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Analysis of Lead Levels in the Urine of Active and Passive Smokers: Implications for Health Risks

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ABSTRACT An active smoker is someone who smokes cigarettes, resulting in an impact on their health, as well as on passive smokers and the surrounding environment. Smoking exposes individuals to the risk of lead inhalation due to cigarette smoke. Accumulated lead from smoked cigarettes can pose a health risk. This study aimed to identify respondent characteristics and analyze lead levels in both active and passive smokers. The research employed a descriptive approach with quantitative analysis. The sample consisted of urine samples from 20 active and passive smokers in the vicinity of Wadung Asri, selected using purposive sampling. The study was conducted at the Toxicology Laboratory, TLM Department of the Health Polytechnic in Surabaya, and at BARISTAND from October 2022 to May 2023. Based on the characteristics of active and passive smokers, regarding age, those aged 21-44 accounted for 25% of active smokers and 30% of passive smokers, those aged 45-59 constituted 10% in both categories, and those aged 60-74 constituted 15% of active smokers and 10% of passive smokers. The study results revealed that lead levels in the urine of active smokers ranged from a high of 0.1592 µg/mL to a low of 0.0885 µg/mL. Conversely, in passive smokers, lead levels in the urine ranged from a high of 0.0885 µg/mL to a low of 0.000032 µg/mL. Thus, the conclusion drawn from this study is that one respondent exhibited lead levels exceeding the normal threshold of <0.15 µg/mL.

INDEX TERMS Urine, Active Smokers, Passive Smokers, Lead (Pb) Levels, AAS (Atomic Absorption Spectrophotometer)

I. INTRODUCTION

The lack of public awareness regarding the dangers of smoking has made smoke-free areas difficult to establish, This is evident from the fact that ≤ 70% of smokers in Indonesia start smoking before the age of 19. Smoking is a major factor that causes various detrimental effects in numerous aspects [1]. According to the World Health Organization, areas exposed to cigarette smoke pose health risks to both active smokers and passive smokers, The connection between smokers and various diseases is exemplified by lung cancer [2][3]

Smoking is an activity that occurs outside an environment that can influence individuals towards external and internal factors. Internal factors can have an impact and may involve both biological and psychological aspects, one of which is stress relief [4]. On the other hand, external factors are harmful to the body, especially among adolescent smokers. Influences from smoking peers and being in an environment with smokers play a significant role [5][6]

The dangers of smoking in the body's immune system include causing constriction in brain blood vessels due to the presence of nicotine and a decrease in oxygen levels in the body, including the brain and other organs [7]

Cigarettes can harm active smokers as well as those exposed (secondhand smoke), commonly known as passive smokers [8]. The components of tobacco make it difficult for smokers to quit due to the addictive substance nicotine and psychological factors, where smokers feel a loss of certain activities when attempting to quit [2][9]

Cigarettes, known as "rokok" in Indonesian, are cylindrical in shape and made of paper material, measuring around 70-120 mm in length with a diameter of 10 mm. They consist of processed tobacco leaves [10]. Cigarettes are easily accessible as they are freely sold in markets. The cigarette packaging bears the warning, "Smoking can kill you." The term "rokok" originates from the French word "cigare" or cigar, while the term "cerutu" comes from Spanish [11][12]

Lead (Pb), also known as Plumbum, is a heavy metal with bluish-gray color that is found in small amounts in rocks, soil, and plants [13]. Human activities have significantly increased the presence of lead, up to 300 times more than natural levels [14]. Lead (Pb) is categorized as a hazardous pollutant [15][16]

The initial entry of lead (Pb) into the human body is through the respiratory system at around 40%, followed by ingestion through the digestive system at a percentage of approximately 5-10%. Lead is partially stored in soft tissues and bones, with excretion occurring through the kidneys and the digestive system. This exposure is especially concerning for children and adults with poor hygiene practices. Lead (Pb) can be inhaled and absorbed through the lungs and the digestive system [17][18][19]

The impacts caused by lead can also disrupt health, including interfering with blood formation, causing disruptions in the excretory system, leading to health disturbances in the central nervous system, as well as experiencing health issues in the reproductive system [15].

