Concentration of Urinary 1-Hydroxypyrene (1-OHP) in Bus Drivers as a Biomarker of Polycyclic Aromatic Hydrocarbons (PAHS) Exposure in Depok City, Indonesia

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ABSTRACT— ***Transportation is a sector growing rapidly in urban areas in Indonesia. Polycyclic Aromatic Hydrocarbons (PAHs) is a compound resulting from motor vehicle exhaust gases. Several types of PAHs and their metabolite results are classified carcinogenic to humans, and one of them is 1-Hydroxypyrene (1-OHP) compound. The objective of this study was to determine 1-OHP levels in bus driver urine at Depok bus station and determine the risk factors influencing the amount of 1-OHP in urine. The research design was cross-sectional involving two groups of 18 bus drivers and 16 workers of non-drivers as the comparator. Risk factors for the amount of 1-OHP in urine were analyzed using multiple linear regression data analysis. The results show that 1-OHP concentration in urine of driver group (0.51 mol/mol creatinine) is higher than non-driver group (12.29 mol/mol creatinine). Variables of occupation, education, number of cigarette consumption per day and type of cooking fuel have a significant relationship with the concentration of 1-OHP in urine (p<0.05). In the multivariate analysis, it is found that the most dominant factors are education, occupation, income, number of cigarette consumption per day, use of PPE, consumption of roasted food, and type of cooking fuel. In conclusions, the concentration of 1-OHP in urine is significantly different between the respondent groups and influenced by several other individuals factors.***

Keywords--- Biomarker, PAH, 1-OHP, Bus Drivers, Depok, Indonesia

1. INTRODUCTION

The development of transportation sector increases air pollution in urban areas. The transport sector contributes greatly to air pollution in urban with the existence of motor vehicle exhaust gas emissions. One of the pollutants in the air is Polycyclic Aromatic Hydrocarbons (PAHs). It is formed as a result of incomplete combustion of organic material, spread in the environment and it is in the form of a mixture. The main source of human exposure to PAHs comes from the work environment, active and passive smokers, food and water and air pollution, a coke production and a graphite electrode manufacturing plant, coal burning [1,2,3,4]. Polycyclic Aromatic Hydrocarbons (PAHs) is compound that has a harmful impact on health. Most types of PAs are known to trigger tumors in animal experiments through the respiratory tract, gastrointestinal tract and skin contact. There are more than 100 types of compounds belonging to PAH. However, there are 17 types of PAHs which are dangerous to health, one of which is Benzo(a)pyrene (BAP). Naturally BAP occurs as a result of volcanic eruption. However, as the result of human activity, BAP exists in the air, generated through burnings of plants, wood, baked food, household fuel and automotive fuel combustion, toll station, cook oven emission [5,6]. The main source of indoor Benzo(a)pyrene in the air is wood burning for cooking and cigarettes [7,8]

Benzo(a)pyrene becomes air pollutant that requires the attention of world public health because its effects are quite serious. In the short-term exposure, the contact with skin causes irritation and a burning feeling, while the long-term exposure to benzo(a)pyrene can cause asthma [9], cardiac autonomic dysfunction [10], reproduction [11], cancer [12,13], even result in death. IARC classifies BAP as group 1 carcinogenic which is a compound that has been shown to cause

carcinogenic to humans [14]. The results also mention that 1-OHP affects sperm quality of individuals exposed to PAHs [11].

The use of biomarker as biological exposure marker provides benefit to show the relationship of environmental exposure with the disease risks. Biomarker for exposure to Polycyclic Aromatic Hydrocarbons (PAHs), can be performed through Polycyclic Aromatic Hydrocarbons (PAHs) genotoxic, urine metabolites, Polycyclic Aromatic Hydrocarbons (PAHs) DNA-Adduct causing cancer [13,15], and Polycyclic Aromatic Hydrocarbons (PAHs) protein-adducts. From all of them, pyrene metabolite in the urine is often used as an indicator of exposure to Polycyclic Aromatic Hydrocarbons (PAHs), specifically benzo(a)pyrene. 1-hydroxypyrene (1-OHP) provides an overview of 90% pyrene metabolism in the human body through the urine. 1-hydroxypyrene (1-OHP) has a residence time of 6-35 hours, in average is around 18-20 hours. Therefore, it can provide an overview of exposure in the last 24 hours or within a short exposure time [16].

