesia No. HK.01.07/MENKES/1600/2022, establishing a leukocyte reference value of 3,600–10,600 cells/mm³. However, several respondents demonstrated leukocyte counts exceeding the upper normal limit. Duration of employment was included as a descriptive characteristic of the respondents.

Table 2.
Correlation between Blood Lead (Pb) Levels and Total Leukocyte Count

Variabele	Correlation (r)	Significance (p)	N
Lead (Pb) WBC	0,202	0,420	18

Table 2 demonstrates that there was no statistically significant correlation between blood lead (Pb) levels and total leukocyte count, with a significance value of $p = 0.420$ ($p > 0.05$). The Pearson correlation coefficient ($r = 0.202$) indicates a very weak positive correlation between blood lead levels and leukocyte count; however, this relationship was not statistically significant.

DISCUSSION

Based on the findings presented in Table 1, all manusia silver respondents in this study had blood lead (Pb) levels exceeding the risk exposure threshold, indicating that they had experienced lead exposure with potential biological consequences. The mean blood lead level was 0.49 ± 0.18 ppm, with a minimum value of 0.29 ppm and a maximum of 0.99 ppm. All measured values surpassed the permissible blood lead threshold established by the Ministry of Health of the Republic of Indonesia under Decree No. 1406/MENKES/SK/IX/2002, which sets the acceptable range at 0.10–0.25 ppm. These findings suggest chronic lead exposure related to occupational activities conducted in roadside environments and corroborate previous research by Azzahra et al. (2025), which reported elevated blood lead levels and hematological alterations among manusia silver workers, indicating the potential for lead accumulation in the body.

The mean total leukocyte count among respondents was 9,635 cells/µL, which remains within the normal reference range established by Regulation of the Minister of Health of the Republic of Indonesia No. HK.01.07/MENKES/1600/2022 (3,600–10,600 cells/mm³). However, several respondents exhibited leukocyte counts exceeding the upper reference limit. These results indicate that although all respondents had blood lead levels above the risk threshold, the impact on total leukocyte count was not consistently observed. Duration of employment, presented as a respondent characteristic, was further considered to describe potential long-term exposure contributing to lead accumulation.

As shown in Table 2, despite elevated blood lead levels in all subjects, the association between blood lead concentration and total leukocyte count was not statistically significant ($r = 0.202$; $p = 0.420$). A p-value greater than 0.05 indicates the absence of a significant relationship, suggesting that increased blood lead levels were not consistently accompanied by an increase in leukocyte count. The low correlation coefficient further indicates a weak association. These findings suggest that, within this population of manusia silver workers, lead exposure had not produced a consistent effect on total leukocyte count. This may be influenced by respondent characteristics, particularly the relatively short duration of employment (1–5 years) among most participants.

The primary sources of lead (Pb) exposure include air pollution from motor vehicle emissions in high-traffic areas, the use of lead-based paints in buildings and children's toys, and environmental contamination from industrial activities (Hardiansyah, 2025). Lead from vehicle emissions and ambient air may be directly inhaled, whereas lead-containing paint can deteriorate into fine dust particles that are easily inhaled or ingested, thereby increasing the risk of bodily accumulation.

Lead may enter the body through dermal contact during occupational exposure and subsequently circulate in the bloodstream, where approximately 95% binds to erythrocytes. Toxicologically, lead is classified as an immunomodulatory toxicant rather than an acute cytotoxic agent. Consequently, it does not directly induce marked increases or decreases in leukocyte counts. Under conditions of relatively limited intensity and duration of exposure, the resulting effects tend to be subclinical. Mild to moderate lead exposure does not typically provoke systemic inflammation or substantial bone marrow damage sufficient to disrupt the balance between leukocyte production and destruction. Therefore, total leukocyte counts may remain within normal ranges despite the occurrence of lead exposure (Hong et al., 2025; Huang et al., 2022; Meng et al., 2021).

In the body, lead exists primarily as Pb^{2+} ions and is known to interfere with hematopoiesis in the bone marrow. Suljević et al. (2021) reported that exposure to lead chloride ($PbCl_2$) resulted in lead accumulation within bone marrow cells, particularly macrophages and heterophils, characterized by phagocytic granule formation. This exposure reduced hematopoietic blast cells and impaired differentiation and maturation processes, including lymphoblast development. Lead-induced oxidative stress and mitochondrial damage in hematopoietic stem cells (HSCs) may reduce proliferative capacity and blood cell formation, potentially leading to decreased leukocyte production in cases of substantial exposure.