In this study, urine samples were used, which are the metabolic waste products excreted by the kidneys and processed within the body through the process of urination. The kidneys filter these waste products through the ureters, and the remaining waste is expelled from the body through the urethra [20][21][22]

Based on a survey conducted in the vicinity of Wadung Asri, Sidoarjo, there are approximately five families with smokers, including both active and passive smokers. Both active and passive smokers are at risk of lead exposure due to passive smoking. According to [23], passive smokers can experience even greater negative consequences from exposure to cigarette smoke, leading to increased health issues due to higher exposure and environmental factors.

In this study, the wet digestion method was utilized to break down organic metal compound into inorganic metal in the samples, which later could be processed and analyzed. Nitric acid (HNO3) solvent was used for this purpose, which has the ability to accelerate the decomposition process and acts as a strong oxidizing agent, serving as a reagent used for wet digestion. The outcome obtained from the wet digestion process was a clear solution, indicating that the destruction results could dissolve completely [24][25]

Infodatin data from the Indonesian Ministry of Health states that the presence of filters at the end of cigarettes results in 75% of the harm caused to passive smokers due to direct exposure to cigarette smoke. In contrast, active smokers take on a 25% risk. Passive smokers are exposed to heavy metal compounds in cigarette smoke, such as nickel, arsenic, chromium, and lead [26].

According to the Central Statistics Agency, the percentage of smokers aged ≥ 15 years in East Java has increased over the past three years: 27.93% in 2019, 27.78% in 2020, and 28.53% in 2021. The World Health Organization reports that tobacco smoking causes the deaths of more than 5 million people each year, with a majority of the impact falling on males, particularly in Asia [27].

A study by [23] titled "Comparison of Lead (Pb) Concentrations in the Urine of Active and Passive Smokers at Gasoline Stations in Lubuk Buaya, Padang" showed that the final results indicated lead concentrations (Pb) in urine samples from active smokers, with the lowest value being 0.113 mg/L. The study found that lead concentrations (Pb) were higher in passive smokers compared to active smokers. Some of the consequences identified in the study included complaints of dizziness. The characteristics of urine include a pH of around 5-7, and in normal urine, the volume excreted daily should be around 1,200 - 1,500 mL.

Another study by [28] titled "Relationship Between Work Duration and Lead (Pb) Exposure in the Urine of Printing Operators at PT Manando Persada Madani" indicated that around 53.85% (7 individuals) met the criteria while 46.15% (6 individuals) did not meet the normal urine limit set by Workplace Exposure Standards and Biological Exposure Indices, which is < 0.15 mg/L for lead in urine.

In a research article conducted by [29] titled "Relationship Between the Level of Lead (Pb) Metal Toxicity and Blood Smear Characteristics in Active Smokers," the study also examined lead levels in the urine of active smokers. The highest recorded concentration was 0.384 mg/dl, while the lowest was 0.002 mg/dl. These levels were considered to be above the normal limit for lead in urine.

Therefore, the substantial number of active smokers and passive smokers may be exposed to heavy metal lead (Pb) contamination from cigarette smoke. Based on the aforementioned background, it is necessary to conduct a study on the Description of Lead Levels in the urine of active and passive smokers in the Surroundings of Wadung Asri. The objective of this study is to identify respondent characteristics and analyze lead levels in the urine of active and passive smokers in the Surroundings of Wadung Asri.

II. METHODHOLOGY

This research is of a descriptive nature with quantitative analysis using the Atomic Absorption Spectrophotometer (AAS) method, aimed at determining the lead (Pb) levels in the urine of active and passive smokers in the surroundings of Wadung Asri. The sample collection location was the vicinity of Wadung Asri, and the sample preparation was conducted at the Toxicology Laboratory of the Medical Laboratory Technology Department, Health Polytechnic Surabaya. The examination of lead levels using the AAS method was carried out at the Standardization and Industrial Services Center in Surabaya. The study was conducted from October 2022 to May 2023. The population of this study consisted of active and passive smokers in the vicinity of Wadung Asri.

The research sample included 10 active smokers and 10 passive smokers, selected through purposive sampling. The inclusion criteria for the samples were that they were active smokers for a minimum of 3 years, passive smokers exposed for a minimum of 3 years, aged ≥ 20 years, willing to participate, and willing to provide a consent letter.

The equipment used in this study included the Atomic Absorption Spectrophotometer, measuring flasks, urine containers, hotplates, and other laboratory tools.

