

Pulmonary

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Analysis of Risk Factors that Affect Pulmonary Function Disorder in the Manufacturing Industry

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ABSTRACT

Dust is one of potential hazard that can affect the health of workers in the work environment. Dust exposures in the manufacturing industry causes pulmonary function disorder of worker. This can occur due to the risk factors of the work environment and individual workers. This study aimed to determine the risk factors that affected the pulmonary function disorder of workers in the manufacturing industry.

The research was observational with cross-sectional design, the population were 286 workers while the total sample were 150 workers in the production unit who have worked at least five years, and willing to become respondents. Data collected from interviews with workers and measurement of environmental parameters. Bivariate analysis used Chi-Square test and multivariate test using PLS-SEM (Partial Least Square- Structural Equation Modeling).

The result of the bivariate showed that there were a significant correlation between the level of inhaled dust, the use of PPE, and nutritional status (p -value < 0.05) with pulmonary function disorder of workers and there are no correlation between total dust levels, gender, age, smoking habits, exercise habits, medical record, temperature, humidity, ventilation, and working period (p -value $> 0,05$). Multivariate test results (PLS-SEM) showed result of the dust exposure factors of 20.1%, physical environment of 11%, individual factors of 18%, and behavioral factors of 15.7% on pulmonary function disorder. The variable of workers pulmonary function disorder was affected by dust exposure, physical environmental factors, individual factors, and behavioral factors to 64,8%.

The research concluded that dust exposure, physical environmental factors, individual factors and behavioral factors affected pulmonary function disorder.

Keywords: Dust, Risk Factors, Pulmonary Function Disorder, Manufacturing

INTRODUCTION

Public health statuses were affected by four main factors, namely environmental factors, community behavior, health services, and heredity. Environmental factors¹⁷ infection was the highest in around 40%. Environmental factors include the physical, chemical, biological, social, and economic environment. One of the environmental factors is the work environment. A work environment is a place where workers carry out activities. A work environment that does not meet the requirements will be at risk of disease emergence.²

There are always potential hazards in a working place that could affect human health or causes occupational diseases.³ Workplace managers are obliged to protect their workers so that they could live healthily and safely from every potential hazard in the workplace.⁴ A potential hazard is ev¹⁰ hazard that can be potential in causing loss, damage, injury, illness, accident, or even resulted in death related to the work processes and systems. Hazards at the workplace include every condition that can cause an adverse effect on occupational safety or welfare and health.⁵

One of the occupational diseases could be encountered by workers who are continuously inhaling chemical compounds or substances used in industries. One of the materials that could enter our lung is the dust particle. Dust that remains in the lungs could cause local irritation or other more.⁶ The size of dust particle at 5-10 μ will be restrained in the upper airway, 3-5 μ will be restrained in the middle airway, namely the trachea and bronchioles, 1 μ will settle in the surface of the alveoli, while 0,1 μ will move in and out of the alveoli because the dust particle will not settle down. The smaller the dust particle size causes more adverse health effects on the respiration system.⁷

Respiratory tract disorders caused by the size of the dust particles is due to the deposition of dust in the respiratory tract. Diseases caused by dust exposure are

generally called *pneumoconiosis*, a type of *pneumoconiosis* depends on the type of dust⁹ at caused it. Types of *pneumoconiosis* include *silicosis* caused by silica or quartz dust, *asbestosis* caused by asbestos dust, *anthracosilicosis* caused by mixed anthracite/carbon, and silica dust, *byssinosis* caused by cotton dust, and *siderosis* caused by tin ore dust.⁷

According to a report from¹³ the World Health Organization (WHO), an estimated 2 million people worldwide are routinely exposed to wood dust at work. Exposure to dust in the work environment can have a negative impact on workers because dust in the work environment can be inhaled by workers and accumulate in the lungs.

The highest exposures were generally reported in the wood and manufacturing industries.⁸ Research conducted by²⁰ Dsman and Nutmeg in 2009 showed that exposure to wood dust affects the respiratory function of workers. Workers who suffered respiratory disorders are 176 workers (53.7%).⁹ The prevalence of workers with pulmonary function disorders in manufacturing industries ranges from 18% to 44%.^{10,11} Based on the preliminary survey, data shows that 26 out of 57 workers with acute respiratory infections visit industrial polyclinics for medication, that numbers were the largest complaint felt by workers.

