Conference Paper

Environmental Factors and Lung Function Impairment among Household Industrial Workers of Stone-Carving Crafts at Maritengngae Subdistrict, Sidrap Regency 2016

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Abstract

When inhaled by humans, $PM_{2.5}$ concentrations in the air deposit in the alveoli which can cause inflammation that decreases lung function. Temperature, humidity, and wind speed can affect workplace air pollutants. This cross-sectional study assessed the relationship between environmental factors ($PM_{2.5}$ concentration, temperature, humidity, and wind speed) and lung function impairment among 100 workers in the Maritengngae subdistrict, Sidrap Regency. Lung function was assessed via spirometry. Temperature, humidity, and wind speed were assessed via a thermohygroanemometer. $PM_{2.5}$ concentration in the workplace was assessed via a Haz Dust EPAM 5000. Chi-square analysis showed $PM_{2.5}$ concentration and wind speed had a significant correlation to lung function impairment. Therefore, it should be considered for implementing health and safety programs among workers, monitoring workplace implementation, and performing occupational health surveillance.

Keywords: Environmental Factor, Lung Function, Stonecutting Industry

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1. INTRODUCTION

Pollutants can contaminate the air and affect human health. Particulate matter (PM) is a pollutant that can be found within air as a result of human activities (anthropogenic), such as transportation, room heating, biomass burning, traffic emissions, and industrial activities [14].

PM can affect human health depends on the size of the area in which the dust is deposited [6]. If $PM_{2.5}$ in the air is inhaled by humans, it will be deposited into the

alveoli, causing inflammation that limits the lungs' capacity to expand [5]. One of the negative impacts of $PM_{2.5}$ exposure in humans is decreased lung function [9].

Although air pollution in every site varies from time to time, emissions are relatively constant [2]. Temperature, humidity, and wind speed influence the condition of air pollution, including air pollutants within a room [4].

The World Health Organization (WHO) Report 2012 shows that respiratory illness, including asthma and Chronic Obstructive Pulmonary Disease (COPD), is ranked as the third main cause of mortality around the world [15]. Riskesdas (Basic Health Research) 2013 shows that COPD prevalence among the ≥30 age group is 3.7%, and the South Sulawesi province is ranked as the province with the third-highest COPD prevalence at 6.7% [8]. Sidrap is one of the South Sulawesi regencies with a high prevalence of lung function impairment. Based on data from two hospitals in the Sidrap Regency, COPD has increased over the past three years. In 2013, there were 112 outpatients and three deaths. Those numbers increased 83% in 2014 and went up again in 2015 by 15%.

The Sidrap Regency is well known as a center for stone-carving productions, such as gravestones, pestles, and mortars. This home industry activity is one of the main income sources for the surrounding community. The crafters have a high risk of being exposed to stone dust particles resulting from the cutting, shaping, and grinding process. This can be observed in workshops, where the air is thick with dust and the temperature is extremely hot. Based on the information collected, most crafters complain about illnesses with symptoms such as coughing and breathlessness; however, they rarely visit a Puskesmas (Primary Health Center) or hospital to receive treatment since they see these conditions as common consequences from their job.

This iceberg phenomenon happening in this area is expected to be much larger than the recorded cases due to the absence of those who suffer from coughing and breathlessness but do not want to be examined in Puskesmas. Therefore, there is an immediate need to assess the crafters' lung function to detect impairment. This research aimed to analyze the correlation between environmental factors ($PM_{2.5}$ exposure, temperature, humidity, and wind speed) and lung function impairment among the stone-carving home industry's crafters in Allakuang Village, Maritengngae Subdistrict, Sidrap Regency, South Sulawesi.

2. METHODS

This study used a cross-sectional design. The sample consisted of the stone-carving home industry's male crafters in the Allakuang Village, Maritengngae Subdistrict, Sidrap Regency that met the inclusive criteria of living in the Allakuang village and being willing to participate. Meanwhile, the crafters who suffer from asthma (while the study was being held or because of a genetic factor) and those who were not present while the research was conducted were excluded from this study. Therefore, 100 respondents were chosen for the sample.

