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Tracing Lead Exposure: An Exploration of Hair and Blood Lead Levels among Container Truck Drivers at PT. T.I.S. Surabaya, Indonesia

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ABSTRACT Lead is one of the heavy metals used as an additive in gasoline to enhance lubrication and combustion efficiency in motor vehicles, such as container truck drivers, and is commonly found on highways. Truck drivers have a higher tendency to inhale air containing lead while on the road, which can lead to poisoning. Hair and blood can serve as biomarkers of lead exposure in the body. The purpose of this research is to determine the lead levels in the hair and blood of container truck drivers at PT. Trans Indo Sakti Surabaya using Atomic Absorption Spectrophotometry (AAS). This research is a descriptive study conducted at the Analytical Chemistry Laboratory of the Department of Medical Laboratory Technology, Health Polytechnic Ministry of Health Surabaya and the Standardization and Industrial Services Center Laboratory in Surabaya from October 2022 to May 2023. The samples used in the study are 15 container truck drivers, selected using purposive sampling technique. This study demonstrates results of the lowest hair lead level value at 0.1936 µg/g and the highest at 3.026 µg/g. Among the respondents, 9 were categorized as having normal levels, while 6 respondents were categorized as having abnormal levels. For the blood samples, the lowest lead level obtained was 0.146 µg/dL and the highest was 3.81 µg/dL. The lead levels are still categorized as normal. The presence of lead in the body is influenced by age, length of employment, duration of work, and smoking habits.

INDEX TERMS Lead, container truck drivers, hair, blood, Atomic Absorption Spectrophotometry (AAS)

I. INTRODUCTION

Air plays a crucial role as an environmental component for sustaining life, and its quality needs to be maintained to support environmental sustainability. If not properly preserved, it can lead to air pollution [1]. Air pollution sources are attributed to various pollutants such as carbon monoxide, carbon dioxide, hydrocarbons, and heavy metals like lead [2][29]. Lead is used in combination with gas fuels to enhance lubrication and combustion efficiency. According to the Environment Project Agency, approximately 25% of lead is contained within the engine, while the remaining 75% is released through exhaust fumes, thus contributing to air pollution [3].

Indonesia ranks third globally in terms of high air pollution levels. The largest contributor to air pollution in Indonesia is the exhaust emissions from motor vehicles containing lead, along with the increasing number of motor vehicle users. The Central Statistics Agency records indicate that the number of motor vehicles in Indonesia reached 136.32 million units in 2020. East Java is the province with the highest number of motor vehicles, totaling 22 million units. From this total, there are 19.35 million motorcycles, 1.88 million passenger cars, 732.67 thousand trucks, and 35.3 thousand buses [4].

Adult workers such as drivers face a high risk of exposure to air pollution containing lead. They encounter this exposure throughout the day, from sunrise to evening, due to their activities on congested motorways. Even during breaks, they remain exposed to air pollution from vehicle exhaust fumes. As a result, over the years, these workers are continuously exposed to lead-containing pollution, which poses a serious health concern for them [5][30].

The presence of lead in the air poses a serious threat to health. Inhaled lead particles can easily reach the deepest parts of the lungs and be absorbed almost entirely into the

bloodstream. As a result, lead exposure can lead to systemic poisoning, causing symptoms such as headaches, shortness of breath, and chest pain that have negative impacts on the body [6][35]. Furthermore, the impact of lead presence in the air can disrupt hemoglobin biosynthesis, leading to anemia. It can also contribute to elevated blood pressure, kidney damage, and nervous system disorders. Prolonged exposure can harm the brain, resulting in decreased IQ and concentration [7].

