Internal Factors Related to Pulmonary Function Status of Workers at UD X

Faktor Internal Pekerja yang Berhubungan dengan Status Faal Paru pada Pekerja UD X

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ABSTRACT

Introduction: The processing of marble stone produces air pollution in the form of dust. Dust emission is generated from cutting, scraping, and polishing processes. The type of dust emission is Particulate Matter 2.5 (PM2.5). The dust level and exposure period can cause lung problems and respiratory complaints. The study aims to determine the factors related to the pulmonary function's status of workers at UD X, Campurdarat Sub-district, Tulungagung District. **Metods:** This research used cross-sectional research design and quantitative approach. The sample of this study was 32 people consisting of 26 workers exposed to dust and 7 workers unexposed to dust. The independent variables include were gender, age, working period, education level, smoking habit, and use of Personal Protective Equipment (PPE). **Results:** In general, the pulmonary function of workers at UD X was quite good. **Conlusion:** The smoking habit and the use of PPE had a relationship with the pulmonary function of workers at UD X, Campurdarat Sub-district, Tulungagung District.

Keywords: internal factor of worker, pulmonary function, workers

ABSTRAK

Pendahuluan: *Proses pengolahan batu marmer menghasilkan cemaran udara berupa debu. Emisi debu dihasilkan dari proses pemotongan, penskrapan dan pemolesan. Jenis emisi debu yang dihasilkan berupa Particulate Matter 2,5 (PM2.5). Kadar debu yang tinggi dan terakumulasi dalam jangka waktu lama akibat proses respirasi dapat menyebabkan gangguan paru dan keluhan pernapasan. Penelitian ini bertujuan untuk mengetahui faktor internal yang berhubungan dengan status faal paru pada pekerja di UD X Kecamatan Campurdarat, Kabupaten Tulungagung.* ***Metode:*** *Penelitian ini menggunakan desain penelitian cross sectional dengan pendekatan kuantitatif. Sampel penelitian ini sebanyak 32 orang yang terdiri dari 26 pekerja terpapar debu dan 7 pekerja yang tidak terpapar debu. Variabel bebas pada penelitian ini yaitu jenis kelamin, usia, masa kerja, tingkat pendidikan, kebiasaan merokok dan penggunaan APD.* ***Hasil:*** *Secara umum, kondisi status faal paru pada pekerja di UD X tergolong cukup baik.* ***Simpulan:*** *Terdapat hubungan antara kebiasaan merokok dan penggunaan APD terhadap status faal paru pekerja di UD X Kecamatan Campurdarat, Kabupaten Tulungagung.*

Kata kunci: *faktor internal pekerja, pekerja, status faal paru*

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INTRODUCTION

Industrial development aims at stimulating economic development of a country, so that it will be beneficial for the country's next developmental stage. One of the consequences of industrial development is the increase of industrial waste, including air pollution that can change environment's ambience and indoor air quality (Mukono, 2010). Air quality standard for national ambience according to the Regulation of the Minister of Environment and Forestry (2010) consists of sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), hydrocarbon (HC), particulates ($PM_{2,5}$ and PM_{10}), dust (TSP), lead (Pb), and dustfall.

Air as one of the natural components is extremely crucial, so the quality must be maintained and improved to provide optimal supporting capacity for living beings. Air

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pollution occurs along with the rapid industrial development. It can also be the result of atmospheric change due to an intrusion of both natural and artificial contaminants into the natural environment (Mukono, 2010).

Excessive exposure to air pollution can affect human body. One of air pollutants potentially causes pathological damage to human is particulates. High and stable concentration of particulate matters in some areas can be harmful for human health. Particulates are mostly investigated due to its ability to penetrate into the deepest part of human's lungs (Marpaung, 2012).

The Particulate Matter (PM) is air pollutant comprising of some mixtures of solid and liquid particles. Dust particulates fall into two categories based on size, namely dust particulates less than or equal to 10 micrometer (PM10) and those less than or equal to 2.5 micrometer (PM2,5) (Environmental Protection Agency, 2017). PM 2.5 can be directly or indirectly formed in the air. Under the on Regulation of the Minister of Health (2002) concerning Health Requirements for Workplace Environment in Offices and Industry, the maximum dust level in the industrial work environment at an eight-hour measurement is 10 mg/m^3.

