Factors Related to Pulmonary Function Status of Animal Feed Industry Workers in Surabaya

Faktor yang Berhubungan dengan Status Faal Paru Pekerja Industri Pakan Ternak di Surabaya

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ABSTRACT

Introduction: Workplace air that contains dust and microorganism when inhaled by workers into respiratory tract can accumulate and cause lung function disorder. This study aimed to analyze the correlation between the concentrations of dust with the concentration of microorganism and analyze the association of worker characteristics, dust and microorganism concentration to lung physiology status. **Method:** This study adopted cross sectional design. The sample consisted of 24 workers who were randomly selected from factory and 10 workers who were totally selected from the administration area for respirable dust, microorganism concentration monitoring and workers' characteristics data collecting. **Result:** Concentration of respirable dust has strong correlation with bacteria (rs = 0.704) and fungi (rs = 0.662) concentration. Variables that had significant association with pulmonary function status were age (p = 0.000), tenure (p = 0.008), the degree of smokers (p = 0.000), the dust concentration (p = 0.000), the bacteria concentration (p = 0.000), and the fungi concentration (p = 0.000), while the use of PPE mask (p = 0.890) had no significant association with pulmonary function status. **Conclusion:** Factors that related to pulmonary function status are age, tenure, degree of smokers, respirable dust, bacteria, and fungi concentration. Respirable dust concentration has significant positive correlation with bacteria and fungi concentration**.**

Keywords: concentration of dust, concentration of microorganism, pulmonary function status

ABSTRAK

Pendahuluan: *Debu dan mikroorganisme yang terkandung di udara lingkungan kerja jika terhidup masuk ke saluran respirasi pekerja dapat terakumulasi dan menyebabkan gangguan fungsi paru. Penelitian bertujuan untuk menganalisis korelasi antara konsentrasi debu dengan konsentrasi mikroorganisme dan hubungan karakteristik pekerja, konsentrasi debu, dan mikroorganisme dengan status faal paru.* ***Metode:*** *Penelitian ini menggunakan desain cross sectional. Sampel terdiri atas 24 pekerja yang secara acak disampling dari area pabrik, serta 10 pekerja yang disampling secara total dari area administrasi untuk dilakukan mengukuran kadar debu respirabel dan mikroorganisme udara serta pengumpulan data karakteristik pekerja.* ***Hasil:*** *Terdapat korelasi kuat antara konsentrasi debu dengan konsentrasi bakteri (rs = 0,704) dan jamur (rs = 0,662) di udara dengan arah korelasi yang kuat. Variabel yang memiliki hubungan yang signifikan dengan status faal paru antara lain usia (p=0,000), masa kerja (p=0,008), derajat perokok (p=0,000) konsentrasi debu (p=0,000), konsentrasi bakteri (p=0,000), dan konsentrasi jamur (p=0,000, sedangkan pemakaian masker (p=0,890) memiliki hubungan yang tidak signifikan dengan status faal paru.* ***Simpulan:*** *Faktor yang berhubungan dengan status faal patu antara lain usia, masa kerja, derajat perokok, konsentrasi debu, bakteri, dan jamur. Konsentrasi debu memiliki korelasi positif dengan konsentrasi bakteri dan jamur.*

Kata kunci: *konsentrasi debu, konsentrasi mikroorganisme, status faal paru*

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INTRODUCTION

The feed factory is a business unit processing raw materials into feed (Retnani (2014)). Feed raw material consists of organic materials such as grains (like corn and soy) that are processed mechanically through grinding and mixing which produce dust and pollution for environment. The dust resulted

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from feed production activities generate grain dust that could endangers the workers' health (Health and Safety Executive, 2013).

The workers at feed factory are potentially exposed to a large number of dust during their working processes (Haltensen, 2013). The exposure of grain dust in large quantities is known to cause respiratory symptoms Marchand et al. (2017); Cottica et al. (2004). The dust that is inhaled by the respiratory tract can settle and interact with lung cells that triggers inflammatory reactions and irritation that cause pulmonary disorders (Amin, 2000). The impaired pulmonary function leads to reduced-oxygen to the forces of lung tissue for body's metabolic processes (Ganong, 2015). According to the Regulation of the Ministry of Manpower Number 1 of 1981, it is stated that pulmonary function disorders caused by an exposure to organic dust is an occupational disease.

The effects of exposure to grain dust against respiratory are respiratory tract symptom and functional changes symptom. The disease that is caused by exposure to dust has resulted rhinitis, asthma, COPD, chronic bronchitis, extrinsic allergic alveolitis such as farmer's lung disease (fever, cough, shortness of breath, joint-pain, and weight-loss), organic dust toxic syndrome such as grain fever (symptoms-like flu along with coughing and discomfort in the chest), and occupational asthma Health and Safety Executive, (2013). The chronic exposure to grain dust contributes a decline in pulmonary function permanently (Marchand et al., 2017).