Integrated Bus Station of Depok City, is a bus station that has an important position in the land transportation in Depok. In 2008, of PAHs concentrations especially air BAP in Margonda Highway Depok, it was obtained an average BAP concentration of 0.39 µg/m^3, categorized as medium exposure level by WHO. In addition, 1-OHP levels of urine which was a biological marker of PAHs exposure in the traffic police officer on duty at Margonda highway was higher than the police officer assigned in the room. Bus driver at Depok bus station was a risky populations exposed to PAHs because their work required in and out of the bus station every day. Therefore, the objective of this study is to identify the risk factors that affect the levels of 1-Hydroxypyrene (1-OHP) in urine as a biomarker of Polycyclic Aromatic Hydrocarbons (PAHs) exposure in bus driver at Depok bus station.

2. MATERIAL AND METHODS

The procedures of the research has been done in accordance with the Helsinki Declaration as revised in 2013. This study used a cross-sectional design in two groups: high exposure and low exposure. The population in this study was bus station workers in Depok, West Java. The workers were divided into two groups: high exposure group and the comparator was low exposure group. High exposure group was the drivers of non-air conditioned inter-city bus with the designated route of Depok bus station. Whereas the comparison group was people working inside the bus station office, both Technical Implementation Unit (UPT) employees of bus station or ticket selling agent. The study involved 18 people of driver group and 16 people of non-driver group. The sampling calculation used the formula of hypothesis test. The mean of differences referred to a previous study conducted by [17]. The sampling was incidental sampling method with the inclusion criteria: older than > 17 years old, the working time of at least 1 year, and not undergoing kidney disease treatment. The data collection from respondents used interview technique with questionnaire covering demographic condition, economic condition, weight, height, marital status, education, occupation, smoking habits, alcohol consumption, consumption of roasted food and the type of cooking fuel.

Urine Sampling and Analysis

The sampling of urine was performed by each respondent. The urine was collected using a container specifically with a diameter of 5 mm. Urine samples were taken after exposure, namely at the end of the work shift. The amount of urine collected was approximately 25-50 ml, this amount would be carried out the analysis when appropriate. Urinary 1-OHP was analyzed using the method of [18] and urinary creatinine was measured using Jaffe's method.

Statistical analysis

Univariate analysis was conducted to see the frequency distribution of the variables studied, they were respondent characteristics, work characteristics, risk behaviors and the concentrations of 1-OHP in urine. In this analysis, it was used mean, median, minimum maximum value, standard deviation and coefficient of variance for numerical data and percentage or proportion for categorical data. In bivariate analysis, it was used independent T test and Pearson correlation test. Of each analysis, it was used P value, R, and R^2. Meanwhile, the multivariate analysis used multiple linear regression analysis. The statistical analysis used SPSS 17.00 program.

3. RESULTS

From the 1-OHP levels based on Control Exposure Limit (CEL) value grouping set by [19] equal to 0.49 µmol/mol urinary creatinine, it was found that in the group of driver as many as 9 people (50%) that exceed the limit of non-driver group there were 3 people (18.8%) exceeding the CEL limit. Meanwhile, in both group there were two 12 people (35.3%) having concentrations above the CEL values (Table 1).