Lead enters the body through the respiratory and digestive systems. Absorption through respiration leads to its entry into the bloodstream and lungs. It then binds with blood in the lungs and circulates throughout the body's tissues. Lead tends to accumulate in the body due to slow excretion. Its half-life in blood is approximately 25 days, in soft tissues about 40 days, and in bones as long as 25 years. Once lead enters the body, it circulates through the tissues, accumulates, and is partially excreted through urine (75-80%), feces (15%), as well as through bile, sweat, and other routes. A significant portion is also stored in hair and nails [8]. Inhaled lead metal can be absorbed by the respiratory tract at around 40% and through the digestive tract at approximately 5-10%. About 95% of the absorbed lead is bound to red blood cells, while the remaining portion is bound to plasma. It is then distributed throughout the body's tissues. This includes soft tissues like bone marrow, the nervous system, kidneys, and liver, as well as harder tissues like bones, teeth, nails, and hair [9][31]. Lead tends to accumulate and deposit in hair over a prolonged period. Hair contains structural proteins, particularly keratin, which is composed of cysteine amino acids with disulfide bond groups (-S-S-) and cystine with sulfhydryl groups (-SH). Both of these groups enable hair to strongly bind to heavy metals like lead [10].

There are hazardous effects caused by lead exposure that can be experienced by individuals who come into direct contact with lead pollution sources, such as container truck drivers in the Tanjung Perak area of Surabaya. Based on research [11], Tanjung Perak Surabaya being a major port in the Eastern Indonesia region makes container shipping activities in the area highly bustling, with constant movement of ships and cargo to and from Surabaya. PT. Trans Indo Sakti is one of the companies operating in the Tanjung Perak area, providing container transportation services to various destinations both within and between cities and provinces. This situation exposes container truck drivers to the risk of inhaling air containing lead along the busy roadways due to vehicle exhaust emissions. This continuous exposure contributes to an increase in lead concentration in the body.

In research [12], the lead levels found in the hair of truck drivers range between 1.260 – 1.860 mg/L. These levels are within the normal range, but many truck drivers experience health complaints. In another study conducted by [13], the lowest lead level in hair was obtained from a minibus driver with 3 years of experience, measuring 12.20 µg/g. On the other hand, the highest level was recorded from a driver with 30 years of experience, measuring 91.44 µg/g. The lead levels in the hair of minibus drivers exceeded the threshold limit. This indicates that the duration of employment significantly influences lead levels in the body. The longer a driver operates a vehicle on the road, the more frequent their exposure to air containing lead.

Not only hair, but blood can also be used to examine lead levels in the body. When lead enters the body, a portion of it binds to red blood cells and circulates throughout the bloodstream to all parts of the body. Research conducted [14], found an average lead level in the blood of public transportation conductors to be 1.523 µg/dL. The discovered lead levels fall within the normal range. Meanwhile, in another study conducted by [15], obtained a lead content in the blood of gas station attendants at 10.16 µg/dL. According to data from the Indonesian Ministry of Health (2013), a person's blood lead level is considered normal if it's <10 µg/dL. Therefore, the average lead levels in the blood of gas station attendants are above the normal limit (>10 µg/dL). These results indicate elevated lead levels, likely attributed to the fact that gas stations are highly busy environments, and many attendants tend to neglect proper personal protective equipment (PPE), resulting in the rapid inhalation of lead-laden air. This lead likely comes from gasoline that is being filled into motor vehicles and from exhaust gases emitted by vehicles after refueling. The purpose of this research is to determine the lead levels in the hair and blood of container truck drivers at PT. Trans Indo Sakti Surabaya using Atomic Absorption Spectrophotometry (AAS).

Whether in large or small amounts, lead in the body can be hazardous due to its toxic nature and accumulative properties within the human body [10]. Repeated or continuous exposure to lead, even in small quantities, can lead to the accumulation of lead in tissues and organs, ultimately causing lead poisoning [5]. The continuous effects of lead damage typically lead to unclear side effects in almost all body systems. The resulting negative impacts include miscarriages and premature births, cognitive issues, hypertension, cardiovascular diseases, and impaired kidney function [3]. The effects of lead can damage various organ systems in the human body, especially the sensory system, blood-forming system, kidneys, heart, and reproductive system. Accumulation of high levels of lead in the blood can lead to gastrointestinal conditions, loss of consciousness, weakness, hypertension, kidney damage, neuromuscular issues, and pathophysiological outcomes as well as damage to focal sensory systems and behavioral changes [7][32]. Given the statement above, it is necessary to conduct research to determine the lead levels in the hair and blood of container truck drivers at PT. Trans Indo Sakti Surabaya.