The impaired pulmonary function can be an airflow obstruction called as obstructive pulmonary disorder. It is characterized by a decrease in Forced Expiratory Volume in 1 Second (FEV1). The impaired pulmonary function is a barrier and restrictive lung development characterized by impairment of Forced Vital Capacity (FVC). Besides, the impaired pulmonary function occurs due to a fusion mix of obstruction and restriction marked by the decline of ratio value of FEV1/FVC (Umami, 2017); (Hikmayanti, 2018).

Various studies on pulmonary function disorders in the industry with organic dust exposure have been done. A research project by Mohammadien et al (2013) on the Flour Mill industry workers has found that the workers that were exposed to dust had value measurement of spirometry parameters (FEV1, FVC, and FEV1/FVC that decreased as compared to workers whom were not exposed to dust. A research project by Iyogun et al (2018) on grain processing industry got the same result. It was about a decrease in FEV1 on workers that were exposed to dust as compared with non-exposed workers. In Indonesia, a study on pulmonary function as a result of exposure to dust had also been done by Briyan and Kayanto (2017) in the animal feed industry, stating that exposure to dust environment have a risk of 10 times on a decreased FVC.

The grain dust was made from various components including wheat, rice, corn, and contaminants such as microorganisms (like bacteria and fungi). The microorganisms inhaled into the respiratory tract can also cause impaired pulmonary function. The health effects associated with exposure to grain dust is a result of the inhalation of various components of microorganisms. The exposure to high concentrations of dust and contamination of microorganisms have been reported in various industries that manage and process grain (Marchand et al., 2017). The health effects resulted from inhalation of grain dust are more strongly associated with microbial components rather than the concentration of dust itself (Douwes, Thorne and Heederik, 2003).

Conducting a measurement against concentration of microorganisms in the air is needed even the concentration number of grain dust in working environment low. A research by Haltensen (2013) in animal feed industry showed that despite a relatively low dust exposure, the exposure of microorganisms already exceeds the standards and it potentially endangers health. The exposure of dust is significantly correlated with the concentration of bacteria and fungi. It can be considered that the greater the level of air pollution by grain dust, the higher the concentration of microorganisms exposed to the workers.

The animal feed industry in Margorejo Surabaya produces various types of poultry through various production processes such as mixing and grinding. The activities in the industry generate dust. After preliminary studies, it was known that there were 60% of workers who had respiratory complaints including cough, shortness of breath, wheezing, and discomfort in the chest during their works. It is feared as a sign of pulmonary function disorder as the workers work with an exposure of dust and microorganisms during the production processes.

The purpose of this research was to analyze 1) the correlation between the concentration of dust and concentration of bacteria and fungi, 2)

workers' characteristic and the levels of dust and microorganism relationship with pulmonary function status.

METHOD

This study was an observational study with cross sectional design. Samples were 24 production workers as an exposed group, and 10 clerical workers as a unexposed group.

The research data were obtained through questionnaires for respondents. The equipment for respirable dust sampling was Personal Dust Sampler (PDS) with glass microfiber filter intended to measure the levels of respirable dust in accordance with SNI 7325:2009 procedures about methods for measuring personal respirable dust level in the workplace air. The measurements were done personally to each worker of 24 production workers and 10 administrative workers. The measurements were carried out on July 1, 2019 at 07.00 am to 12.00 pm.

The measurement concentration of microorganisms was done by using Microbial Air Sampler (MAS) and being incubated by using Nutrient Agar Plate for culturing bacteria and Sabaroud Agar for culturing fungi during 24 hours at a temperature of 35-37oC, and finally calculated the number of the colonies per meter cubic air (CFU/m3).

The measurement of pulmonary function status was done by using a spirometer in the morning at 07.00 am before the workers start working. Examination on this study used portable digital spirometer/spirometer contec SP10. The parameters includes FEV1, FVC. The normal value by American Thoracic Society are FEV1 ≥ 80%, and FCV> 80%.

Table 1. The Result of Dust Measurement in Animal Feed Industry Surabaya, 2019

Group	N	Mean	SD	Min	Max	p-value
Prod	24	2.22	1.47	0.37	6.45	0.000
Adm	10	0.09	0. 12	0.01	0.35	

Table 2. The Measurement Result of Bacterial Concentration in Animal Feed Industry Surabaya, 2019

Group	N	Mean	SD	Min	Max	p-value
Prod	24	1479.1	871.5	197	2628	0.004
Adm	10	549.2	612.8	197	1895	

Hence, the results were analyzed by Chi-Square test, Fisher exact, Mann Whitney, and Spearman correlation test.

RESULT

Respirable Dust Levels

Respirable dust level was measured in 2 different groups to see the differences of dust level in production and administration group. Measurement was performed at 6 points that represent each part of working activities. The measurement in the production area was done at 5 points: dumping, grinding, mixing, palleting, and sacking off. At one point, the administration was measured the production's dust concentration in the production area (2.22 mg/m3) which was higher than the administration area (0.09 mg/m3).