Table 1: 1-OHP Category in urine on driver and Non-Driver Based on the Value of CEL

1-OHP Concentration in urine (µmol/mol urinary creatinine)	Drivers		Non-Drivers		Total	
	Number	%	Number	%	Number	%
Above *Control Exposure Limit*	9	50	3	18.8	12	35.3
Below *Control Exposure Limit*	9	50	13	81.3	22	64.7
Total	18	100	16	100	34	100

Control Exposure Limit = 0.49 µmol/mol creatinine (ACGIH, 2013)

Table 2 shows in the BMI category, the largest concentration was in the category of underweight. Not married had the mean of 1-OHP concentrations higher than married. On education and income variables, it was also showed the mean of 1-OHP in urine was higher in educated and low-income workers. Drivers had higher concentrations than non-drivers. Behavior did not wear PPE, smoking and use of cooking fuels other than gas also had higher concentration of 1-OHP in urine. In this study, it was found 1-OHP concentrations in urine higher than those who did not roasted foods.

A significant relationship among the variables of education, occupation, cigarette consumption per day and type of cooking fuel with a concentration of 1-OHP in urine of workers is shown in Table 3.

Table 2: Relationship Between 1-OHP Concentration and Various Variables

Variables	N	Mean of 1-OHP (µmol/mol urinary creatinine)	SD (µmol/mol urinary creatinine)	P-value	CI (95%)
IMT					
Underweight	1	0.69	0.19		
Normal	19	0.37	0.45	0.569	-0.37-0.71
Overweight	14	0.43	0.32		
Marital Status					
Unmarried/single	3	0.49	0.22	0.641	-0.3-0.49
Married	31	0.4	0.33		
Education					
Low	16	0.52	0.39	0.041	0.01 – 0.43
High	18	0.3	0.19		
Income					
Low	6	0.62	0.61	0.073	-0.2-0.53
High	28	0.36	0.21		
Occupation					
Driver	18	0.51	0.37	0.039	0.33-0.7
Non-driver	16	0.29	0.2		
Use of PPE					
No	7	0.59	0.57	0.083	-0.03-0.50
Yes	27	0.36	0.20		
Smoking Habit					
Yes	31	0.41	0.33	0.845	-0.43-0.36
No	3	0.45	0.3		
Roasted Food Consumption					
Yes	15	0.32	0.23	0.176	-0.37-0.07
No	19	0.47	0.37		
Types of Fuel					
Other than Gas	3	1.05	0.38	0.000	0.39-1.01
Gas	31	0.32	0.22		

Table 3: Relationship Between 1-OHP Concentration and Length of Work, Number of Cigarette Consumption and Smoking Duration

Variables	R	R^2	P-value
Length of work	0.189	0.036	0.284
Number of cigarette consumption per day	0.572	0.327	0.001
Smoking duration	0.015	0.000	0.935

Based on multiple linear regression multivariate analysis, (Table 4) it was obtained dominant variables affecting the concentration of 1-OHP in urine are education, occupation, income, consumption of cigarettes per day, use of PPE, fuel consumption, and type of cooking fuel, showing a positive correlation with medium strength/cohesion (R = 0.766).

Table 4: Final Model Resulting From Multiple Linear Regression Analysis of Risk Factors of 1-OHP Concentration in Urine

Variables	B	R	R^2	Adjusted R Square	P-value
Variables	1.989	0.766	0.587	0.449	0.004
Education	-.027				
Occupation	-.128				
Income	.052				
Number of cigarette consumption per day	.010				
Use of PPE	-.119				
Roasted food consumption	-.051				
Types of fuel to cook	-.673				

4. DISCUSSION

Based on the measurement of 1-hydroxypyrene (1-OHP) concentration in urine indicates that the mean of 1-OHP concentration in driver is higher than non-driver group. This is in line with the research conducted by [20] on bus drivers in Denmark. The high concentration of 1-OHP in urine is because the exposure received by the bus drivers (outdoor) is higher than non-drivers. Bus drivers in everyday life are on highway, a non AC buses. However, non-drivers are working indoors, mostly air-conditioned. Referring to the Control Exposure Limit launched by [19], the average of 1-OHP concentration in urine of average driver group is already above the CEL value, therefore, it is needed control. The control can be performed by modifying the exposure in environment and the exposure coming from human activities. On exposure to PAHs sources environment, it can be derived from the combustion of fuel for motor vehicles, smoking habits, steam/smoke of cooking oven at restaurants, and so on.