II. METHODHOLOGY

The type of research conducted is descriptive. Sample collection and data gathering were performed simultaneously through interviews and laboratory

examinations to determine the levels of lead in hair and blood specimens of Truck Drivers at PT. Trans Indo Sakti Surabaya.

This research was conducted at the Analytical Chemistry Laboratory of the Department of Medical Laboratory Technology, Health Polytechnic Ministry of Health Surabaya, which served as the site for sample destruction. The examination of hair and blood samples were carried out at the Standardization and Industrial Services Center Laboratory in Surabaya. This study was conducted from October 2022 to May 2023. The samples taken were hair and blood specimens used as research materials. Then, the samples were collected using purposive sampling technique (based on criteria predetermined by the researcher).

A. TOOLS AND MATERIALS

The tools employed for sample collection include scissors, syringes, plastic clips, tourniquets, EDTA tubes, coolbox, alcohol swabs, and cotton. On the other hand, equipment utilized for the sample destruction and lead level analysis encompass Atomic Absorption Spectrophotometry (AAS), cuvettes, an analytical balance, Whatman filter paper, hot plate, measuring glass, beaker glass, measuring flask, brown bottles, dropper pipettes, volumetric pipettes, and stirring rods. The materials utilized comprise hair and blood samples from container truck drivers at PT. Trans Indo Sakti Surabaya, with reagents including distilled water (aquades), concentrated nitric acid (HNO_3), concentrated perchloric acid ($HClO_4$), and $Pb(NO_3)_2$.

B. RESEARCH PROCEDURE

Two grams of hair are weighed and placed in a 100 mL beaker glass. Then, 15 mL of concentrated HNO_3 is added, followed by heating on a hot plate at 100°C for 15 minutes. Afterward, 5 mL of concentrated $HClO_4$ is added, and the mixture is stirred using a stirring rod while being heated on the hot plate. Once completed, the solution is transferred to a 100 mL flask using filter paper and diluted with distilled water (aquades) to reach a volume of 100 mL [7].

Pipette 2 mL of blood into an Erlenmeyer flask. Then, add concentrated nitric acid (HNO_3) and heat the mixture using a hot plate at 100°C. Once heated, remove it from the hot plate and let it cool to room temperature. After cooling, filter the solution using Whatman filter paper, then transfer it to a 100 mL measuring flask and add distilled water (aquades) to reach a volume of 100 mL [16].

The preparation of a 1000 ppm lead (Pb) stock solution is carried out by weighing 0.1599 grams of $Pb(NO_3)_2$ and transferring it into a 100 mL volumetric flask. Then, dissolve it using 7 mL of concentrated HNO_3. Once all the $Pb(NO_3)_2$ is dissolved, add (dilute) distilled water (aquades) and homogenize the solution. The next step involves preparing standard stock solutions of 100 ppm, 10 ppm, 5 ppm, 2 ppm, 1.5 ppm, 1 ppm, and 0.1 ppm [3]. To prepare a 10 mg Pb/L standard metal solution, pipette 100 mg Pb/L from the stock solution into a 100.0 mL volumetric flask. Then, add distilled water (aquades) up to the mark on the flask and homogenize the solution. Lead concentrations of 0.0 ppm, 0.05 ppm, 0.1 ppm, 0.2 ppm, 0.5 ppm, 1 ppm, and 2 ppm can be prepared by taking 0.0 mL, 0.5 mL, 1.0 mL, 2.0 mL, 5.0 mL, 10.0 mL, and 20.0 mL, respectively, from the 10 ppm lead stock solution. Each of these volumes is transferred into a 100 mL volumetric flask. Then, distilled water (aquades) is added to the mark on the flask to achieve the concentrations of 0.0 ppm, 0.05 ppm, 0.1 ppm, 0.2 ppm, 0.5 ppm, 1 ppm, and 2 ppm of lead [7]

Creation of the standard curve involves preparing standard solutions of 2 ppm, 1 ppm, 0.5 ppm, 0.2 ppm, 0.1 ppm, and 0.05 ppm. These solutions are then analyzed using an atomic absorption spectrophotometer at a wavelength of 217 nm. After obtaining the standard curve, the destructed specimen solutions are read at a wavelength of 217 nm using the atomic absorption spectrophotometer equipped with a lead hollow cathode lamp. The absorbance of each specimen is recorded [16].