The materials and reagents required for this research were a minimum of 50 mL urine, Nitric Acid (HNO_3) solution, distilled water, deionized water, and a standard lead (Pb) solution with a concentration of 100 mg/L. The research procedure involved collecting a minimum of 50 mL urine samples in the morning. The urine samples were then examined and prepared using the wet digestion method with Nitric Acid (HNO_3) solution. The solution was heated on a hotplate until it turned clear. After cooling down, the sample was transferred into a 50 mL measuring flask. Once the sample was clear, it was tested using the Atomic Absorption Spectrophotometer with a wavelength of 217 nm.

A. PREPARATION OF STANDARD LEAD SOLUTION 1000 µg/L

The preparation of the lead solution involves pipetting the lead stock solution containing approximately 50 ppb (mg/L) into a provided 20 mL plastic container. Subsequently, this container is placed on the sample rack of the instrument labeled as R1.

B. SAMPLE EXAMINATION USING THE WET DIGESTION METHOD

Pipette 5 mL of urine sample into an Erlenmeyer flask and then pipette 20 mL of distilled water (aqua dest) into the same flask. Next, perform wet digestion using nitric acid (HNO_3) solution by heating the mixture on a hotplate until a clear solution is obtained. Allow it to cool, then transfer the sample into a 50 mL measuring flask using a funnel and filter paper. Add distilled water up to the calibration mark, transfer the solution into a vial, and analyze it using an SSA instrument at 217 nm wavelength as determined by the previously established calibration curve [30].

C. MEASUREMENT OF THE STANDARD SOLUTION USING AN ATOMIC ABSORPTION SPECTROPHOTOMETER (AAS).

Automated dilution using an Atomic Absorption Spectrophotometer (AAS) instrument results in a series of concentrations: 0.0 ppm, 2.5 ppm, 5.0 ppm, 7.5 ppm, 10.0 ppm, 15.0 ppm, and 20.0 ppm. The determination and optimization of the curve on the SSA instrument are aligned with the instrument's usage instructions for testing Pb metal, specifically at a wavelength of 217 nm. The wavelength at this maximum absorption curve is used to measure the concentration of Pb in the sample. The maximum wavelength is determined by first inserting the hollow cathode lamp, turning on the power button of the SSA instrument, and then adjusting the desired Pb lamp using the software. The "Zero Set" function establishes the wavelength along the Pb absorption curve, ranging from low to high concentrations, using a blank solution. Subsequently, the concentration of lead in urine can be measured using the previously digested sample to provide results [31].

The absorbance obtained from each sample measurement is calculated using the equation: $Y = ax + b$, where:

- Y = Absorbance
- a = Y-axis intercept
- x = Added concentration
- b = Intersect (Kartikasari, 2016).

The collected data were analyzed descriptively by presenting the research results in the form of tables and lead level percentages based on the researcher's criteria for active and passive smokers' urine in the Surroundings of Wadung Asri.

III. RESULTS

The data from the research on lead levels in the urine of active and passive smokers in the surroundings of Wadung Asri were obtained through questionnaires administered to active and passive smokers based on respondent criteria, including smoking duration, duration of exposure to cigarette smoke, number of cigarettes consumed, and age of respondents.

The examination involved using urine samples collected from both active and passive smokers. These samples were coded and then subjected to wet digestion, a process carried out at the Health Polytechnic Department of Medical Laboratory Technology Surabaya campus. The examination of lead levels was performed using the Atomic Absorption Spectrophotometer method at the Standardization and Industrial Services Center in Surabaya.

The results of the examination of lead levels in the urine of active and passive smokers, using the Atomic Absorption Spectrophotometer method at the Standardization and Industrial Services Center in Surabaya, are reported in units of µg/L. The data presentation in this study is in µg/mL units, which need to be converted first in order to be compared with the normal value threshold according to the Ministry of Health Regulation number 1406/MENKES/SK/XI/2002, which is 0.15 µg/mL. The data can be observed in Table 4.1 for active smokers.

