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THE EFFECTS OF LEAD (Pb) EXPOSURE TO BLOOD Pb CONCENTRATION AND HEMOGLOBIN LEVELS IN BOOK SELLERS AND STREET VENDORS OF SURAKARTA

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Abstract

Anemia is still a public health problem in the world and in Indonesia. WHO (2008) reported more than 75% of anemia in Asia is iron deficiency and 63.5% anemia in Indonesia is caused by lack of nutrition. Previous studies described that lead (Plumbum / Pb) can decrease hemoglobin levels. Sriwedari markets' book sellers and Solo Wholesale Center's street vendors are susceptible populations exposed to Pb as a result of motor vehicle exhaust. Approximately 70% of Pb in vehicle exhausts emissions are emitted into the air. This study aimed to analyze the effects of Pb exposure on blood Pb concentration and hemoglobin levels. This study was a quantitative observational analytic study with cross sectional design conducted in 2015-2016 at Sriwedari Market. Samples were 97 respondents obtained through random sampling and Spearman correlation was used for data analysis. Result showed that there were association between Pb exposure in the air and blood Pb levels (p=0,000; r=0,606) and blood Pb levels and hemoglobin levels (p=0,000; r=-0,623)

Introduction

The use of motorized vehicles is a major requirement for the present community. Use of motor vehicles in Indonesia is increasing from year to year and leads to the high amount of gasoline consumption (Nurbaya and Wijayanti, 2010). The use of petrol means increasing levels of Lead/Plumbum (Pb) as a result of motor vehicle exhaust emission in the air which also increasing air pollution, with no exception in human health (Nawrot, 2006).

Pb is a metal that is extremely harmful to human health. Pb can accumulate in the body and cause acute and chronic intoxication (Ray, 2015). Acute intoxication causes hemolytic anemia, whereas chronic intoxication of Pb can cause hypochromic microcytic or normocytic anemia (Malekirad, 2013; Guzel, 2012). Exposure of low dose Pb could still causes interference on the body without showing clinical symptoms (Nawrot, 2006). Besides being very dangerous for its poisonous effect to the environment, Pb also has an impact on the decrease of hemoglobin (Hb) in the blood. The high intensity of motor vehicles usage in Indonesia may increase the levels of Pb in the air and increase the risk for anemia due to Pb (Laila, 2013).

Pb enters the human body through a variety of ways, such as through breathing

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(inhalation), gastrointestinal, and even by dermal contact. However, an important route for human Pb exposure is through the respiratory tract or inhalation (Suksmerri, 2008). Pb that entered the body will not stay in the body completely, only approximately 5%-10% of the amount ingested would be absorbed by the gastrointestinal tract, and approximately 5% only of the 30% that is absorbed through breathing will stay in the body. Pb left in the body will clump, especially in the skeleton (90-95%). To determine a person's Pb intoxication, analysis of Pb content in the blood was performed (Liu, 2015).

Book sellers of Sriwedari markets and street vendors of Solo Wholesale Center are informal sector workers or vulnerable populations to Pb exposure as a result of motor vehicle exhaust. For 8 hours per day and more than 5 years, these people are exposed to vehicles' Pb passing in the workplace. At initial observation, they often complain about dizziness and weakness, and initial examination mostly revealed below normal hemoglobin levels. This study aimed to analyze the effects of Pb exposure on blood Pb concentration and hemoglobin levels of Sriwedari Market's book sellers and Solo Wholesale Center's street vendors.

Methods

This study was a quantitative observational analytic study with cross sectional design. The population in this study is Sriwedari Market back gate booksellers and Solo Wholesale Center street vendors. Samples of 96 respondents who met the inclusion criteria were obtained through random sampling. Pb levels in the air and in the blood of respondents were measured using Atomic Absorption Spectrophotometry (AAS). Analysis of air Pb and Pb levels in the blood were carried out at the laboratory of Mathematics and Science, UNS, whereas hemoglobin levels test was conducted by photoelectric colorimeter instrument at Solo laboratory. Spearman correlation statistical test was used to analyze the primary data.