III. RESULT

One of the requirements for metal analysis using Atomic Absorption Spectroscopy (AAS) is that the sample should be in the form of a solution. Therefore, before analyzing the metal content in the sample, it needs to undergo a process called destruction. Destruction is a treatment that transforms and disintegrates the sample into a measurable form, enabling the assessment of the underlying substances within it [3]. Subsequently, hair and blood samples from container truck drivers at PT. Trans Indo Sakti Surabaya were measured using an Atomic Absorption Spectrophotometer (AAS). The lead levels obtained in this study are compared to the normal values of lead in the body for each respective specimen. Several abnormal results were found in hair specimens, while blood specimens showed normal results for all respondents. The research findings are presented in TABLE 1.

TABLE 1

Data from the examination of lead levels in the hair and blood of container truck drivers at PT. Trans Indo Sakti Surabaya

Num	Sample Code	Lead Levels in Hair (µg/g)	Lead Levels in Blood (µg/dL)
1.	ST1	1,8176	2,93
2.	ST2	1,029	1,27
3.	ST3	3,026	3,81
4.	ST4	1,3993	1,86
5.	ST5	2,9135	3,19
6.	ST6	1,8023	2,63
7.	ST7	0,5922	0,169
8.	ST8	0,9139	1,15

Num	Sample Code	Lead Levels in Hair (µg/g)	Lead Levels in Blood (µg/dL)
9.	ST9	1,032	0,226
10.	ST10	0,5174	0,162
11.	ST11	1,0991	2,51
12.	ST12	1,0756	1,58
13.	ST13	2,6091	1,94
14.	ST14	0,1936	0,146
15.	ST15	1,017	0,251

From TABLE 1, the examination results of lead levels in hair and blood samples from 15 container truck drivers at PT. Trans Indo Sakti Surabaya were obtained. The known lead levels will be compared with the normal values for lead in the body. The normal lead levels in hair specimens range from 0.007 to 1.17 µg/g, while the normal lead levels in blood specimens are below 10 µg/dL. Then, the data in this study is presented using cross-tabulation or crosstab to observe the correlations among respondent characteristics based on age, work period, duration of work, smoking habits, health complaints, as well as lead levels in hair and blood. The cross-tabulation data for hair specimens is presented in TABLE 2.

TABLE 2

Cross-tabulation of lead levels in hair specimens of container truck drivers at PT. Trans Indo Sakti Surabaya

	Age (years)				Working Period (year)		Working Time (hours/day)		Smoking Habit		Health Complaints	
	20-30	30-40	40-50	>50	5-10	>10	5-7	>7	Smoke	Not Smoke	Headache	No Complaints
Hair Lead Levels (Normal)	3	4	2	0	9	0	3	6	7	2	0	9
Hair Lead Levels (Abnormal)	0	0	4	2	1	5	0	6	6	0	3	3
Total	3	4	6	2	10	5	3	12	13	2	3	12

TABLE 2 reveals that among the respondent age characteristics within the age range of 40 – 50 and >50, both have abnormal hair lead levels. This demonstrates that age influences lead levels in the body. Additionally, from the work period characteristic, 5 respondents with a work period of >10 years have abnormal lead levels, compared to 1 person with a work period of 5 – 10 years. Work period characteristics influence lead levels in the body. Regarding the tenure characteristic, it's noted that there are more container truck drivers with a tenure of >7 years. Looking at smoking habits, there are 13 container truck drivers who smoke, indicating a significant number of active smokers among the respondents. The duration of smoking can influence lead levels in the body. Furthermore, under the characteristic of health complaints, it's evident that 3 respondents reported headaches as a complaint, categorizing them as abnormal. This demonstrates that lead levels in the body can impact an individual's health condition. The distribution of lead content data in hair specimens is presented graphically in FIGURE 1.