Tulungagung District is one of the biggest marbles-producing areas in Indonesia. There are two sub-districts which become the industry center, Campurdarat and Besuki. The marble production in Campurdarat Sub-district reaches 32,371 m^3. Marble mining has been carried out by private business entities. Mined marble stones are then processed into various products, including floors, tables, chairs, statues, and even bathtubs. Within the industry center, there is a mining area where various companies, either small or medium-to-large, engage in marble processing sector. It automatically opens many employment opportunities for the local community.

The marble stone industry is one of the industries contributing to air pollution. Marble stone processing potentially causes pollution of dust which is produced during cutting, scraping, and polishing. Marble dust contains several chemical substances, such as CaO, SiO, and MgO. Its content (PM2.5) is almost equal to limestone dust.

The whole processing consists of several stages, namely cutting, scraping, drying, caulking, heating, polishing, and drying. During the whole process, it produces air pollution in the form of dust from cutting, scraping, and polishing. The type of dust emission is $PM_{2,5}$ (Particulate Matter 2.5). Some processes still require humans as the operators and expose them to the pollution. High level of long-term dust accumulation during respiratory process can trigger some lung diseases and respiratory complaints.

The long-term exposure to dust can cause permanent change to pulmonary function in the form of obstructive lung disease. It can also cause pulmonary fibrosis if it is continuously inhaled during work (Hapsari, 2009). Meanwhile, this research is conducted at one of the marble processing industries in Tulungagung District which have the most workers and larger than other similar industries.

This research aims to observe some internal factors related to the pulmonary function status of workers at UD X, a marble processing industry in Campurdarat Sub-district, Tulungagung District.

METHODS

This observational research was conducted at the marble processing industry of UD X, Campurdarat Sub-district, Tulungagung District. Based on the analysis nature and method, this research was included in the quantitative analytical research with the cross-sectional study. The research period started from October 2017 to July 2018.

The population of the research was all workers at the marble processing industry of UD X, Campurdarat Sub-district, Tulungagung District. It included as many as 70 people, which were then comprised to 48 workers at the location exposed to dust and 22 workers at the location unexposed to dust. The sampling method utilized stratified random sampling technique with two groups: exposed and unexposed groups. The sample of this research consisted of 33 workers: 26 workers exposed to dust and 7 workers unexposed to dust. Criteria as respondents included respondents' willingness and work period (must be at least 1 year).

Measurement of physical quality of work environment for dust level was assessed using EPAM-5000 monitor. Pulmonary function was tested using spirometer. This research had received an approval from National Ethic Commission of Health, Faculty of Public Health,

Universitas Airlangga, with the ethics certificate number: 274-KEPK.

RESULTS

Company Overview

UD X is one of the marble processing companies located in Campurdarat Sub-district, Tulungagung District. The products of UD X are marble stone handicrafts with export quality. This industry located in two separate locations, workshop or production place and showroom or product exhibition site.

UD X has operated for more than 25 years. The company was established due to extraordinary marble stone potential around UD X, which is marble stone as natural resources in the south of Tulungagung. This industry also opens employment for the local community.

The number of workers at UD X is 38 people. The workers are divided into two groups: 30 workers exposed to dust and 8 workers unexposed to dust. The group exposed to dust works in grinding, sawing, plucking, and scraping marble stone. Meanwhile, the unexposed group works at the store and the company office.

The raw materials in the production process are white and black marble stones. The materials do not only come from the marble stone mine in Tulungagung, but also from other districts like Blitar, Trenggalek, and Ponorogo. The average raw marble processed at UD X is as much as 30 m^3/week.

The production process at UD X is divided into two different stages. The first stage intends to produce the square products used as floors or walls; while the second stage intends to produce handicrafts like sculpture decoration and household furniture.

Characteristics of Respondents

The respondent characteristics in the marble processing industry are presented in Table 1. They include sex, age, working period, education level, smoking habit, and the use of PPE. The respondents are categorized into two, namely workers exposed to dust and those unexposed.