Pulmonary function disorders happened in workers due to risk factors from the environment and individuals. Environmental risk factors include total dust levels, inhaled dust levels, exposure time, room ventilation, room temperature, and humidity. Individual risk factors that can affect pulmonary function disorders based on previous research include nutritional status, age, working period, use of personal protective equipment, length of exposure, history of the disease, smoking habits, and years of work.^{12,13} The results of the initial study stated that the risk factors for long exposure, exercise habits, use of masks, and dust concentration had an effect on pulmonary physiological disorders

among workers in the production unit of cement industry with the Odds Ratio value for exposure time is 2.253 times.¹³ Other studies have found the effect of inhaled dust and the use of personal protective equipment against pulmonary function disorders of wood processing workers.¹⁴

The manufacturing industry is one of the working environments in which dust exposure is risky for workers. One of the existing manufacturing industries is Industries that produces chairs, tables, nursing beds, and study chairs, and other furniture. The production process in this industry produces dust as a residue that could be harmful to the health of workers because its raw materials are wood, fabric, and metal. Production processes that are at risk of dust exposure are the welding, painting, and assembly processes carried out in the painting, welding, warehouse, assembling, framing, chrome plating, polishing, Woodline (woodworking) sections, nailing (nailing), and bending (bending of pipe).¹⁵

It is important to control risk factors during the production process in the manufacturing industry. These efforts are carried out by monitoring and measuring the work environment so that environmental prevention and handling can be carried out. Technical control, administrative control, and the use of personal protective equipment (PPE) are some efforts to protect the workers in order to occupational health issues and other adverse effects.¹⁶

Based on the background, the central theme in this study is that dust exposure in the manufacturing industry can cause pulmonary function disorders in workers. It can occur due to risk factors from the work environment and individuals (workers). Risk factors for the work environment include total dust levels, inhaled dust levels, length of dust exposure, room temperature, room humidity, and room ventilation. Individual risk factors include gender, age, working period, medical record, nutritional status, smoking habits, exercise habits, and

use of personal protective equipment. Efforts in supervising and measuring the work environment factors must be carried out to prevent and control the work environment against pulmonary function disorders in manufacturing industry workers.

METHOD

The type of research used is observational with a cross-sectional design. Measurement of the independent (risk factor) and dependent (effect) variables is carried out at the same time and only once. The sample is selected using a proportional sampling method by selecting a sample from a list of workers in each section of production. The sample in this study were production workers who were at risk of being exposed to dust, amounting to 150 respondents. This number is based on the minimum sample for PLS-SEM is ten times the number of variables.¹⁷ The sampling was done randomized by selecting a list of workers that has met the sample criteria (aged between 20-55 with a minimum of 5 years working period), and then it was classified accordingly to its working unit, the number of the sample will be taken proportionally from each part of the working production unit and a simple random sampling method was done to determine the sample that will be used.