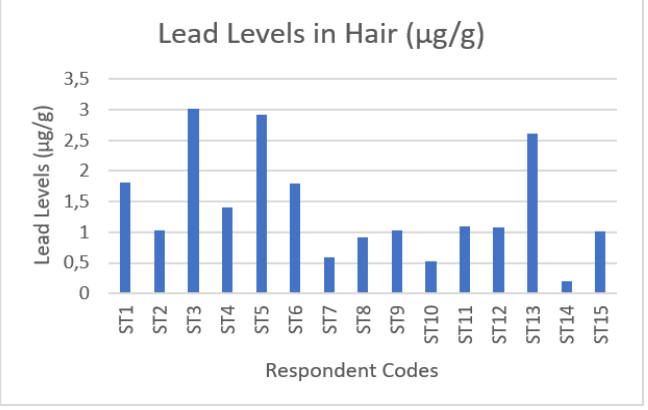

FIGURE 1. Graph of Lead Levels in Hair Specimens

In FIGURE 1, the distribution of lead levels in hair specimens is depicted. It's observed that 9 individuals have lead levels in hair specimens categorized as normal or below the threshold, while 6 individuals have lead levels categorized as abnormal or above the threshold. The acceptable range for normal lead levels in hair specimens is 0.07-1.17 µg/g [17]. Next, the data regarding lead levels in blood specimens of container truck drivers at PT. Trans Indo Sakti Surabaya will be presented, and it will be compared with the normal values. The cross-tabulation data for blood specimens will be presented in Table 3.

TABLE 3

Cross-tabulation of lead levels in blood specimens of container truck drivers at PT. Trans Indo Sakti Surabaya

	Age (years)				Working Period (year)		Working Time (hours/day)		Smoking Habit		Health Complaints	
	20-30	30-40	40-50	>50	5-10	>10	5-7	>7	Smoke	Not Smoke	Headache	No Complaints
Blood Lead Levels (Normal)	3	4	6	2	10	5	3	12	13	2	3	12
Blood Lead Levels (Abnormal)	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	4	6	2	10	5	3	12	13	2	3	12

In TABLE 3, the lead levels in the blood of container truck drivers at PT. Trans Indo Sakti Surabaya that have been tested are presented. The characteristics of the respondents include age, work period, tenure, smoking habits, and health complaints. It's observed that all 15 container truck drivers have lead level results within the normal range. The normal concentration of lead levels in adult blood is less than 10 µg/dL [18]. The distribution of lead content levels in blood can be visualized using a bar chart. The data distribution of lead content in blood specimens is presented graphically in FIGURE 2.

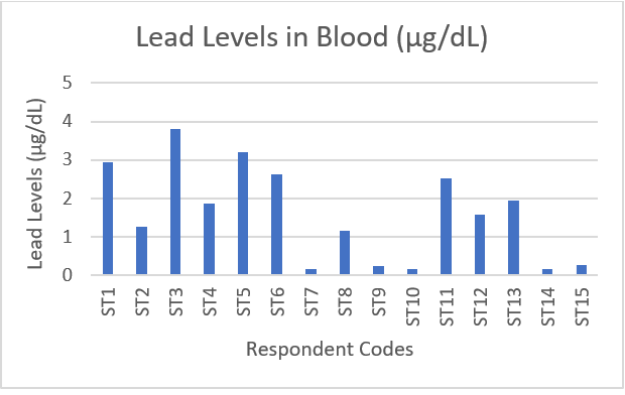

FIGURE 2. Graph of Lead Levels in Blood Specimens

FIGURE 2 illustrates the lead level results in the blood of container truck drivers at PT. Trans Indo Sakti Surabaya. From the data, it's evident that all 15 respondents have lead levels within the normal range. The highest recorded lead level is for the respondent with sample code ST3 at 3.81 µg/dL, while the lowest is for the respondent with sample code ST14 at 0.146 µg/dL.