TABLE 4
Lead (Pb) Levels in Urine of Active Smokers

No.	Sample Code	Lead (Pb) Test Results Carbon Furnace (µg/L)	Results have been converted (µg/mL)
1	P.2151	2.71	0.00271

No.	Sample Code	Lead (Pb) Test Results Carbon Furnace (µg/L)	Results have been converted (µg/mL)
2	P.2155	0.8	0.0008
3	P.2158	5.67	0.00567
4	P.2159	1.64	0.00164
5	P.2292	0.83	0.00083
6	P.2294	2.43	0.00243
7	P.2297	0.16	0.00016
8	P.2298	159.2	0.1592
9	P.2473	0.32	0.00032
10	P.2474	0.013	0.000013

TABLE 5

Lead (Pb) Levels in Urine of Passive Smokers

No.	Sample Code	Lead (Pb) Test Results Carbon Furnace (µg/L)	Results have been converted (µg/mL)
1	P.2152	0.47	0.00047
2	P.2153	4.11	0.00411
3	P.2154	0.065	0.000065
4	P.2156	0.051	0.000051
5	P.2157	0.032	0.000032
6	P.2293	1.24	0.00124
7	P.2295	0.7	0.0007
8	P.2296	0.72	0.00072
9	P.2299	0.22	0.00022
10	P.2300	88.5	0.0885

Source Reference:
Minister of Health Decree number 1406/MENKES/SK/XI/2002. Description: Normal value < 0.15 µg/mL

Table 4 shows that the highest lead (Pb) level in the urine of active smokers is 0.1592 µg/mL, identified in sample code P.2298. Meanwhile, the lowest lead level in the urine of active smokers is 0.000013 µg/mL, observed in sample code P.2474. As for Table 5, it illustrates the results of lead levels in the urine of passive smokers. The highest lead level is found in sample code P.2300, amounting to 0.0885 µg/mL. Conversely, the lowest lead level in the urine of passive smokers is obtained from sample code P.2157, yielding a result of 0.000032 µg/mL.

TABLE 6

Characteristics of Respondents

No	Smoker Type	Age	Quantity	Percent (%)
1	Active Smoker	a. 21-44 years	5	25 %
		b. 45-59 years	2	10 %
		c. 60-74 years	3	15 %
2	Passive Smoker	a. 21-44 years	6	30 %
		b. 45-59 years	2	10 %
		c. 60-74 years	2	10 %
Total			20	100 %

Based on the WHO's statement in Table 6, it is indicated that among active smokers, the age range of 21-44 years is represented by a percentage of 25%. The middle age range of 45-59 years is represented by a percentage of 10%, and the elderly age range of 60-74 years is represented by a percentage of 15%.

On the other hand, passive smokers in the age range of 21-44 years constitute 30% of the population, in the age range of 45-59 years, it is 34%, representing the middle age category with a percentage of 10%, and finally, in the elderly age range of 60-74 years, it is 10%. For both active and passive smokers within the age range of 21-44 years, the population is indicated to be 25% for active smokers and 30% for passive smokers.

Cross-tabulation analysis (Crosstabs) is a simple yet powerful method of analysis to explain relationships between variables. There are some basic principles to consider when creating cross-tabulation tables in order to clearly reveal the relationships between variables.

Crosstab analysis is a method of analysis presented in tabular form that displays cross-tabulation of observed data. This cross-tabulation or contingency table is used to identify and determine whether there is correlation or relationship between one variable and another. Crosstab analysis is a method to tabulate multiple different variables into a matrix. The analyzed table represents the relationship between variables in rows and variables in columns.

Based on the cross-tabulation table by age and gender, it can be observed that both active smokers and passive smokers samples generally exhibit low average lead levels. There is one sample with high lead levels, particularly among active smokers within the age range of 21-44 years and male gender.

In the category of males, with lead levels < 0.15, there are 16 individuals, and with lead levels > 0.15, there is one individual. Meanwhile, for females, there are 3 individuals with lead levels < 0.15, and there are no individuals with lead levels > 0.15, with a total of 20 respondents comprising both males and females.

In the cross-tabulation table related to smoking habits and smoking behavior, the average lead levels in the urine of both active smokers and passive smokers tend to be low. Among active smokers, one sample with criteria of frequent cigarette consumption and smoking in public places has a high lead level in the urine.