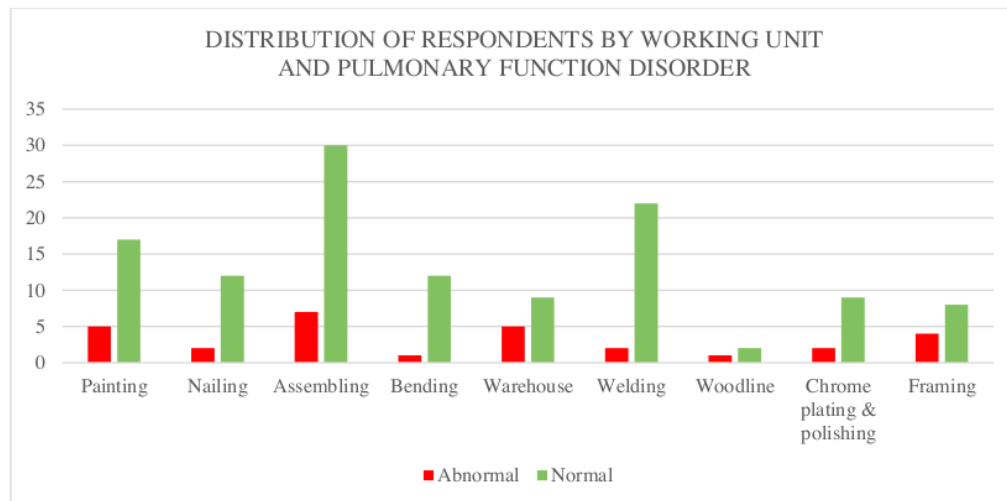
RESULTS AND DISCUSSION

Research on risk factors that affect pulmonary function disorders has been conducted on 150 workers in the production section of the manufacturing industry, X Industry Cimahi. The research was conducted by measuring workers' pulmonary function, total dust level, inhaled dust level, room temperature, room humidity, room ventilation, workers' height, and weighing. Interviews were conducted to determine age, exercise habits, smoking habits, medical history, the period of work, length of exposure to dust,

while the use of protective equipment was accompanied by observation.

Respondents were obtained from the production unit of the manufacturing industry. The production unit of the manufacturing industry consists of 9 parts, namely 1) painting, 2) welding, 3) warehouse, 4) assembling, 5) frame, 6)

Chrome (chrome plating) & polishing 7) woodline (woodworking), 8) nailing (nailing), and 9) bending (pipe bending). The distribution of respondents who suffered pulmonary function disorders based on their workplace, as shown as in the graph below:



Graph 1. Distribution of Respondents by Working Unit

The results showed in Graph 1 that the distribution of workers with pulmonary function disorders were found in all parts of the production. The highest number was found in the assembling unit as many as 7 people, 5 people in the painting unit, 5 people in the warehouse unit, 4 people in the frame section unit. The total number of respondents who suffered pulmonary

function disorders was 29 people consisting of 18 mild restrictions and 11 mixed people.

Bivariate analysis of the independent variables with the dependent variable was performed using the Chi-Square test. The following are the results of a bivariate analysis of risk factors associated with pulmonary function disorders of workers can be seen in Table 3 as follows:

Table 1. Results of Bivariate Analysis of Independent Variables with Dependent Variables

Variables	Pulmonary Function		p-Value	OR (CI 95%)
	Abnormal n (%)	Normal n (%)		
The Inhaled Dust Level				3,216
Does not meet the requirements.	18 (33,3)	36 (66,7)	0,009	(1,397-7,406)
Meet the requirements.	11(11,5)	85 (88,5)		
The use of PPE				3,571
No	25 (24,5)	77 (75,5)	0,034	(1,167-10,930)
Yes	4 (8,3)	44 (91,7)		
Nutritional Status				3,648
Does not meet the requirements.	22 (28,2)	56 (71,8)	0,008	(1,450-9,177)
Meet the requirements.	7 (9,7)	65 (90,3)		
Total Dust Level				0,805
Does not meet the requirements.	24 (19,5)	99 (80,5)	0,880	(0,292-2,220)
Meet the requirements.	5 (18,5)	22 (81,5)		
Gender				0,804
Male	29 (19,6)	119 (80,4)	1,000	(0,743-0,871)
Female	0 (0)	2 (100,0)		
Age				0,582
>31 Years old	28 (19,7)	114 (80,3)	1,000	(0,069-4,992)
20-30 Years old	1 (12,5)	7 (87,5)		
Smoking Habits				1,410
Yes	18 (21,7)	65 (78,3)	0,546	(0,614-3,236)
No	11 (16,4)	56 (83,6)		
Exercising Habit				1,085
No	27 (19,4)	112 (80,6)	1,000	(0,221-5,313)
Yes	2 (18,2)	9 (81,8)		
Medical Record (Disease)				1,714
Yes	7 (23,3)	23 (76,7)	0,380	(0,672-4,372)
No	22 (18,3)	98 (81,7)		
Environmental Temperature				2,207
Does not meet the requirements.	27 (20,6)	104 (79,4)	0,371	(0,480-10,141)
Meet the requirements.	2 (10,5)	17 (89,5)		
Environmental Humidity				1,474
Does not meet the requirements.	12 (21,4)	44 (78,6)	0,474	(0,648-3,350)
Meet the requirements.	17 (18,1)	77 (81,9)		
Workplace Ventilation				0,785
Does not meet the requirements.	24 (18,7)	104 (81,3)	0,770	(0,263-2,337)
Meet the requirements.	5 (22,7)	17 (77,3)		
Working Period				1,134
>11 Years	26 (19,5)	107 (80,5)	1,000	(0,303-4,239)
5-10 YearsTahun	3 (17,6)	14 (82,4)		

Table 1 shows that there is a significant correlation between inhaled dust levels and pulmonary function disorders with a value of $p = 0.009$ and an odds ratio of 3.216, which means that workers in a work environment that inhales dust levels exceeding 3 mg/L are at risk of 3.216 times compared with workers who work in a work environment with dust levels less than 3 mg/L.