IV. DISCUSSION

A. IDENTIFYING RESPONDENT CHARACTERISTICS

The research conducted on container truck drivers at PT. Trans Indo Sakti Surabaya yielded results indicating the presence of lead levels in hair and blood samples. Data obtained from this study, as shown in TABLES 2 and TABLE 3, reveal that the characteristics of respondents based on age indicate that the highest age group is between 40 – 50 years old. This can be interpreted as age influencing the lead levels in the body. However, in older individuals, specifically those over 50 years old, there is a higher risk observed. This is evident from the research findings which show that as the age of the respondents increases, the percentage of lead levels in the body also increases. This can be attributed to the fact that as age increases, the resilience of certain organs diminishes in response to the effects of lead [19]. Furthermore, when examining the characteristics of respondents based on years of service, it is evident that the highest years of service are found in the group of respondents who have worked as container truck drivers at PT. Trans Indo Sakti Surabaya for 5 to 10 years, compared to those who have worked for more than 10 years, where the percentage is lower. This indicates that the years of service does not always affect the lead levels in the body. There are other factors at play, such as dietary habits and a healthy lifestyle, which can contribute to lowering lead levels in the body [20].

In the characteristics of respondents based on their duration of work, it is noted that the highest duration of work is found in the group of respondents who have worked as container truck drivers at PT. Trans Indo Sakti Surabaya for more than 7 hours per day. The length of daily working hours reflects the extent of exposure to vehicle exhaust emissions. The longer the exposure to lead-contaminated environments, the greater the lead content in a person's body [21].

Looking at the characteristic of smoking habits, the highest percentage is 86.7%, with 13 out of 15 respondents having a smoking habit. There is a significant difference in

lead levels between individuals who smoke and those who do not. It is suspected that the lead originates from tobacco leaves used in cigarette manufacturing. Lead in tobacco leaves could be remnants from cultivation, fertilizer application, or pre-existing lead in the soil [5]. The chemical compounds present in cigarettes cause gas exchange to become very difficult and lead to a decrease in cilia function. This disruption interferes with the regenerative process of epithelial cells, and cilia become unable to filter lead-contaminated air when it enters the lungs. As a result, the more frequent the smoking habit, the higher the lead levels in the body [22][33]. Moving on to the characteristics based on health complaints, the highest percentage is 80%, with 12 out of 15 respondents not reporting any health complaints. The presence of lead in the body depends on each individual, and other factors that influence this are health status, the food consumed, and the body's ability to absorb the lead that enters the body [23].

B. LEAD LEVELS IN HAIR OF CONTAINER TRUCK DRIVERS AT PT. TRANS INDO SAKTI SURABAYA

Hair can be used as an indicator of lead contamination. The lead metal that enters the body can accumulate in the hair. In TABLE 1, the lowest lead level in hair among container truck drivers at PT. Trans Indo Sakti Surabaya is 0.1936 µg/g, while the highest is 3.026 µg/g. The normal range for lead levels in hair is 0.007 – 1.17 µg/g [18], this indicates that the lead levels in the hair of container truck drivers at PT. Trans Indo Sakti Surabaya, as seen in Table 2, show that 9 respondents fall within the normal category, while the remaining 6 respondents have lead levels in their hair that exceed the normal limit, categorizing them as abnormal. This is because the accumulation of lead in hair occurs over a significant period of time, and it is challenging for it to be deposited elsewhere due to hair's strong binding properties with metal, particularly lead. The structural protein content in hair, especially amino acids like cysteine with disulfide bond groups and cystine with sulfhydryl groups, enables hair to efficiently bind heavy metals like lead [10].

The heavy metal lead can enter the human body through both the respiratory and digestive tracts. Once absorbed by the body, lead mixes with the blood and is then circulated throughout the body. Heavy metals like lead tend to accumulate in certain organs such as the kidneys, liver, and adipose tissue. The metabolic byproducts of heavy metal lead are excreted through urine and can also deposit in hair, nails, and teeth [24]. Clusters of sulfhydryl groups (-SH) and cystine sulfide bonds (-S-S-) in the hair have the capability to bind heavy metals that enter the body, trapping them within the hair. Since sulfide compounds readily bond with heavy metals, when these metals enter the body, they are bound by the sulfide compounds present in the hair [17][34].