Results and Discussion

Based on the results of ambient air measurements for ± 1 hour in the market area, we obtained the results of Pb concentration in the air, Pb concentration in the blood, and hemoglobin levels as shown in Table 1.

The results showed that the average concentration of Pb in the air was 0,041 μg/Nm^3 with the lowest concentration of 0.018 μg/Nm^3 in the book market and 0.074 μg/Nm^3 is the highest levels on street vendors. According to the Government Regulation Number 41 year 1999 regarding Air Pollution Control mentioned that quality standard of Pb in ambient air is 2 μg/Nm^3, thus the measurement results of Pb concentration derived from vehicles, both on the book market and street vendors were still safe because it was below the quality standard value. Nonetheless, airborne Pb surveillance should be continued as the use of motorized vehicle keep increasing that Pb in the air may increase in the future. According to OSHA (2004), when Pb in the work environment air reached 40 μg/m3 and workers were exposed for 30 days or more, health surveillance became compulsory.

Table 1 showed the average concentration of Pb in the blood of respondents is 26.16 μg/dL, which was in the normal range of ≤ 40 μg/dL. However, the highest Pb blood concentration found was 57.30 μg/dL, which already exceeded normal limits, and a total of 12 respondents (12.5%) had a Pb content of more than 40 μg/dL, 3 of which (3.1%) had Pb concentration

Table 1. Variable Tendency of Pb Concentration in Air and Blood, and Hemoglobin Levels

Variable	Unit	Mean	Std. Deviation	Min	Max	Range	Normal Value
Pb in air	μg/Nm^3	0.041	0.028	0.018	0.074	0.056	-
Pb in blood	μg/dL	26.16	11.69	0	57.30	57.30	≤ 40
Hemoglobin levels	g/dL	13.00	2 , 17	8.70	17.70	9.00	-
a. Men		15.11	1.00	12.90	17.70	4.80	≥ 13
b. Women		12.09	1.89	8.70	17.00	8.30	≥ 12

above 50 μg/dL.

Based on the category of Pb contamination in the blood of adults, those concentration fall under acceptable category since it was still in the range of 40-80 μg/dL. This category showed that the absorption is increased due to Pb pollution at abnormal levels, but still considered safe (Liu, 2015). Pb blood concentration of > 50 μg/dL may interfere with hemoglobin production. Therefore, the respondent with Pb concentration of 57.30 μg/dL will require continued monitoring to prevent exposure and more accumulation of Pb in the body that can interfere with the formation of hemoglobin. Based on the results of the measurement, respondents with Pb concentration above 50 μg/dL required monitoring.

The average hemoglobin levels based on measurements using the photoelectric colorimeters was 13.00 g/dL (Table 3). The average hemoglobin levels of men were 15.11 g/dL, higher than women (12.09 g/dL). This was consistent with the theory that hemoglobin levels were higher in male than female. When analyzed based on the normal value, the average hemoglobin levels in men and women were both still in the normal level. However, the mean hemoglobin levels in women were almost at lower limit of the normal range.

Table 2 showed the results of the Kruskal-Wallis test to compare the levels of hemoglobin by Pb concentration category in the blood. There was a significant difference (p 0.003) where the mean hemoglobin levels for respondents with normal Pb levels were higher than the respondent with higher average Pb concentration.

According to the OSHA 1910.1025 standard of Pb in appendix C, if exposure to Pb was low, e.g. below 40 μg/dL (blood), monitoring needed to be carried out every 6 months. If Pb in the blood of workers reached more than 40 μg/dL, it must be monitored every two months until the level decreased below 40 μg/dL. If the blood Pb concentration reach 60 μg/dL or more, OSHA required the worker to be transferred or rested with monthly surveillance and might only be working again after Pb blood concentration falls below 40 μg/dL.