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The results also showed that there was a significant correlation between the use of personal protective equipment and personal pulmonary function with a value of $p = 0.034$ and an odds ratio of 3.571, which means that workers unequipped with personal protective equipment have a risk of 3.571 times compared to workers equipped with personal protective equipment. There is also a significant correlation between nutritional status and

pulmonary function disorders with a value of $p = 0.08$ and an odds ratio of 3,648, which means that workers that do not meet the ideal range of nutritional status ($BMI = <18.5$ or > 25) is at risk by 3,648 times, compared to workers in an ideal range of BMI (18,5-25).

¹⁹The data processing uses the Multivariate Partial Least Square Structural Equation Modeling (SEM PLS) test, which is to determine the complexity of the correlation between a latent variable and other latent variables, as well as the correlation of a latent variable and its indicators. There are two latent variables, namely exogenous and endogenous. Exogenous variables

(exogenous variables) are independent variables or variables that are affecting, while endogenous variables (endogenous variables) are the dependent variable.^{17,18}

In this study the exogenous variables consisted of total dust (pd1), inhaled dust (pd2), use of personal protective equipment (p1), smoking habits (p2), exercise habits (p3), ambient temperature (f1), environmental humidity (f2), room ventilation (f3), gender (i1), age (i2), nutritional status (i3), working period (i4), and medical record (i5), while the endogenous variable is pulmonary function as assessed by the indicator FVC value (fp1) and FEV1 (fp2).

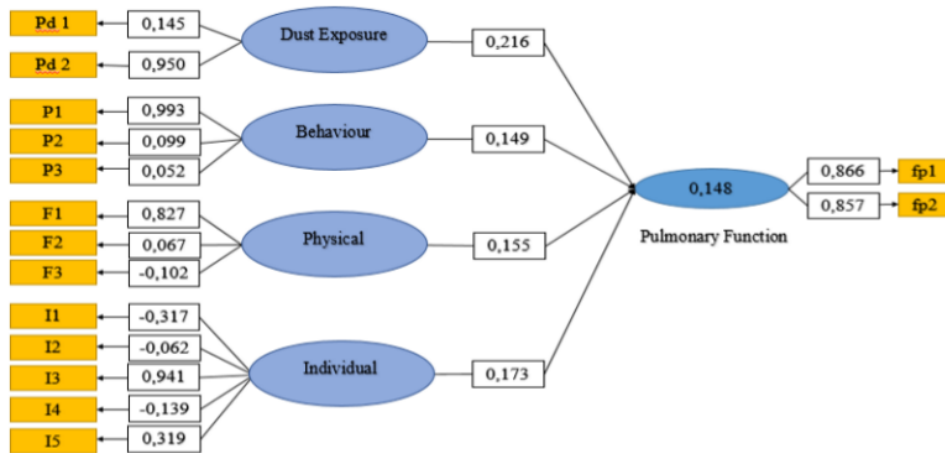


Figure 1. Preliminary Structural Equation Analysis Research Model

Figure 1 shows that the evaluation of the outer model, namely the measurement of each construct of the latent variable as a reflective indicator tested, is its validity and reliability. Validity testing requires the loading value of the indicator correlation factor with the latent variable greater than 0.5.¹⁸ Figure 1 shows that some variables loading value factor under 0,5 which is pd1, p2, p3, f2, f3, i1, i2, i4, and i5 on the indicator should be discarded. The variables whose loading factor was more than 0.5 were pd2 (inhaled dust), p1 (use of

PPE), f1 (room temperature), and i3 (nutritional status).¹⁵

After testing the measurement model (outer model), a structural model (inner model) is carried out to predict the correlation between latent variables, and then looking at the significance value, namely looking at the t-statistic. The t-statistic value will come out when the model is bootstrapped. The t-statistic value greater than 1.96 indicates that the latent variable is significant at the significance level $\alpha = 0.05$.^{17,18} The image of the model after Bootstrapping is as follows:

