Conference Paper

Analysis of Personal Exposure to Particulate Matter 2.5 and Subjective Respiratory Diseaseamong Mechanical Test Officers

Aisyah Indriani, Anisa Kurniati, and Doni Hikmat Ramdhan

Department of Occupational Health and Safety, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia

Abstract

Exposure to particulate matter 2.5 ($PM_{2.5}$) in both the short and long term is known to result indeath by respiratory diseases. This study aimed to measure personal exposure concentrations to $PM_{2.5}$ and the percentage of subjective respiratory complaints frommechanics in the Vehicle Testing Centre (VTC) unit Ujung Menteng in 2015. This study was a descriptive study that measured the personal exposure concentration of $PM_{2.5}$ during working hours; it used personal sampling equipment, such as theLeland Legacy pumpand the Sioutas Cascade Impactor. The research subjects were 21 mechanical test officers. The results showed that the average personal exposure concentration of $PM_{2.5}$ experienced by mechanical test officers amounted to 272.35μm/m^3, and 90.5% ofthe mechanical test officers experienced respiratory complaints with the most common complaints being nasal congestion (76.2%) and a sore throat (57.1%). The highest average exposures to $PM_{2.5}$ that were experienced by the mechanical test officers were in mechanical testing area 2, which was the testing area for heavy vehicles.

Keywords: Particulate Matter 2.5 ($PM_{2.5}$); respiratory complaints; vehicle testing

Corresponding Author:
Doni Hikmat Ramdhan
doni@ui.ac.id

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1. INTRODUCTION

Poor air quality is a major public health problem, especially in urban areas. According to a WHO (2014) report, approximately seven million people in the world die due to air pollution [1]. Particulate matter (PM) is a dangerous pollutant of various sizes; exposure to it cancausehigh mortality rates due to air pollution. The size of airborne PM is an important factor affecting the health of thoseexposed to PM, where smaller particulates will result in more dangerous health effects [2]. $PM_{2.5}$ is one type of particulate that has a small size; if inhaled,it can penetrate into the lower respiratory tract as well asthegas exchange in the lungs and can then travel through the bloodstream [2, 3].

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$PM_{2.5}$ exposure in the short and long term is associated with a variety of acute and chronic adverse health effects,such as asthma, lung cancer, and cardiovascular disease [4]. In the workplace, exposure to $PM_{2.5}$ is a problem for workers' health. At railroads, workers are exposed to $PM_{2.5}$ from diesel exhaust; their risk of developing chronic lung diseases increases by 2.5% annually [5]. High exposure to $PM_{2.5}$ is also present for 55 outdoor workers in Mexico and Puebla, as well as tollbooth guardsin Taiwan [6]

Several studies have shown that the main source of $PM_{2.5}$ is vehicle emissions. In addition, vehicles using diesel fuel alsoresults inhigh emissions of $PM_{2.5}$ or Diesel Particulate Matter (DPM). One workplace that contributes to raising $PM_{2.5}$ or DPM exposure is the Vehicle Testing Centre (VTC). The VTC performs feasibility testing onmotor vehicles in Jakarta; each day it tests hundreds of thousands of vehicles.

The emissions enhancement of $PM_{2.5}$ or DPM will increase the exposure of $PM_{2.5}$ for mechanical test officers,which can increase their risk for developing many diseases, some of which are respiratory diseases. Their high risk of developing respiratory diseases and the lack of $PM_{2.5}$ Threshold Limit Values (TLV) have led the researchers to believe that it is important to carry out this research.

2. METHODS

$PM_{2.5}$ was collected according to the US EPA IP-10A method, which adapted SKC using the Sioutas Cascade Impactor and which can divide PMs by size. Quartz fiber filters were placed in the impactor and sucked by the Leland Legacy personal pump at a flowrate of 9 liters/min. Twenty-onemechanics from the Ujung Menteng VTC were selected to use thePM personal exposure apparatus during their work hours. The mean concentration of PM was calculated with a gravimetric method using microbalance, where all the filters were being conditioned in a balance room for 24hours before the initial and final weights were taken. The subjective respiratory health effect was measured using a questionnaire adapted from the American Thoracic Society. The questionnaire was used to measure acute respiratory health issues and other health problems. The data analysis was performed by univariate analysis for personal exposure concentrations of $PM_{2.5}$ and subjective respiratory complaints, while the bivariate analysis determined the average personal exposure to $PM_{2.5}$ between officers with and without respiratory complaints.