In each hair and blood sample, the lowest lead content is found in the sample from respondent with code ST14, while the highest is found in the sample from respondent with code ST3. When examining the characteristics of these respondents, it is evident that the respondent with code ST14 is 27 years old and has worked as a container truck driver for 5 years, with a daily work duration of 7 hours. In comparison, the respondent with code ST3 is 65 years old and has worked as a container truck driver for 18 years, with a daily work duration of 10 hours. This study indicates that age, years of service, and daily work duration influence the lead levels in an individual's body. Age is a determinant of a person's physical condition and affects various physiological aspects within the body. As age increases, the body undergoes natural processes of aging and physiological decline [25]. As someone ages, they tend to become more vulnerable to the effects of lead and the risk of lead accumulation in the body [19]. In the study [10], it demonstrates the influence of length of service on the lead levels in the bodies of gas station employees. On the other hand, study [12] states that length of working refers to how long an individual spends time on the road while driving a truck during a day. The longer a person works or is exposed to an environment containing lead, the greater the likelihood that the lead content in their body will increase.

Furthermore, smoking habits also play a significant role in the level of lead in the body. 13 out of 15 respondents have a smoking habit, and 6 of them have lead levels in hair specimens categorized as abnormal. The quantity of cigarettes consumed each day can influence the lead levels in the body. Exposure to cigarette smoke contributes to the lead levels in the body, as the lead content in cigarettes is inhaled into the body. The exposure to lead through cigarettes depends on the amount of lead present, the percentage transferred into cigarette smoke, and the percentage absorbed by the body [13][41]. This is supported by the research conducted [22], which states that there is a significant correlation between smoking habits and lead levels in hair.

However, upon further comparison, there is a significant difference between respondents with codes ST6 and ST11. It is known that both respondents, with codes ST6 and ST11, are 49 years old and have a smoking habit. However, the respondent with code ST6 has lead levels in hair categorized as abnormal, while the respondent with code ST11 has lead levels in hair categorized as normal. It's evident that the respondent with code ST6 smokes more cigarettes daily compared to the respondent with code ST11. The quantity of cigarettes consumed can indeed influence the presence of lead in the body. The respondent with code ST11 follows a healthy lifestyle and consumes foods rich in antioxidants, which enables the body to gain additional protection against the negative impacts of lead exposure and enhances the body's ability to counteract harmful substances [22][39]. In the study [25], it is stated that a healthy lifestyle plays a role as an effective preventive measure to reduce the risk of lead exposure.

C. LEAD LEVELS IN BLOOD OF CONTAINER TRUCK DRIVERS AT PT. TRANS INDO SAKTI SURABAYA

Apart from using hair samples, blood samples can also be used to detect the presence of lead in the body. When lead enters the body through the respiratory tract, a portion of it gets

absorbed by blood vessels in the lungs and enters the bloodstream. Subsequently, lead will be distributed to various organs throughout the body through the bloodstream circulation [17]. From TABLE 1, the lowest lead level in the blood of container truck drivers at PT. Trans Indo Sakti Surabaya is 0.162 µg/dL, while the highest is 3.81 µg/dL. The normal range for lead levels in blood is 10 µg/dL [17], This indicates the lead levels in the blood of container truck drivers at PT. Trans Indo Sakti Surabaya, as seen in Table 3. All respondents have lead levels in their blood that fall within the normal category.

If we look at TABLE 1, it's known that 6 out of 15 individuals have lead levels in their hair specimens above the normal value or categorized as abnormal, while their blood specimens are still within the normal range. This is due to the fact that when lead enters the body, it binds to the blood in the lungs and circulates throughout the tissues. Lead in the blood has a half-life of approximately 25 days, whereas lead in hair represents accumulated lead within the body and tends to deposit in the hair for an extended period [10][40].

The concentration of lead in blood is crucial in evaluating lead exposure, as it aids in diagnosing poisoning and serves as an exposure index to assess the level of danger, both for individuals exposed through occupation and the general population. Blood lead levels depict the dynamic interplay between exposure, absorption, distribution, and excretion, making it an indicator to discern ongoing exposure [26][36].

The absorbed lead is distributed to blood cells, soft tissues, and bones. Lead present in the blood is excreted after 25 days, lead in tissues is excreted after 40 days, and lead in bones is excreted after 25 years. The absorption of lead (Pb) through inhalation or the respiratory tract is influenced by three processes: deposition, mucociliary clearance, and alveolar clearance. Deposition occurs in the oropharynx, tracheobronchial tree, and alveoli. Deposition depends on the particle size of lead inhaled and its solubility. Larger particles tend to deposit more in the upper respiratory tract compared to smaller particles [27][37]. The percentage of inhaled airborne lead that reaches the bloodstream is estimated to be around 30% to 40%, depending on particle size, solubility, respiratory volume, individual physiological variations, and psychological conditions affecting lung absorption. Chemical substances ingested enter the body through the gastrointestinal tract. Absorption can occur along the digestive tract, from the mouth to the rectum. The primary site of absorption is the small intestine [28][38].