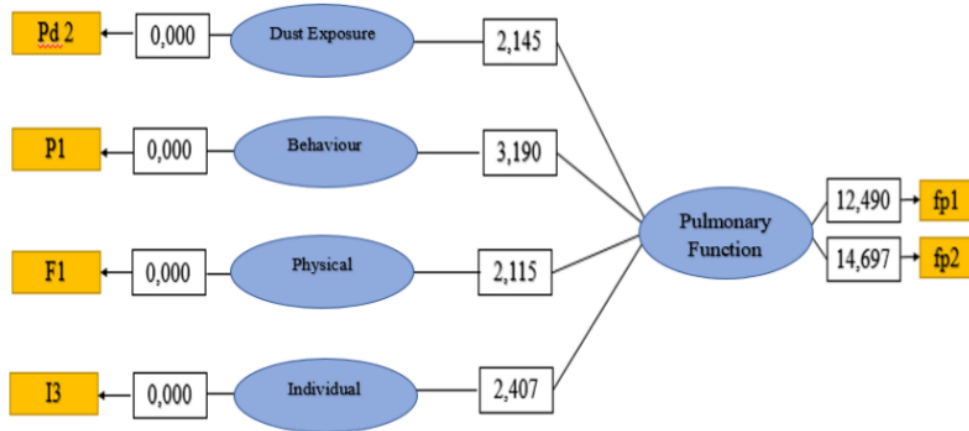


Figure 2. The Final Structural Equation Analysis Research Result Model

The structural model (inner model) is a model that describes the correlation between latent variables.¹⁸ The results of

the path coefficient and t-statistical value obtained through the bootstrapping process are as follows:

Table 2. Structural Model Path Coefficient Values

	Mean Sample	Standard Deviation	T-Statistics	p-Value
Physical Factor-->Pulmonary Function	0,110	0,052	2,115	0,034*
Individual Factor--> Pulmonary Function	0,183	0,075	2,407	0,016*
Dust Exposure Factor--> Pulmonary Function	0,208	0,094	2,145	0,032*
Behavioral Factor--> Pulmonary Function	0,156	0,049	3,190	0,001*

Note: *) significant with a significance level of 5%

Table 2 shows that the path coefficient obtained from the correlation between physical environment variables and pulmonary function disorders is 0.110 with a t-statistics of 2.115, individual characteristics of 0.183 with a t-statistics of 2.407, exposure to inhaled dust of 0.208 with a t-statistics of 2.145 and behavior of 0.156 with a t-statistics of 3.190. The t-statistics of the four variables is greater than 1.96 thus it can be concluded that the influence of the physical environment, individual characteristics, exposure to inhaled dust, and behavior on pulmonary function disorders are significant.

The results of the multivariate analysis using PLS-SEM showed that dust exposure had an effect of 20.1%, 11% physical environment, 18% individual factors, and 15.7% behavior towards pulmonary function disorders. Pulmonary function variables of workers at X Industry Cimahi is affected by dust exposure, physical environment, individual characteristics, behavior by 64.8% while the rest is affected by other factors not included in the model (not studied). The square adjusted R-value of 0.104 (less than 0.20) means that the model is weak.

Research has been conducted to determine the risk factors that affect pulmonary function disorders. These risk factors come from the environment and individual workers. Pulmonary function disorders are determined by conducting a spirometer test, which is an examination of the lungs of 150 workers in the manufacturing industry. The results showed that there were 29 people with pulmonary function disorders in the form of restrictions (18 people) and combination (11 people).

Most of the workers examined were male workers, 148 men and the remaining 2 were women out of the 150 people examined. This number shows that a men worker were more dominant. There were 29 male workers with pulmonary function disorders. The results showed that gender was not a risk factor for pulmonary function disorders.

The spirometer value in women is lower than in men, in women, the FEV1 and FVC values decline at an earlier age (20 years) compared to men who began to decline at the age of 25 years, this is because it is related to physiological and anatomical conditions.¹¹ The results of this study are in line with Mulyati's research that has stated that there was no correlation between gender and the incidence of byssinosis in the textile industry. S One of the factors that cause the gender variable was not one of the risk factors for pulmonary function disorders was because of the lack of variation in male and female workers.