Table 1. The Distribution of Respondents of the Marble Processing Industry Workers at UD X in 2018

Variable	Work Location				Total	
	Exposed		Not Exposed			
	n	%	n	%	N	%
Sex						
Male	26	100	2	28.6	28	84.8
Female	0	0	5	71.4	5	15.2
Age						
>66	0	0	1	14.3	1	3
56-65	4	15.4	1	14.3	5	15.2
46-55	10	38.5	2	28.6	12	36.4
36-45	10	38.5	2	28.6	12	36.4
26-35	2	7.7	1	14.3	3	9.1
Working Period						
≤ 5	6	23.1	0	0	6	18.2
6-12	9	34.6	4	57.1	13	39.4
13-19	5	19.2	3	42.9	8	24.2
≥ 20	6	23.1	0	0	6	18.2
Education Level						
Elementary School	9	34.6	5	71.4	14	42.4
Junior High School	9	34.6	1	14.3	10	30.3
Senior High School	8	30.8	1	14.3	9	27.3
Smoking Habit						
Heavy smoker	7	26.9	2	28.6	9	27.3
Moderate smoker	11	42.3	0	0	11	33.3
Light smoker	6	23.1	0	0	6	18.2
Non-smoker	2	7.7	5	71.4	7	21.2
Use of PPE						
Without PPE	15	57.7	2	28.6	17	51.5
With PPE	11	42.3	5	71.4	16	48.5

Majority of workers at UD X are male (84.8%), while the rest (15.2%) are female. Based on the worker's age, most workers are within 36-45 years old (36.4%) and 46-55 years old (36.4%). Minority of worker's age falls into the age range of more than 66 years old (3%).

Most respondents (39.4%) have worked at UD X for 6-12 years. The workers mostly have elementary school education (42.4%). The worker's smoking habit is divided into four categories, namely heavy, moderate, light, and non-smokers. Most respondents (33.3%) are moderate smokers. The use of Personal Protective Equipment (PPE) among the respondents is as many as 51.5%.

The Measurement Results of Environmental Quality in the Workplace

Table 2. The Measurement Result of Physical Quality of UD X in 2018

Location of Measurement	Temperature and Humidity (°C and %)	Dust Level (mg/m^3)
Exposed	32,1 and 50	6,573
Unexposed	33 and 46	0,039

The measurement of physical quality of work environment at UD X, Campurdarat Sub-district, Tulungagung District, consists of temperature, humidity, and dust level. The location comprises two locations: exposed and non-exposed to dust. The table above displays the measurement result of physical quality of work environment. The highest measurement result for dust level is at the location exposed to dust, namely 6.573 mg/m^3; while unexposed location records 0.039 mg/m^3.

The Measurement Results of Worker's Pulmonary Function

The measurement of worker's pulmonary function is conducted at UD X using spirometer. Based on the examination result, it is found that as many as 19 workers (73.1%) at the exposed location have normal pulmonary function; while 7 workers (26.9%) at the exposed location and 2 workers (28.5%) at the unexposed location record abnormal pulmonary function status. The pulmonary function disorder experienced by the workers at X locations is the restrictive lung disease. As many as 7 workers at UD X have the pulmonary disorder in the form of light restriction while 2 workers experience moderate disorder.

Table 3. The Pulmonary Function Status of Workers at the Marble Processing Industry of UD X in 2018

Work Location	Pulmonary Function Status		Total
	Normal	Restrictive Lung Disease	
Exposed	19	7	26
	73.1%	26.9%	100%
Not exposed	5	2	7
	71.5%	28.5%	100%
Total	24	9	33

The Relationship between Respondent Characteristics and Pulmonary Function's Status at UD X

Sex

Table 4. The Relationship between Sex and Pulmonary Function of Workers at UD X in 2018

Sex	Pulmonary Function Status		Total	p-value
	Restriction	Normal		
male	7	21	28	0.597
	25%	75%	100%	
female	2	3	5	
	40%	60%	100%	

Table 4 illustrates that most male respondents have normal pulmonary function. This category has as many as 21 respondents (75%). From the chi-square statistical test result, the obtained p-value is 0.597 (>α 0.05). It demonstrates that there is no relationship between sex and pulmonary function of workers at UD X, so that sex does not guarantee their pulmonary function.