From TABLE 3, it is evident that the lead exposure among container truck drivers is not excessively high and still falls within the normal range. In the study [6], it is stated that there are several factors influencing blood lead levels, such as the amount of exposure, duration of exposure, and the route of lead entry into the body. The variation in blood lead content among adults can be attributed to various environmental and geographical factors in the locations they are situated.

If someone's blood lead levels fall within the normal range, it can be attributed to various factors such as age, years of service, daily work duration, smoking habits, as well as a healthy lifestyle involving the consumption of nutritious food daily. Consuming foods rich in vitamin D and calcium can reduce the absorption of lead by the body. This is because both these substances have the ability to bind to lead, altering the lead's affinity to target tissues during the transport process and absorption mechanism in the intestines, making it more difficult for lead to be absorbed [23][42].

The results from the interviews with the respondents show that 80% of them do not experience any health complaints, while 20% have reported experiencing health issues like headaches. Even though only a small percentage experience health complaints, it's important not to disregard them. While the amount of lead entering the body might not be substantial, the accumulation of lead over a prolonged period can lead to toxic effects that are harmful to various bodily functions [25][43].

The weaknesses of this research include incomplete filtration of the destruction results, which could potentially affect the readings within the instrument. Additionally, the unstable temperature of the hot plate prolonged the destruction time. As for limitations, the cost of the examination was relatively high. Furthermore, the hair samples collected were from male container truck drivers, which posed a slight challenge due to the relatively short length of male hair. The use of laboratory equipment was constrained, leading to a considerable duration for sample destruction, whereas blood samples required immediate processing as they could not be preserved for an extended period.

Using personal protective equipment such as masks and hats can reduce lead exposure while working. Container truck drivers who do not use personal protective equipment while working are more susceptible to lead exposure, leading to elevated lead levels in their bodies. The examination of lead levels in container truck drivers in this study was conducted to understand the extent of lead concentration within the body, enabling preventive measures to be taken before further lead exposure occurs.

V. CONCLUSION

From the research results regarding the lead levels in the hair and blood of container truck drivers at PT. Trans Indo Sakti Surabaya, several conclusions were obtained. Based on the characteristics of respondents to truck drivers at PT. Trans Indo Sakti Surabaya, the characteristics of the respondents showed the highest percentage of age 40% was obtained from the age group between 40-50 years, the highest percentage of 66.7% employment was obtained from the group of respondents who had worked as container truck drivers at PT. Trans Indo Sakti Surabaya for 5-10 years, the highest percentage of 80% working time was obtained from the group of respondents who had worked as truck drivers at PT. Trans Indo Sakti Surabaya for more than 7 hours/day, the highest percentage of 86.7% was obtained from

respondents who had smoking habits and the highest percentage of 80% was obtained from groups without health complaints. Lead levels in blood specimens of container truck drivers at PT. Trans Indo Sakti Surabaya, the lowest was 0.146 µg/dL and the highest was 3.81 µg/dL. These lead levels are normal. Meanwhile, lead levels in hair specimens of container truck drivers at PT. Trans Indo Sakti Surabaya, the lowest was 0.1936 µg/g and the highest was 3.026 µg/g. There were 9 respondents including the normal category group and 6 other respondents including the abnormal category group.

As for suggestions that can be conveyed to the public, especially those who work as container truck drivers, is that they are expected to use personal protective equipment such as masks and hats while working to reduce lead exposure in the body and consume nutritious food. While suggestions for future researchers are expected to be able to develop this research by using different types of heavy metals such as arsenic, cadmium, chromium, mercury etc. and also more varied parameters such as urine and fingernails. For the next researchers, it is expected that they use different professions as research samples, such as transportation drivers, gas station workers, and parking attendants who are potentially exposed to lead on a daily basis.

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