The workers who were respondents aged between 20 and 55 years, most of them aged 40-49 years as many as 66 people. Respondents who suffered pulmonary function disorders at the age of more than 30 years old were 28 people. The age variable was not a risk factor for pulmonary function disorders in this study. The results of this study are in accordance with the results of previous research conducted by Husaini which stated that there was no correlation between age and the incidence of occupational disease in welding

workers.¹⁹ Hasil penelitian Girma's research results stated that there was no correlation between age and pulmonary function disorders in steel industry workers in Ethiopia.²⁰ This is possible because of good nutritional status and obedience to using personal protective equipment (masks).

Respondents with a working period of more than 11 years were 133 people and 17 people worked for 5 to 10 years. Pulmonary function disorders due to dust exposure will emergence after workers have had prolonged contact with dust, thus the longer the working period, the more risk of the emergence of pulmonary function disorders.²¹ The working period variable is not a risk factor for pulmonary function disorders in this study. This is possible because of the worker's vulnerability, the length of work per day is according to the standard of 8 hours per day. The results of this study are in accordance with Husaini's research which states that there is no correlation between working years and occupational diseases in welding industry workers.¹⁹ This is in line with previous research conducted by Wulandari which stated that there was no significant correlation between working period and the incidence of pulmonary function disorders in the workspace.²² Muhammadiyah's research results stated that there was no correlation between working period and pulmonary function disorders of workers in the textile industry in Egypt.²³

The results of interviews with respondents about whether or not they had a record of diseases related to respiratory disorders such as asthma, bronchitis, tuberculosis, and dust allergy, obtained a data of 30 people who had a record of previous respiratory disease while 120 people stated that they had no record of respiratory diseases. Medical record of a disease is not a risk factor for the pulmonary function disorder of workers in this study. The results of this study are in line with previous research conducted by Hinson which stated that there was no significant

correlation between the previous medical record of diseases and pulmonary function disorders of textile workers in Benin.¹¹ This is possible because the history of the disease that the respondent suffered from relapsed rarely and was mild and only 2 people had pulmonary function disorders out of 30 people who previously had a medical record of the disease.

Most of the workers' have a poor nutritional status were 78 people. There were 22 of the 78 workers who suffered pulmonary function disorders who had poor nutritional status. Nutritional status is a very important factor because a lack of nutritional status can result in decreased immune intermediary cells which can increase susceptibility to infection, while excess nutritional status in the presence of fat deposits can decrease pulmonary function so that pulmonary ventilation will cause to the decline of pulmonary function. Immune cells in the respiratory tract are ruled by T lymphocytes which can kill, isolate, and collect incoming strange objects. Workers who are exposed to dust and as a result of the decrease in immune intermediary cells, thus the T-lymphocytes cannot form a defense against dust or particles that enter the respiratory tract as a result, dust or particles that enter the respiratory tract can eventually reach the lungs. The dust that reaches the lower airways stimulates an immune-inflammatory reaction that causes the accumulation of dust-filled macrophages, thus pulmonary fibrosis eventually occurs and causes the lungs to become stiff and its expansion capability becomes limited.²⁶

One of the effects of malnutrition is the decline in a person's immune function so that they are prone to infections such as coughs, colds, diarrhea, and a decreased ability of the body to detoxify strange objects that enter the body such as dust. Nutritional status is a risk factor for pulmonary function disorders. This is in line with the results of Nazikhah's research which states that nutritional status affects pulmonary function disorders.²⁴ This

research is also in line with previous research conducted by Putri on flat cement board industry workers in the Malang area which stated that the nutritional status of workers had a significant effect on disorders of pulmonary function in the flat cement board industry.²⁵ This study is in line with research conducted abroad by Raheleh in Iran, which states that nutritional status affects pulmonary function disorders in street sweeper workers.²⁶

There are 54 workers with high inhaled dust levels, spread in nine work units and the most occurs in the assembling section. The production process in the assembling section that allows exposure to high inhalation of dust is the activity of assembling furniture raw material components into finished furniture. Dust exposure in the work environment of the manufacturing industry is one of the potential hazards. The harm of dust for health is that if it gets into the human respiratory organs, it can cause disease in workers. Respiratory system disorders can occur in workers, characterized by excessive mucus secretion which causes the main symptoms that often occur that are coughing, shortness of breath, and general fatigue.¹⁶