Age

Table 5. The Relationship between Age and Pulmonary Function Status of Workers at UD X in 2018

Variable	p-value
Age **Pulmonary Function**	0.368

Table 5 presents the relationship between age and pulmonary function status of workers at UD X using Spearman correlation test. Based on the statistical test result, the obtained p-value is 0.368, which is larger than α (0,05) and signifies

no relationship between age and pulmonary function status of workers at UD X. Therefore, workers' ages are not necessarily correlated with his pulmonary function status.

Working Period

Table 6. The Relationship between Working Period and Pulmonary Function Status of Workers at UD X in 2018

Variable	p-value
Working Period **Pulmonary Function Status**	0.114

Table 6 indicates the relationship between working period and pulmonary function status of workers at UD X using Spearman correlation test. From the statistical test result, the obtained p-value is 0.114, which is larger than α (0.05) and indicates that there is no relationship between working period and pulmonary function status of workers at UD X.

Education Level

Table 7. The Relationship between Education Level and Pulmonary Function Status of Workers at UD X in 2018

Variable	p-value
Education Level **Pulmonary Function Status**	0.234

Table 7 shows the relationship between education level and pulmonary function status of workers at UD X using Spearman correlation test. Based on the statistical test result, the obtained p-value is 0.234 (α = 0.05), which means that there is no relationship between education level and pulmonary function status of workers at UD X.

The Relationship between Smoking Habit and Pulmonary Function Status of Workers at UD X

Table 8 demonstrates the relationship between smoking habit and pulmonary function status of workers at UD X using Spearman correlation test. Based on the statistical test result, the obtained p-value is 0.03, which is larger than α (0.05) and indicates that there is a relationship between smoking habit and pulmonary function status of workers at UD X. The correlation coefficient value is 0.378 which can be categorized as weak relationship.

Table 8. The Relationship between Smoking Habit and Pulmonary Function Status of Workers at UD X in 2018

Variable	p-value
Smoking Habit **Pulmonary Function Status**	0.03

The Relationship between the Use of PPE and Pulmonary Function Status of Workers at UD X

Table 9 indicates that most respondents using PPE have normal pulmonary functional status, encompassing as many as 15 respondents (93.7%). From the chi-square statistical test, the obtained p-value is 0.017. which is less than α (0.05), indicating a relationship between the use of PPE and pulmonary function's status of workers at UD X. The contingency coefficient value is 0.416, which can be categorized as moderate relationship.

Table 9. The Relationship between the Use of PPE and Pulmonary Function's Status of Workers at UD X in 2018

Use of PPE	Pulmonary Function Status		Total	p-value
	Restriction	Normal		
Without PPE	8	9	17	0.017
	47.1%	52.9%	100%	
With PPE	1	15	16	
	6.3%	93.7%	100%	

DISCUSSION

The Dust Level at UD X

Marble dust is produced from the marble processing, encompassing cutting, scraping, and polishing. It contains chemical substances, such as silicon dioxide (SiO_2), calcium oxide (CaO), and magnesium oxide (MgO).

The dust measurement at UD X utilizes EPAM-5000 monitor. The measurement results of dust level at UD X show 6.573 mg/m^3 at the location exposed to dust and 0.039 mg/m^3 at the unexposed location. The measurement results are still within the normal limit in accordance with the Regulation of the Minister of Manpower

and Transmigration Number 13 Year 2011 on Threshold Value Limits of Physical and Chemical Factors in the Workplace. The Threshold Value Limits (TVL) of dust according to the regulation is 10 mg/m^3.