TABLE 7

Cross-tabulation table based on smoking habits and smoking behavior

		Age			Gender		Smoking Habit				Smoking Behavior			
							Active Smoker		Passive Smoker		Active Smoker		Passive Smoker	
		21-44 years	45-59 years	60-74 years	Male	Female	a.	b.	c.	d.	a.	b.	c.	d.
Lead Level	<0,15	10	4	5	16	3	8	1	8	2	8	1	5	5
	>0,15	1	0	0	1	0	1	0	0	0	1	0	0	0
Total		11	4	5	17	3	9	1	8	2	9	1	5	5
Smoker Type	Active Smoker	5	2	3	10	0	9	1	0	0	9	1	0	0
	Passive Smoker	6	2	2	7	3	0	0	8	2	0	0	5	5
Total		11	4	5	17	3	9	1	8	2	9	1	5	5

Information:

- Smoking habit

a. Frequently consume cigarettes
b. Occasionally consume cigarettes
c. Frequently exposed to cigarettes
d. Occasionally exposed to cigarettes

- Smoking Behavior

a. Frequently smoke in public places
b. Occasionally smoke in public places
c. Frequently exposed among smokers
d. Occasionally exposed among smokers

Considering factors such as age, smoking habits, and smoking behavior that can influence the presence of lead levels in the body, the characteristics of smoking habits and behavior can be inferred from Table 7.

IV. DISCUSSION

Based on the results of lead level examination in the urine of active smokers and passive smokers in the surrounding environment of Wadung Asri, with a sample size of 20 urine samples that produced an average lead level within the normal range, as seen in Tables 4.1 and 4.2. There was one sample from an active smoker that exceeded the normal limit, with a result of 0.1592 µg/mL. The lead level results showed that the lead level in the urine of active smokers was consistent with the study conducted by [23], which reported a lead level of 0.122 mg/L. Meanwhile, for passive smokers, the highest result was 0.0885 µg/mL, which is still within the normal limit of < 0.15 µg/mL according to the threshold set by the Minister of Health Decree (Kepmenkes) number 1406/MENKES/SK/XI/2002 [32]

The average lead level in urine for both active and passive smokers is not solely derived from cigarette smoke, but can also be influenced by various other factors, which could affect the examination results. Therefore, the lead level might appear elevated due to the varied habits and behaviors of each respondent. This can be observed in sample code P.2298, where the elevated lead level is caused by factors such as frequent smoking and smoking behavior not only in the local environment but also in public places.

The research employs the Atomic Absorption Spectrophotometry method, a method of analysis involving the absorption of energy in radiation by atoms based on their energy levels. Absorption causes electrons in atomic shells to be excited to higher energy levels. The resulting radiation has varying wavelengths for different elements. Absorption/emission of radiation results from electron transfers between different energy levels [33], using a wavelength of 217.0 nm due to the BARISTAND's SOP specifications. According to SNI, two wavelengths are acceptable, 283.3 nm and 217 nm. The choice of 217.0 nm for lead atom analysis in an Atomic Absorption Spectrophotometry device with a carbon furnace is due to the high sensitivity indicated by the Cathode Lamp used.

Atomic Absorption Spectrophotometry has the advantage of high sensitivity and ease of use, but the disadvantage lies in its reliance on specific cathode lamps for different metal elements and the corresponding determinations [34]

The wet digestion process aims to separate organic compounds within samples. Wet digestion involves breaking down organic metal compounds into inorganic forms, making them analyzable. It involves the degradation of the sample using strong single acids or mixtures, followed by oxidation using an oxidizing agent. Some solvents used in wet digestion, whether singly or in mixtures, include HNO_3, H2SO4, hydrochloric acid, and HClO4. The outcome of wet digestion is a clear solution, signifying complete solubility [24][35]

In this study, wet digestion uses an HNO_3 solution, with the sample heated on a hot plate at 100-200°C. This process transforms required organic substances into inorganic forms using a strong acid oxidized by an oxidizing agent [23]. This process takes about 30 minutes per sample, and more HNO_3 is required for larger sample quantities [36]. HNO_3 usage can result in a brownish-colored gas during the destruction process [24]. The solution becomes clear, then the sample is cooled for around 15 minutes, filtered with filter paper, placed in a 50 mL measuring flask, and diluted with aquabides. The destructed solution is then examined for lead using Atomic Absorption Spectrophotometry.

The process of examining lead content in urine samples using Atomic Absorption Spectrophotometry begins with destructed samples being filtered into 2 mL containers. These containers are placed in the instrument's sample rack, from smallest to largest numbers. The instrument's auto-dilution process involves creating a concentration series (0, 2.5, 5, 7.5, 10, 15, and 20 µg/L) based on the SOP from BARISTAND. The process takes about 30 minutes to obtain the concentration series. If the desired curve forms, the next step is to test the samples. The samples are pipetted (20 µg) and the instrument processes the absorbance readings, which are then used in linear equations to calculate lead content in µg/L (micrograms per liter) units.