Leukocytes are relatively stable hematological parameters and typically increase only in response to systemic inflammation, active infection, or extensive tissue injury. In the context of lead exposure, effects are often subclinical and not necessarily accompanied by quantitative changes in leukocyte count. Leukopoiesis—the process of white blood cell formation and maturation—occurs primarily in the red bone marrow through differentiation of hematopoietic stem cells into various leukocyte lineages (Villella et al., 2025).

The hematopoietic system possesses tightly regulated homeostatic mechanisms that maintain equilibrium between blood cell production and destruction under normal physiological conditions. Hematopoietic stem cells remain largely quiescent in the absence of pathological stimuli. According to Carpenter and Maryanovich (2024), during steady-state hematopoiesis, leukocyte production remains stable and adjusts only to meet basal physiological needs. Quantitative increases in leukocyte production typically occur in response to strong biological signals, such as acute inflammation or infection, mediated by elevated pro-inflammatory cytokines. Conversely, chronic toxicant exposure associated with low-grade inflammation may not generate sufficient cytokine signaling to shift the hematopoietic system from its steady-state condition, thereby maintaining total leukocyte counts within normal limits (Carpenter & Maryanovich, 2024; Huang et al., 2022; Meng et al., 2021).

Lead is a non-infectious chemical toxicant that does not directly elicit an acute immune response. Chronic exposure more commonly induces low-grade oxidative stress and metabolic alterations without necessarily activating systemic inflammatory pathways that stimulate leukopoiesis. Huang et al. (2022) reported that chronic lead exposure more frequently affects leukocyte function and subpopulation distribution rather than total leukocyte count. This suggests that the hematopoietic system may still preserve quantitative balance in white blood cell production.

Compensatory hematological mechanisms enable the body to balance leukocyte production and destruction as long as the bone marrow remains structurally and functionally intact. In cases of non-acute chronic exposure, adaptive mechanisms may preserve hematological homeostasis, particularly in individuals with relatively short exposure durations (Hong et al., 2025; Meng et al., 2021). Thus, although biological exposure to lead occurs, significant quantitative alterations in total leukocyte count may not yet be apparent.

Long-term lead exposure may result in progressive accumulation within the body and increase the risk of chronic toxicity. Mariadi et al. (2023) reported that absorbed lead gradually distributes to various tissues, with substantial storage in hard tissues such as bones and teeth, and accumulation in soft tissues including the liver, kidneys, spleen, and brain. Because storage occurs gradually and increases with prolonged exposure, blood lead levels at a single time point may not fully reflect total body burden. Consequently, chronic toxic effects may emerge over extended periods.

Elsir and Alrasheed (2018) observed that health effects of lead exposure were more pronounced among workers with exposure durations exceeding 10 years compared to those with shorter exposure periods. In short-term exposure, lead may remain temporarily in blood and soft tissues and may still be eliminated through excretory pathways such as urine, feces, and sweat before substantial deposition in hard tissues occurs (Mariadi et al., 2023). Therefore, biological effects—particularly on hematological parameters such as leukocyte count—may not manifest during relatively brief exposure periods.

In this study, respondent characteristics also included smoking habits, with all participants reporting cigarette consumption ranging from 4 to 36 cigarettes per day. Similar to chronic low-dose lead exposure, smoking may induce mild inflammatory responses without necessarily causing leukocytosis. Barus (2025) reported that smoking exposure is not consistently associated with changes in total leukocyte count in the absence of acute systemic inflammation. The finding that all respondents maintained leukocyte counts within normal ranges despite lead exposure and smoking suggests that the combined exposures may not yet have reached a threshold sufficient to disrupt hematopoietic balance. This likely contributes to the absence of a statistically significant association between blood lead levels and total leukocyte count.

This study has several limitations. The relatively small sample size may limit statistical power and generalizability. Additionally, some blood samples experienced clotting, potentially affecting sample quality and hematological measurement accuracy. The study assessed only total leukocyte count as an immune parameter, thereby limiting the ability to evaluate specific immune responses or leukocyte subpopulations. Furthermore, the relatively short observed duration of lead exposure precludes comprehensive assessment of long-term cumulative effects.

CONCLUSION

Based on the findings of this study, lead (Pb) exposure among manusia silver workers with an exposure duration of 1–5 years has not demonstrated a significant alteration in immune system status as reflected by total leukocyte count. These results suggest that, within this duration of exposure, the immunological effects of lead may not yet be clearly detectable through routine hematological examination using total leukocyte parameters. Nevertheless, the interpretation of these findings should be approached with caution, as they remain influenced by the limitations in the study scope and methodological approach.

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