The mechanism of dust entering the lungs is as follows: dust is inhaled in the form of dust particles, dust measuring between 5-210 microns will be held by the upper airway, dust measuring 3-5 microns will be restrained by the middle airway, whereas dust that is 1-3 microns in size is called respirable. Respirable dust is the most harmful dust because it will be restrained on the surface of the alveoli/mucous membrane, causing pulmonary fibrosis, while dust measuring 0.1-1 microns restrained on the upper surface of the alveoli.^{16,19} Pulmonary dysfunction due to dust exposure can affect productivity and quality of work. Inhaled dust level is a risk factor for pulmonary function disorder. It is in line with Nazikhah's research that states there is a

significant effect between inhaled dust levels and pulmonary function disorders in shipyard companies.²⁴

The total dust level measured in the work section shows the highest in the painting room, which was 0.476 mg/m³. This means that it exceeds the required threshold value, which was 0.150 mg/m³. Parts of work with total dust level exceeding the threshold value other than the painting room was nailing, assembling, welding, bending rooms, and warehouse. The process that allows a high level of total dust in the room is the activity of smoothing of metal surfaces and painting furniture frames as well as from the production process which produces dust, smoke, and steam. This condition is only possible because the room ventilation that meets the requirements is only in the painting room, but the airflow velocity in the room is deficient based on the measurement results using an anemometer, thus the dust was restrained in the workspace.

High total dust level does not necessarily cause pulmonary dysfunction because there is a limit to the size of dust that can be inhaled by workers. Total dust level was not a risk factor for pulmonary function disorder in this study. This result is in line with the previous research conducted by Perdana which stated that there was no significant correlation between total dust levels and pulmonary function disorders of workers in the cement industrial production unit.¹³ The possible factor was that there was no significant correlation between total dust levels and pulmonary dysfunction due to the varying size of dust above particulate matter which is not respirable dust.

Room temperatures that exceed the threshold value of 28°C are in the room for painting, assembling, welding, bending, woodline, warehouse, chrome plating & polishing, and framing room allowing workers to be exposed to heat while doing their work. High air temperature at work can affect fatigue because the body will experience a lot of fluid loss or dehydration, in such conditions the body will carry out a

physiological mechanism by releasing heat to stabilize the core body temperature which ranges from 37 °C. This condition will affect the decline and vulnerability of the worker's immune system. Room temperature is a risk factor for pulmonary function disorders in this study. The results of this study are in line with the previous research conducted by Yu Sheng Shen using PLS-SEM analysis which states that the environmental temperature indicator influences the mortality rate due to respiratory disease.²⁷ Environmental temperature can affect pollutants in the air, if the temperature is low it will trap air pollutants thus it won't spread anywhere else in the room, whereas when the temperature is high it will accelerate chemical reaction which causes dust particles to last longer in the air, thus enabling workers to be at increased risk of pulmonary function disorders.¹⁶

Workspace humidity exceeds the 60% threshold value, namely the nailing, warehouse, chrome plating & polishing, and framing room. Humidity in the workspace can affect worker fatigue so that productivity decreases, and causing harm to the immune system and health status. The effect of moisture on dust is that dust can absorb water vapor around it and cause the molecular weight to increase and reduces the possibility of dispersion that can result in an increased risk to the workers' health when inhaled.²⁸ Room humidity is not a risk factor for pulmonary dysfunction of workers in this study. The results of this study are in line with previous research conducted by Gunarso that stated there was no significant correlation between environmental humidity and pulmonary function disorders in the communities around Semen Toraja Ltd.²⁸

The results of the study on the area of room ventilation showed that 128 people worked in rooms with poor ventilation. These results indicate that the supply of fresh air for the production room is very insufficient. Room ventilation was not a risk factor for pulmonary dysfunction in

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this study. This result is in line with previous research conducted by Wulandari that stated that there was no significant correlation between the ventilation area and the incidence of pulmonary dysfunction in the workspace.²² It is possible because the airflow velocity is not good (less than 7.1 L/sec), hence the ventilation function is not optimal.²¹

The use of personal protective equipment, especially masks, is intended to protect workers from exposure to dust in the work environment. Most of the work environments have dust levels above the threshold (>3 mg/m³). The results showed as many as 102 workers were not used to wearing masks at work, which make them at risk of being exposed to dust that would accumulate in the lungs. Workers do not comply with using personal protective equipment (masks) for various reasons, such as discomfort in using PPE while working, difficulty in breathing, and not being used to it.