Currently, smoking for many individuals is perceived as a crucial need that cannot be easily abandoned in their daily lives. Those who start smoking often become addicted over time due to the presence of addictive substances like nicotine and various psychological factors. This addiction becomes a crucial factor in the smoking habits of individuals, particularly among adults. The presence of nicotine, an addictive substance, and psychological factors such as the feeling of losing a certain activity when quitting smoking, coupled with the addictive nature of cigarette content, makes it difficult for smokers to quit [2].

Active smokers are those who directly engage in smoking activities, inhaling the majority of cigarette smoke themselves. Active smokers often believe that smoking is enjoyable and can alleviate temporary worries, despite the fact that this relief is short-lived and detrimental to health [4]. While active smokers are directly affected by the dangers of smoking, it also poses a risk to those who are exposed to secondhand smoke, referred to as passive smokers [8]. Various factors, both from the social environment and demographic influences, motivate individuals to smoke. Psychological factors also play a role in the development of smoking habits, as some individuals might feel a sense of loss when trying to quit. Environmental factors, such as being surrounded by other smokers, also contribute to the habit [2][37]

Furthermore, smoking behavior is observed across various occupations, age groups, and genders. The associated risks of smoking are widely recognized by most people. Smoking is a harmful habit that not only negatively impacts the individual smoker's health but also has adverse effects on their social life and economic status.

An individual's smoking behavior is a response to external stimuli, especially direct influences that affect their decision to smoke. Stimuli received by the body, both internal and external, contribute to internal factors that influence smoking behavior. Internal factors, especially biological and psychological factors, lead to smoking behavior.

Food, beverages, inhaled air, the general environment, and the workplace are potential sources of lead (Pb) exposure. Consuming contaminated food and beverages can often lead to non-occupational lead exposure. Lead carbonate and lead sulfate are responsible for the majority of occupational exposure in the respiratory and digestive systems. Lead intake ranges from 100 to 350 g/day, with 20 g absorbed through the inhalation of lead vapor and air pollutants [38][39][40]

In this study, morning urine samples are used, which have a more concentrated characteristic compared to midday urine and first appear in the early morning after waking up [41]. In the examination results where the lead level exceeds the normal limit of < 0.15 µg/mL, the respondent's urine sample appeared turbid. This could be due to the accumulation of lead in the body, which disrupts the excretion process carried out by the kidneys. Such lead exposure within the body can hinder kidney functions [42], and according to [43], there is a direct relationship between lead exposure and kidney disease.

Based on the characteristics of active and passive smoker respondents, in terms of age, it was found that among active smokers, 25% were in the age range of 21-44 years, and among passive smokers, 30% fell within the same range. For the age range of 45-59 years, both active and passive smokers constituted 10% each, and for the age range of 60-74 years, 15% were active smokers and 10% were passive smokers. The research results regarding lead levels in the urine indicated that the highest lead level for active smokers was 0.1592 µg/mL, and the lowest was 0.0885 µg/mL. Meanwhile, for passive smokers, the highest lead level was 0.0885 µg/mL, and the lowest was 0.000032 µg/mL.

Therefore, it can be concluded that within the urine specimens of this study, there was one respondent who had a lead level exceeding the normal threshold of < 0.15 µg/mL. The weakness of this study is the limited number of respondents to enhance and emphasize the researcher's findings.

V. CONCLUSION

The conclusion of this research is as follows: The characteristics of active and passive smoker respondents were determined based on age. The highest lead level was found among those aged 21-44 years. On average, the gender distribution was predominantly male. The influence of smoking habits and behaviors varied among respondents due to different contributing factors that resulted in both high and low lead level samples. The highest lead level for active smokers was 0.1592 µg/mL, while the lowest was 0.000013 µg/mL. For passive smokers, the highest lead level was 0.0885 µg/mL, and the lowest was 0.000032 µg/mL.

The researcher's recommendation for active smokers is to significantly reduce cigarette consumption due to potential harm to themselves and others, particularly passive smokers who are not engaged in smoking but are still affected by the secondhand smoke from active smokers. For future researchers, it is suggested to investigate other heavy metal levels in urine, blood, and hair samples among both active and passive smokers with varying respondent characteristics and in different research locations.

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