In this study, it is found that the variables of education, occupation, cigarette consumption per day and type of cooking fuel are related with the concentration of 1-OHP in urine. Workers with higher education are largely non-driver group working indoors so that they get lower PAHs exposure and the concentration of 1-OHP in urine is smaller. However, most of low-education workers are drivers who get higher exposure. Driver occupation has 1-OHP concentration in urine higher than non-drivers. This is because the driver group has more outdoors activities, so that they get higher PAHs exposure outdoor. The data in this study is in line with that performed by [17,20], showing that 1-OHP levels of driver urine are higher than in the comparator group

Total consumption of cigarettes per day affects the amount of PAHs exposure entering into the human body. The higher the number of cigarettes smoked, the higher the PAHs exposure to the human body is. This study shows that the number of cigarettes affects the 1-OHP levels in urine, in which every increase of 1 rod of cigarette consumption per day will increase 1-OHP level by 0.023 μmol/mol urine creatinine. Research conducted by [21] mentions that the 1-OHP levels at office workers in the industrial areas in Japan and Vietnam who do not smoke have the 1-OHP level far below the standards set and have a small chance of non-carcinogenic and carcinogenic health effect disruption including mutagenic and teratogenic effects. Factors of smoking habits, diet and region of residence (urban and sub-rural) are also significant difference factor of 1-OHP levels in individuals of society in Kinshasa (Democratic Republic of Congo) [22].

The finding in this study is that the content of 1-OHP in urine of users of fuel other than gas is higher than that using gas. This is in line with research conducted by [23] finding that 1-OHP concentration in urine is related to with the habit of cooking using stove/charcoal. In another study, it is obtained a significant difference of 1-OHP levels between employees of restaurants in Vietnam exposed to cooking oven and 1-OHP in the control with the value of respectively 2.23 ng/mg creatinine and 0.39 ng/mg creatinine [12] and on [24] research, showing the significant difference in 1-OHP levels between workers exposed to restaurant kitchen oil and steam and workers and workers are not exposed as the control with 1-OHP value of 6.0 (SD 8.0) mmol/mol creatinine in workers and 2.4 (SD 4.3) mmol/mol creatinine in the control with the factor of length of working hours also affects the levels of 1-OHP on the workers. The use of fuels other than gas (firewood, kerosene) can cause incomplete combustion. PAHs is a hydrocarbon compounds formed by incomplete combustion. Therefore, it can increase the concentration of PAHs in air. Increased PAHs in the air may increase exposure to human body through the respiratory tract to thereby increasing the 1-OHP level in urine. An effort to reduce the concentration of PAHs in the air is by replacing the use of firewood into gas.

Although in this study it is not measured health effects or biomarker, several studies have shown a strong correlation between PAHs and 1-OHP and health problems. Increased oxidative stress such as increased levels of urinary MDA is significantly affected by the concentration of urinary PAHs and BAP [24,25]. PAHs also affects the incidence of asthma in children as the results of research conducted in Korea in which the urinary 1-OHP in children with asthma is higher (0.430 ± 0.343 mol/mol creatinine) than urinary 1-OHP in the control of children without asthma (0.239 ± 0.175 mol/mol creatinine) [9]. Cardiac Autonomic Dysfunction also occurs due to PAHs exposure with 1-OPH biomarker in boiler maker workers [10].

5. CONCLUSION

From this study we can conclude that there is a significant correlation of 1-OHP levels between bus driver and bus non-driver at Depok bus station. The dominant factors affecting the concentration of 1-OHP in urine are education, occupation, income, number of cigarettes consumption per day, use of PPE, fuel consumption, and type of cooking fuel.

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7. REFERENCES

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