The independent variables in this research were the workplace environmental factors of $PM_{2.5}$ concentration, temperature, humidity, and wind speed, while the dependent variable was the physiological condition of the crafters' lungs. This study used primary data collected through the measurement method and health examinations. Physiological lung data was collected through spirometry examination, and $PM_{2.5}$ concentration was measured via a Haz Dust EPAM 5000 tool. Temperature, humidity, and wind speed were measured with a thermohygroanemometer. Data collection was performed from April – May 2016. Chi-square was used for data analysis. This study has passed the ethical review procedure and has been declared eligible with the decree of ethics review No. 173/UN2.F10/PPM.00.02/2016 from the Faculty of Public Health, Universitas Indonesia.

3. RESULTS

The measurement of $PM_{2.5}$ Concentration in stone-carving workplaces showed that the average $PM_{2.5}$ concentration in the air was 2.8 mg/m^3, with the lowest $PM_{2.5}$ Concentration being 0.004 mg/m^3 and the highest $PM_{2.5}$ concentration being 9.124 mg/m^3. The temperature in the stone-carving industry workplaces varied between 32.5°C – 35.8°C, with the average being 34.3°C. The temperatures in all industry workplaces exceeded the threshold requirements per the Health Ministerial of Republic of Indonesia Regulation No. 1405/MENKES/SK/XI/2002 on Environmental Health Requirements of Workplace and Industry (Table 1).

The humidity measurement results showed that the average humidity in workplaces was 54.02%, with 41.9% as the lowest humidity and 65.8% as the highest. The average wind speed in stone-carving workplaces was 2.2 m/second, while the slowest wind

Table 1: Distribution of PM2.5 Concentration, Temperature, Humidity, and Wind Speed

Variable	Mean	Median	SD	Min-Max
$PM_{2.5}$(mg/m^3)	2.835	2.8	2.55	0.004-9.12
Temperature (°C)	34.290	34.5	1.02	32.5-35.8
Humidity (%)	54.017	53.3	7.315	41.9-65.8
Wind Speed (m/second)	2.197	1.9	0.792	1.3-3.7

speed was 1.3 m/second and the highest was 3.7 m/second. This showed that none of the wind speeds around those workplaces met the ministrial regulations (Table 1).

3.1. Lung Function Impairment

The stone-carvers' lung function results showed decreased lung function among 62 respondents (62%), restrictive lung function among 56 respondents (56%), and obstructive lung function among six respondents (6%; Table 2).

3.2. $PM_{2.5}$ Concentration

Based on the measurement results, only four of the 41 measurement points met the threshold of $PM_{2.5}$ concentration stipulated by the US EPA. Analysis of the results showed a significant correlation between $PM_{2.5}$ concentration and lung function impairment, demonstrating a 4.17-times greater risk to suffer lung function impairment compared with those in workplaces with $PM_{2.5}$ concentrations that meet safety requirements.

3.3. Temperature

There is no correlation between workplace temperature and lung function impairment; however, the data showed a significant proportion difference between respondents who work in circumstances with a temperature ≥ 34.29°C (67.3%) and < 34.29°C (55.6%). Furthermore, statistical test results showed that respondents who work within a temperature condition of ≥ 34.29°C have a 1.64-times greater risk of developing lung function impairment (Table 2).

Table 2: Association of Environmental Factors with Lung Function Impairment

Variable	Lung Function				Total		OR (95% CI)	p-value
	Impaired		Normal					
	N (62)	%	N (38)	%	N (100)	%		
$PM_{2.5}$ Concentration								
> 35 mg/m	51	71.8	20	28.2	71	100	4.2 (1.68- 10.38)	0.003
≤ 35 mg/m^3	11	37.9	18	62.1	29	100		
Temperature								
≥ 34.29 °C	37	67.3	18	32.7	55	100	1.6 (0.73-3.71)	0.320
< 34.29 °C	25	55.6	20	44.4	45	100		
Humidity								
< 65% or > 95%	58	63	34	37	92	100	1.7 (0.40-7.27)	0.474
65-95%	4	50	4	50	8	100		
Wind Speed								
< 1.9 m/sec	37	80.4	9	19.6	46	100	4.8 (1.93-11.77)	0.001
≥ 1.9 m/sec	25	46.3	29	53.7	54	100		

3.4. Humidity

Statistical analysis of the correlation between humidity and lung function impairment showed no significance. However, statistical test results showed that respondents who work within a humidity condition that did not meet the requirements have a 1.7-times greater risk to suffer impaired lung function compared with those in a workplace circumstance that meets the humidity criterion.