Industries are required to provide PPE for workers and other people who enter the workplace.³ The use of PPE for workers was the last option whereas there were four hierarchy of risk control in the workspace has not been implemented, those four hierarchy were elimination, substitution, engineering, and administrative, when not implemented it might workers' health issues.¹⁶ Personal protective equipment must meet the requirements such as comfortable when being worn, does not give disturbance while at work, does not limit the movement of workers, providing effective protection for workers, and meet aesthetic requirements.¹⁶ Personal protective equipment, especially masks must comply with the standard, which is the type of respirator mask that is capable of filtering 2.5 micron dust..

Non-compliance with personal protective equipment (masks) is a risk factor for pulmonary function disorder. The results of this study are in line with the results of Nazikhah's research which states that the factor of using personal protective

equipment (masks) affects lung function disorders and is also in line with Putri's research results which state that there is a correlation between the use of personal protective equipment (masks) and pulmonary function disorder.^{24,25} This research is also in line with the research conducted by Nurul in Malaysia that stated there is a significant correlation between wearing masks while working with pulmonary function disorders of workers in the steel industry. The use of masks on workers will reduce the harmful dust exposure, so that workers productivity remains high and ultimately increases life expectancy.²⁹

The number of workers with a smoking habit is 83 out of the total number of 150 respondents. Smoking habit was not a risk factor for pulmonary function disorder in this study. The results of this study are in line with previous research conducted by Nazikhah which stated that there was no significant correlation between smoking habit and pulmonary function disorders.²⁴ The results of this study are also in line with previous research conducted by Suwanto which stated that there was no significant correlation between smoking habit with respiratory complaints among workers in the aluminum pan-industry.³⁰ It is possible because the respondent is still in the light smoker category (10 cigarettes per day). This is also in line with previous research by Neghab which stated that there was no correlation between smoking and pulmonary function disorders in the wood industry in Iran.³¹

Workers who irregularly exercise are 139 people out of a total of 150 respondents, this shows that exercise has not become a necessity so that workers remain in a fit condition, the exercise criteria for this study are respondents who did a physical activity 30 minutes of sports 3 times a week. Exercise habit was not a risk factor for pulmonary function disorders in this study. The results of this study are in line with previous research conducted by Handari which stated that there was no

significant correlation between exercise habits and the incidence of pulmonary function disorders in locomotive depot workers³² The results of this study are also in line with previous research conducted by Betiandriyan which stated that there was no significant correlation between exercise habits and the incidence of pulmonary function disorders in workers in the painting unit at X Ltd. in Semarang City.³³

CONCLUSION

The number of workers who suffered pulmonary function disorders was 29 people or 19.3% of the total sample of 150 people. There was an effect of dust exposure, physical environment (ambient temperature), individual characteristics (nutritional status), and behavior (use of personal protective equipment/masks) on pulmonary function disorders. Dust exposure has the highest effect on workers' pulmonary function disorders. The affection of these four risk factors on workers' pulmonary function disorders is 64.8%, and 35.2% was affected by other risk factors that were not studied.

SUGGESTION

During working time, workers must wear personal protective equipment, especially wearing masks to reduce the negative impact of inhalation exposure of dust in the workplace. Always pay attention to nutritional intake to maintain optimal nutritional status. The company's policies and commitments in overcoming occupational diseases must be implemented, particularly in tackling with total dust exposure and inhaled dust in industrial environments so that workers will be protected from the negative impacts of dust in the production room. Providing counseling/ training to workers on OSH (Occupational Safety and Health), providing personal protective equipment (PPE) while monitoring its use and implementing sanctions for workers who

violate OSH regulations. Adding exhaust ventilation to the production room for a better air circulation, which will have an impact on complying the a predetermined threshold value on temperature and humidity which will eventually provide a sense of comfort for workers.

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