3. RESULTS

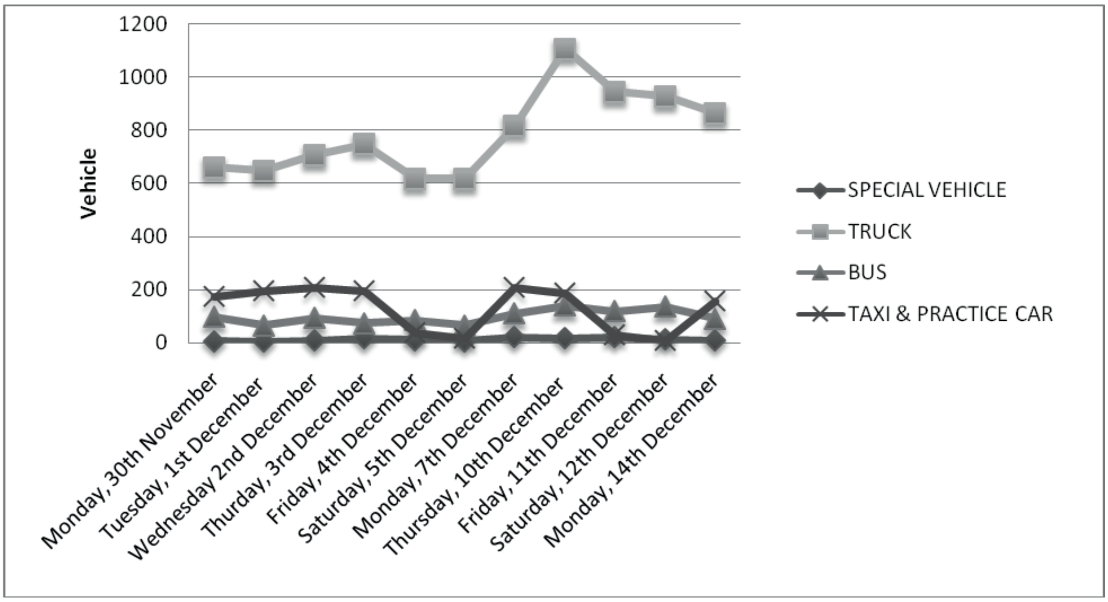

Figure 1: Distribution and Type of Vehicle.

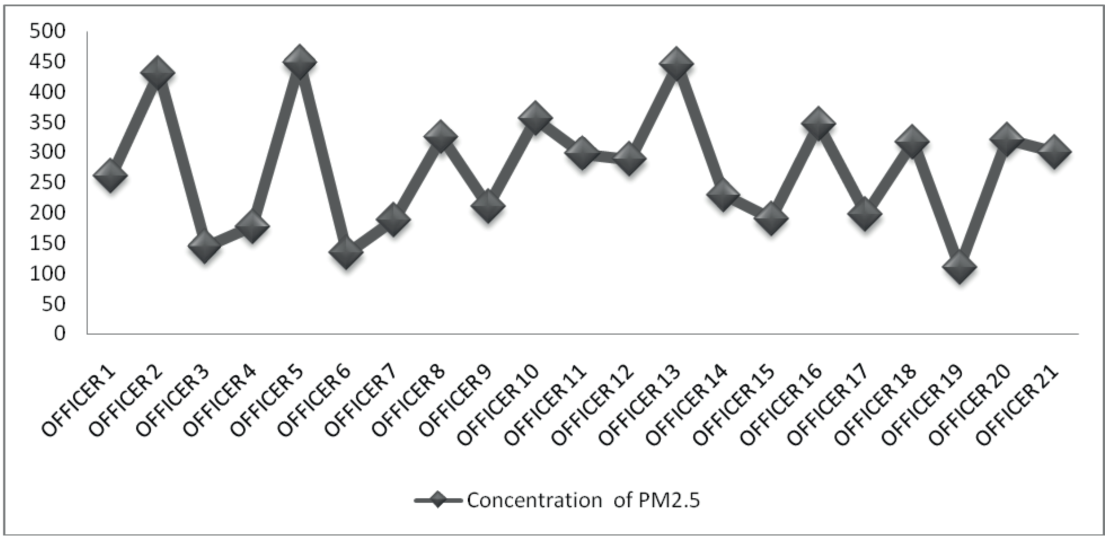

Figure 2: Personal Exposure Concentration of $PM_{2.5}$ in Mechanical Test Officers.

3.1. Distribution amount and type of vehicle

Figure 1 shows that the most common type of vehicle was heavy vehicles (78.65); the overall average of the vehicleswas1,044.81.

3.2. Personal $PM_{2.5}$ exposure concentration in mechanical test officers

Figure 2 shows the personal exposure concentrations of $PM_{2.5}$ among the mechanical test officers. The highest personal concentration of $PM_{2.5}$ exposure was for officer

Table 1: Overview of Subjective Respiratory Complaints.