3.5. Wind Speed

Analysis of wind speed and lung function impairment showed a significant correlation. Respondents who work in a workplace with a wind speed < 1.9 m/second have a 4.8-times greater risk to develop impaired lung function compared than those who work under circumstances with a wind speed ≥ 1.9 m/second.

4. DISCUSSION

The stone-carvers' lung function results showed decreased lung function among 62% of respondents, and 90% of those individuals had a restrictive type of pulmonary disease. This was in line with research conducted among rock-breakers in Mojokerto that showed decreased lung capacity with restrictive pulmonary disease present in 67% of respondents. Decreased lung capacity occurs due to reduced lung elasticity from the fibrosis process stemming from exposure to dust containing silica [10].

The majority of crafters work in environments with $PM_{2.5}$ concentrations that do not meet the safety requirements. This research found that some industries with similar activities have lower $PM_{2.5}$ concentrations. Industries with qualified $PM_{2.5}$ concentrations usually apply a wet method, using grinders connected to water hoses during cutting, shaping, and stone grinding so that the dust can be minimized.

Analysis of $PM_{2.5}$ concentration and lung function results showed a significant correlation, which supports previous studies that have indicated a correlation between increasing $PM_{2.5}$ concentration and lung function impairment. A cohort prospective study by the American Cancer Society among 1.2 million adults in the United States over 26 years (1982-2008) found that the mortality rate among lung cancer increases by 15 – 27% if the $PM_{2.5}$ concentration increases by 10 $\mu g/m^3$ [13].

Analysis showed that those who work in conditions with 1.9 m/second wind speed have a 4.8-times greater risk of suffering impaired lung function compared with those who work in conditions with ≥ 1.9 m/second wind speed. This supports the theory that wind can contain air pollutants, particularly gas and micro-particles. The stronger the wind blows, the more pollutants will be scattered. This makes the pollutants less concentrated so that it is easier to be carried by the wind, and this can change according to the environmental circumstances [1].

Wind flow velocity influences the air movement and circulation inside the room. Wind speed less than 0.1 m/second makes the room uncomfortable because there is no air movement [3]. This is also supported by a study in India that indicated ventilation availability in a kitchen can eliminate pollutants such as $PM_{2.5}$, aliphatic hydrocarbons, and polycyclic aromatic hydrocarbons from cooking activities [11].

Analysis of the correlation between temperature and humidity showed no significance with lung function. However, statistical test results also showed that workers in conditions ≥ 34.29°C are at a 1.64-times greater risk of impaired lung function compared with those who work in circumstances < 34.29°C. Workers in humid conditions

that do not meet the safety requirements are at a 1.71-times greater risk to develop impaired lung function compared to those who work in adequate humidity.

This finding supports previous studies that identified environmental factors, such as humidity and temperature, influence impaired lung function cases [12] and that humidity can affect dust particle concentration in the air [7].

5. CONCLUSIONS

The environmental factors that have a significant correlation with lung function impairment are PM2.5 concentration and wind speed. This study found that some industries with similar activities have lower $PM_{2.5}$ concentrations because they apply a wet method to minimize dust in the workplace by channeling water through a hose attached to the grinder. This method is effective in reducing dust and should be promoted among industry owners. In addition, personal protective equipment (PPE) must be used during work, such as a reuseable full-face respirator that can protect lungs and eyes from iritation and dust exposure. This study also found that wind speed could promote impaired lung function. We could prevent this risk factor by encouraging the industry owners to construct their buildings with proper air ventilation to ensure air circulation in the workplace. Furthermore, this study can hopefully contribute to the local government positioning the stone-carving industry far away from densely populated areas and to push industry owners to meet the standards for industrial health and environmental safety.

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