The results of statistical tests to examine the relationship of exposure to Pb in the air with Pb concentration in the blood and hemoglobin levels were shown in Table 1.

Before the relationship test between variables, we tested the data normality using the Kolmogorov-Smirnov and found that the data were not normally distributed because the p value was <0.05, so we used Spearman correlation test as the statistical test method. Based on table 2, statistical analysis showed the same *p* value in both test which was 0.000 ($p \leq 0.05$). It means that exposure to Pb in the air has a significant association with Pb concentration in the blood and hemoglobin levels. The correlation coefficient (r) is 0.606 which indicates exposure to Pb in the air had a strong relationship with Pb concentration in the blood. A positive r value means the higher the exposure to Pb in the air, the higher the blood Pb concentration, and vice versa. These

Table 2. Hemoglobin Levels by Pb Blood Concentration Category

Pb blood concentration	n (%)	Mean (SD)Hemoglobin	*p* value
≤ 40 μg/dL	84 (87.5)	13.24 (2.15)	0.003*
40 μg/dL	12 (12.5)	11:31 (1.50)	
Total	96 (100)	13.00(2.17)	

*) *p* value obtained through the Kruskal-Wallis test

Table 3. Relationship of Pb Exposure in the Air, Pb Concentration in Blood, and Hemoglobin Levels

No.	Variable	Significance (p)	Correlation Coefficient (r)
1.	Pb in the air with Pb in blood	<0.001	0.606
2.	Pb in the air with Hemoglobin levels	<0.001	-0.623

results were consistent with study by Mardani, (2005) on Traffic Service and Road Transport Officer of Surakarta that Pb concentration in ambient air had a positive correlation with Pb concentrantion in blood. In addition, according to a study by Muliyadi, (2015) there was a correlation between Pb concentration in air with Pb concentration in blood of car painting workers with $\beta = 0.667$ and $p < 0.001$.

In the next variable, the correlation coefficient was 0.623 and it indicated that exposure to Pb in the air have a strong relationship with hemoglobin levels. However, a negative r indicate opposite correlation between the two variables which means the higher exposure to Pb in the air, the lower the hemoglobin levels, and vice versa.

This study showed that respondents who have higher concentration of Pb in blood, have a lower hemoglobin levels. Previous studies also suggest a link between Pb with hemoglobin levels in workers exposed to Pb (Qasim & Baloch 2014; Sadeghi, 2014; Malekirad, 2013). A study by Richard, (2006) showed that exposure to Pb could inhibit heme biosynthesis via coproporphyrinogen enzyme, δ -ALAD and ferrochelatase inhibition. Inhibition of these enzymes caused a decrease in hemoglobin levels in the blood (Ray, 2015). Preventive measures should be taken for workers exposed to Pb in order to avoid hazards caused by Pb intoxication. Primary prevention can be done by avoiding Pb exposure or keeping Pb concentration in air below the threshold value (Flora, 2012; Koh, 2015). In addition, environmental monitoring to measure Pb concentration in the environment and biomonitoring to measure the levels of Pb in the body were important for workers at risk of exposure to Pb (Flora, 2012).

Conclusion

Exposure to Pb in air had a significant correlation with Pb concentration in blood and hemoglobin levels. The higher the concentration of Pb in air, the higher the Pb concentration in blood, and the lesser the hemoglobin levels. Book seller of Sriwedari market was a vulnerable population, and therefore needed appropriate regulation. Regulatory steps could include administration control (adjust the length of working outside the work space that allowed exposure to Pb), use of personal protective equipment (wearing mask to protect from Pb exposure), and getting used to conduct a safe and healthy habit (getting used to the implementation of working hours arrangement in the working place and implemented a disciplined use of masks as well as adequate consumption of nutritious foods and water). The safety and health of informal workers were the responsibility of both the workers themselves and the agency in charge of occupational health in the informal sector such as community health centers. Therefore, the community health center should also be involved in health education of informal sector workers.

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