Respiratory Complaints	Total
	n
Yes	19
No	2

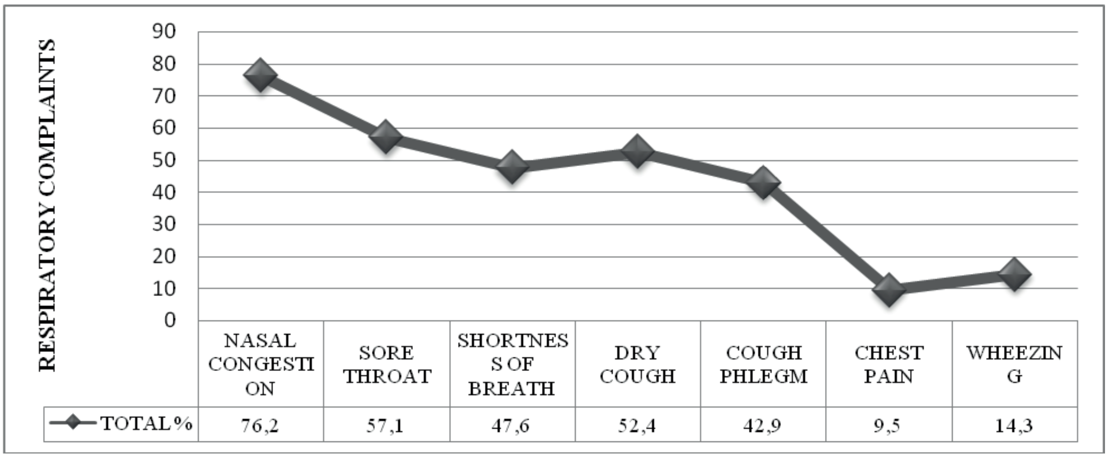

Figure 3: Type of Subjective Respiratory Complaints.

(448.33µg/m^3), and the lowest exposure concentration of $PM_{2.5}$ was for officer 19 (110.69 µg/m^3).

3.3. Subjective respiratory complaints by the mechanical test officers

Based on Table 1, it can be seen that 19 (90.5%) mechanical test officers had subjective respiratory complaints and only two officers (9.5%) did not have subjective respiratory complaints. In mechanical lane 2, all the officers had respiratory complaints; mechanical lanes 1 and 3, however, each had one officer who did not have respiratory complaints.

Based on Figure 3, the most common subjective respiratory complaint was nasal congestion, which was present in 16 officers (76.2%), and the least common was chest pain, which included two officers (9.5%).

3.4. Analysis of the average exposure to $PM_{2.5}$ based on subjective respiratory complaints

In Table 2, it can be seen that the officers who had respiratory complaints also showed a higher average $PM_{2.5}$. However, the officers who had complaints of a dry cough and

Table 2: Distribution of Average Exposure to $PM_{2.5}$ Based on Respiratory Complaints

Respiratory Complaints	Total (n)	Mean (μg/m³)	SD	p value
Nasal Congestion				
No	16	282.44	104.66	0.43
Yes	5	240.43	89.52	
Sore Throat				
Yes	12	290.69	85.92	0.351
No	9	248.09	118.61	
Shortness of Breath				
Yes	10	289.98	103.01	0.461
No	11	256.49	100.85	
Dry Cough				
Yes	10	264.63	95.24	0.744
No	11	279.54	109.68	
Cough Phlegm				
Yes	9	280.93	85.67	0.747
No	12	266.07	114.11	
Chest Pain				
Yes	2	209.86	27.47	0.369
No	19	279.02	103.73	
Wheezing				
Yes	3	274.64	147.85	0.969
No	18	272.07	96.82	

chest pain had an average exposure to $PM_{2.5}$ lower than the officers who did not have respiratory complaints. Based on the results of the statistical tests, on all the respiratory complaints, there was no significant difference between the average exposures to $PM_{2.5}$ for officers who had respiratory complaints.

4. DISCUSSION

4.1. Distribution type of vehicle

There was a large number of vehicles tested on Thursday (December 10, 2015) because the previous day (December 9, 2015) had been a national holiday, which meant there had been no service. Therefore, many vehicles were tested on Thursday. Of the vehicle types,heavy vehicles were the largest. Because of the three-lane mechanical area, mostly heavy vehicles were tested.