Pulmonary Function's Status of Workers at UD X

Lungs are the body organ that is related to the environment outside the body. The maintenance of lung health relies on several factors, such as genetics, environment, social economic condition, and natural aging (Cacciottolo, 2013). Based on the pulmonary function test on 33 respondents at UD X, there are 7 workers (26.9%) at the exposed location and 2 workers (28.2%) at the unexposed location experiencing restrictive lung disease, and no respondent experiences obstructive lung disease. Meanwhile, 24 workers have normal pulmonary function's status. Overall, the number of workers at UD X who experience pulmonary function disorder is 9 people (27.2%) both at the exposed and non-exposed locations. It generally describes that the pulmonary function of the workers at UD X is quite good.

The results of the study in other stone processing industries show high prevalence of workers experiencing pulmonary function disorder. From one of the limestone milling industries in Tuban, as many as 91.6% workers experience pulmonary function disorder (Sudrajad and Azizah, 2016). Meanwhile, at a limestone company called CV. Sri Mulya Putra in Tuban, as many as 13% workers experience pulmonary function disorder (Armaeni and Widajati, 2016). From another research on the workers of limestone industry in Grobogan District, 60% workers experience pulmonary function disorder (Yulaekah, Adi and Nurjazuli, 2007). Compared to those researches, the pulmonary function's status of workers at UD X is considered low at 27.2%. The difference in pulmonary functional status prevalence can be caused by several factors, such as individual characteristics, smoking habit, and the use of PPE.

The Relationship between Sex and Pulmonary Functional Status of Workers at UD X

Sex is physical and biological differences that distinguish male and female. Based on the results of the study, most respondents are male, including as many as 28 respondents (84.85%); while the remaining 5 respondents (15.5%) are female. The frequency distribution of respondent's pulmonary function status based on sex is described as follows: 25% of 28 male respondents experience pulmonary function disorder and 40% of 5 female respondents experience it, as well.

From the statistical test, the obtained p-value is 0.597 larger than α (0.05), which means that there is no relationship between sex and pulmonary function status of workers at UD X. Meanwhile, in the research conducted by Armaeni and Widajati (2016), the relationship between respondent's sex and pulmonary functional status was classified into the very low category since it had the contingency coefficient value of 0.16. On the contrary, the result of this study is not in line with the study of Nurrohman, Harahap, Taufik, and Susanto (2014) which stated that there is a meaningful relationship between sex and respiratory complaints.

The Relationship between Age and Pulmonary Function Status of Workers at UD X

The results of the study explain that most respondents fall into the age range of 36-45 and 46-55 years old. The relationship between age and pulmonary function status of workers at UD X indicates that there is no relationship between worker's age and pulmonary function status. It is discovered from the p-value of 0.368, larger than α (0.05). Therefore, older age does not necessarily correlate with lower pulmonary function status.

This result is in line with the research conducted by Armaeni and Widajati (2016) which stated that that increasing age does not necessarily increase risk of pulmonary function disorder. Likewise, in the research of Nurrohman, Harahap, Taufik, & Susanto (2014), it is discovered that there is no meaningful relationship between age and pulmonary function disorder.

The Relationship between Working Period and Pulmonary Function Status of Workers at UD X

Working period is the period spent by the workers to work in the marble processing industry. Based on the results of the study, most workers have worked at UD X for about 6 to 12 years (as many as 39.4%). The statistical test result obtains the p-value of 0.114 (larger than α = 0.05), which indicates that there is no relationship between the respondent's working period and pulmonary function status. These results are in line with the research conducted by Yulaekah, Adi and Nurjazuli (2007) which also stated that there is no relationship between working period and pulmonary function status. Therefore, based on these results, working period does not necessarily affect the worker's pulmonary function status.

The result of the previous research which is not in line with this research is discovered by Fahmi (2012). He argued that there is a relationship between working period and pulmonary function capacity. The longer the working period is, the longer the worker is exposed to dust, which will accumulate the dust level in their lungs. Another research claimed that the relationship between working period and pulmonary functional status is classified into the moderate category (Armaeni and Widajati, 2016).

The Relationship between Education Level and Pulmonary Function Status of Workers at UD X

The education levels in this research is divided into three levels, including elementary school, junior high school, and senior high school. Most respondents (42.4%) have elementary school education. Overall, the education level of workers at UD X is considered low. From the statistical test result, the p-value is 0.234 which is larger than α (0.05) and indicates that there is no relationship between the education level and pulmonary function status of workers at UD X. The workers' education level does not necessarily affect the pulmonary function disorder of workers at UD X. The results of this research are in line with the one conducted by Nurrohman, Harahap, Taufik, & Susanto (2014). The study stated that there is no statistically meaningful relationship between education level and respiratory complaints.