4.2. Personal concentration of $PM_{2.5}$ in mechanical test officers

The average personal exposure concentration of $PM_{2.5}$ in mechanical test officers was 272.44µg/m^3. Exposure was highest for officer 5 in the area of mechanical lane 2, which had a concentration of 448.33 µg/m^3. Officer5's high personal exposure to $PM_{2.5}$ was due to multiple factors. First, mechanical lane 2 tested most of the heavy vehicles.Heavy vehicles typically use diesel fuel, and diesel emissions contain more $PM_{2.5}$ than other fuels. Research by Ccoyllo et al. (2009) also showed that $PM_{2.5}$ emissions generated by heavy duty vehicles were six times higher than light duty vehicles [7]. Second, mechanical lane 2 is in the middle position of the mechanical room, so $PM_{2.5}$ allegedly resulted from the emissions of various heavy vehicles. Research by Wardencki (2014) showed that the concentration of $PM_{2.5}$ is affected by low wind speeds [8]

The lowest exposure of $PM_{2.5}$ was forofficer19, who was in mechanical lane 1 and had a concentration of 110.69 µg/m^3. Vehicles entering lane 1 did not use diesel fuel, so less $PM_{2.5}$ was produced. In mechanical lane 1, officer 19 was in the closest position to the lane's exit, allowing $PM_{2.5}$ from emissions to be directly carried out by the wind as the wind speed increased. Cheng and Li (2010) showed that the concentration of $PM_{2.5}$ decreases when the wind speed increases [9].

The above elaboration of the two examples shows a very high amount of $PM_{2.5}$ being inhaled by mechanical test officers every day.

Various studies have shown that high exposure to $PM_{2.5}$ can increase the risk of morbidity and mortality due to cardiovascular diseases, respiratory diseases, and other ailments. Many epidemiological studies have shown that a consistent average exposure of $PM_{2.5} \geq 13$µg/m^3 can result in cardiovascular and respiratory diseases. With every 10µg/m^3 increase of $PM_{2.5}$, the risk of developing respiratory diseases increases by 2.13 times,and each 10µg/m^3 increase in $PM_{2.5}$ exposure in the short term amounts to a 0.6 times increased likelihood of experiencing COPD [4, 10, 11]

4.3. Distribution of personal exposure to $PM_{2.5}$ in the mechanical test area

The higher average concentration of $PM_{2.5}$ was due to the lane area being a semi-confined room, which allowed $PM_{2.5}$ from vehicle emissions to accumulate. Cheng et al. (2012) conducted research on the measurement of $PM_{2.5}$ exposure for workers in semi-confined Taipei bus terminals [2]. Their results indicated that $PM_{2.5}$ exposure was higher than $PM_{2.5}$ exposure for workers at the open-air bus terminal; semi-confined lane areas led to a decrease in the wind speed, which increased the concentration of $PM_{2.5}$.

The high average exposure to $PM_{2.5}$ in lane 2 wasalso due to the many heavy vehicles tested. The EPA (2002) showed that 50–90% of diesel exhaust particles are fine particulates [12]. Moreover, other conditions can also increase emissions of $PM_{2.5}$, such as the the vehicle being slowed when inside the lane area of mechanical and being not run-swappable when testing or waiting for testing. The studies of Wang et al. (2010) and Cheng et al. (2012) indicated that $PM_{2.5}$ emissions increase as vehicles slow down and not run during the engine life compared to the post-restart [2, 13]

A lack of control in the mechanical area can also lead to high exposure to $PM_{2.5.}$ The lack of an adequate exhaust fan can change the air exchange capacity. Borgini et al. (2015) showed that $PM_{2.5}$ concentration in an indoor area is influenced by the capacity of air exchange [14]. The lowest average concentration of $PM_{2.5}$ was in lane 1; this was because lane1 is specifically for light vehicles. Cheng et al. (2010) showed that exposure to $PM_{2.5}$ for toll booth guards who served smaller cars was 6.7 times than toll booth guards who served heavy vehicles [9].

4.4. Subjective respiratory complaints

The previous chapter showed that 19 officers (90.5%) had subjective respiratory complaints and that only two (9.5%) did not have respiratory complaints. The most commonly reported respiratory complaint was nasal congestion (76.2%), and the least common complaint waschest pain (9.5%). This result is consistent with the study by Garcia et al. (2013), which examined 447 traffic police in Colombia and showed a high percentage of nasal congestion (59.4%) [15]. However, the low percentage of cough phlegm and wheezing in this study is not in line withthe study by Karita (2001) on traffic police in Bangkok, which showed a high prevalence of cough phlegm and wheezing [16].

However, the results showed no significant difference between the average exposure to PM for officers with and without respiratory complaints. The results were not consistent with other studies, which showed an association between exposure to $PM_{2.5}$ and breathing disorders.

5. CONCLUSIONS

Personal exposure to $PM_{2.5}$ for the mechanical test officer swasan average concentration of 272.437 μg/$m^3$with the highest exposure being 448.333μg/m^3. The highest exposure was in lane 2 because most of tested vehicles were heavy vehicles, while the lowest average concentration of $PM_{2.5}$ was in lane 1, which was the lane for light vehicles. Among the 21 officers, 19 had subjective respiratory complaints (90.5%).

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