The Relationship between Smoking Habit and Pulmonary Function Status of Workers at UD X

The smoking habit of workers at UD X is classified into four groups, namely non-, light, moderate, and heavy smokers. The classification is in accordance with the Brinkman Index (BI) calculation by multiplying the number of cigarettes per day (stick) and the duration of smoking (year). Majority of respondents (38.3%) are moderate smokers. The statistical test result obtains the p-value of 0.03, which is less than α (0.05) and means that there is a relationship between smoking habit and pulmonary function status of the workers at UD X. The correlation coefficient value is 0.378, which can be categorized as weak relationship. Therefore, it can be concluded that the higher the cigarette consumption degree is, the higher the risk of workers to experience pulmonary function disorder will be.

The results are in line with the previous research that there is a meaningful relationship between cigarette consumption and pulmonary function disorder of the workers at the cement packing unit of PT. Tonasa Line Kota Bitung (Anes, Kawatu and Umboh, 2015). Another research at PT. Semen Tonasa – Pangkep stated that smoking habit is the most influential variable to the worker's pulmonary function disorder (Mengkidi, Nurjazuli and Sulistyani, 2006). The worker's pulmonary function disorder is affected by their smoking habit (Sholihah and Tualeka, 2015).

The Relationship between the Use of PPE and Pulmonary Function Status of Workers at UD X

Personal Protective Equipment (PPE) is the prevention to reduce the dust exposure to the workers. Based on the results of the study, most respondents (51.5%) of workers at UD X do not use PPE while working. It can increase the risk of dust exposure due to the marble processing. The percentage of respondents who experience pulmonary function disorder and do not use PPE is 47.1%. The statistical test result obtains the p-value of 0.017, which is less than α (0.05) and indicates relationship between the use of PPE and pulmonary functional status of workers at UD X. The contingency coefficient value of the relationship between the use of PPE and pulmonary functional status is 0.416, which means that the relationship is in the moderate category. Therefore, the better the use of PPE in the workplace, the lower the risk of being exposed to dust which will affect their pulmonary function disorder.

These results are in line with Mengkidi, Nurjazuli and Sulistyani (2006) who argued that the use of PPE is the most influential variable to prevent pulmonary function disorder among workers at PT. Semen Tonasa – Pangkep. Another research that supports these results mentions that the habit of using respiratory protective equipment has moderate contingency coefficient value (Armaeni and Widajati, 2016). However, according to Fahmi (2012), there is no relationship between the use of PPE (mask) with the pulmonary functional capacity.

CONCLUSION

Based on the results of data processing, it is discovered that most respondents are male. Majority of respondents are between 36-45 and 46-55 years old. The respondent's education level is considered low since most respondents have elementary school education. Moreover, most respondents have worked at UD X for about 6 to 12 years. The smoking habit of workers at UD X is classified as not good since most of them are moderate smokers. The use of PPE of workers at UD X is considered not good since most of them do not use PPE while working. The worker's pulmonary function status is generally classified into the good category. The dust level at UD X, Campurdarat Sub-district, Tulungagung District is still under the threshold value limit regulated in the Regulation of the Minister of Manpower and Transmigration Number 13 Year 2011 on Threshold Value Limits of Physical and Chemical Factors in the Workplace. The Threshold Value Limits (TVL) of dust according to the regulation is 10 mg/m^3.

The individual characteristics of sex, age, working period, and education level are not correlated with the pulmonary functional status of workers at UD X. Meanwhile, the smoking habit and the use of PPE have the relationship with the pulmonary functional status of workers at UD X. The higher the smoking frequency, the higher the risk of pulmonary function disorder for the workers. Also, better the use of PPE lowers the risk of pulmonary function disorder for the workers. Both are related to the behavior of workers at UD X, Campurdarat Sub-district, Tulungagung District.

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