Table 3. The Measurement Result of the Concentration of fungi in Animal Feed Industry Surabaya, 2019

Group	N	Mean	SD	Min	Max	p-value
Prod	24	734.8	291.27	205	1118	0.017
Adm	10	394	314.87	205	992	

Table 4. The Distribution of Respondents' Characteristics in Animal Feed Industry Surabaya, 2019

Characteristics of Workers	Group			
	Production		Administration	
	n	%	n	%
Age				
<31 years	9	37.5	8	80
≥ 31 years	15	62.5	2	20
Years of service				
<7 years	10	41.7	7	70
≥ 7 years	14	58.3	3	30
Degrees of Smoker				
Non smoker	12	50	10	100
Light smokers	6	25	0	0
Moderate smokers	4	16.7	0	0
Heavy smokers	2	8.3	0	0
PPE use Frequency				
No	6	25	10	100
Sometimes	12	50	0	0
Always	6	25	0	0

The different result of dust concentration measurements (p-value) = 0.000 showed that there was difference and significant relationship between respirable dust concentration mean in the production and administration in which the concentration of respirable dust in production was higher than the administration.

The Concentration of Bacteria and Fungi

The bacterial concentration measurement was performed at 6 points that represent each part of working activities. The measurement in the production area was done at 5 points: dumping, grinding, mixing, palleting, and sacking off. At one point, the administration was measured. The measurement on concentration of bacteria and fungi was done by using a Microbial Air Sampler (MAS) for 10 minutes on each point. Furthermore, the number of bacteria colonies of Nutrient Agar (NA) was incubated and counted.

Result of measurement on the concentration of bacteria showed that the average concentration of bacteria in the production group (1479.1 CFU/m3) was greater than the administration group (549.2 CFU/m3).

The different result of bacteria concentration measurements of (p-value) = 0.004 indicating that there was differences and significant relationship between bacterial concentration mean in production and administration groups in which the concentration of bacteria in production group was higher than administration group.

Result of measurement on the concentration of fungi showed that the average concentration of fungi in the production group (734.8 CFU/m3) was greater than the administration group (394 CFU/m3).

The different result of concentration measurements of (p-value) = 0.017 showed that there was differences and significant relationship between fungal concentration mean in production and administration groups in which the concentration of fungi in production was higher than administration group.

The Characteristics of Respondents

The respondents of research consisted of exposed group of 24 production workers and none exposed group as clerical workers of about 10 people. The characteristics of respondent included age, years of smoking, habit of using Personal Protective Equipment (PPE), and nutritional status.

Based on the age characteristics of the production and administration groups, the majority of the respondents aged ≥ 31 years old (62.5%) were from production group. The majority of the respondent aged < 31 years (80%) were from production administration group.

Based on the characteristics of working period, the majority of respondents have been working for < 7 years (70%) were from administration group, while the majority of respondents that have been working for ≥ 7 years were from production group.

Based on the smoking degree, the majority of non-smokers respondents (100%) were from production group. The majority of light smoker respondents (25%) were from production group. Medium smokers were 16.7% from production group and heavy smokers were 8.3% from production group.

Table 5. The Correlation between Respirable Dust Concentration and Bacteria Concentration in Animal Feed Industry Surabaya, 2019

		The concentration of bacteria
Dust concentration	r	0.704
	p	0.000
	n	34

Table 6. The Correlation between Dust Concentration and Fungi Concentration in Animal Feed Industry Surabaya, 2019

		The concentration of Fungi
Dust concentration	r	0.662
	p	0.000
	n	34

Table 7. Pulmonary Function Status of Workers in Animal Feed Industry Surabaya, 2019

Group	Pulmonary Function status				p-value
	Normal		Abnormal		
	n	%	n	%	
Production	15	44.1	9	26.5	0.215
Administration	9	26.5	1	2.9	

Table 8. FEV1 and FVC Workers' Value in Animal Feed Industry Surabaya, 2019

Group	% FEV			% FVC		
	Mean	SD	*p*	Mean	SD	*p*
Prod	85.49	8.93	0.000	86.06	8.48	0.000
Adm	106.29	13.84		106.18	12.51	

Based on the use of PPE, workers who never wore PPE were administration group (100%), those who sometimes wore dominantly from production group (50%), and those who always wore dominantly were from the production group (25%).

The Correlation of Respirable Dust with the Concentration of Microorganisms

The results of correlation analysis on respirable dust concentration to the concentration of bacteria had a value of p = 0.000. It means that the concentration of respirable dust and bacteria addressed significant correlation, while the strength of the correlation was rs = 0.704. It means that dust concentration and the concentration of bacteria had strong correlation and positive correlation which means that the larger the concentration of respirable dust, the greater is the concentration of bacteria.

Furthermore, the results of correlation analysis on the concentration of respirable dust at a concentration of fungi had a value of p = 0.000 which means that the concentration of dust and mildew addressed significant correlation, while the strength of the correlation was rs = 0.662 indicating that concentration of respirable dust and fungi had strong correlation and positive correlation which means that the larger the concentration of dust, the greater was the concentration of fungi.

The Status of Pulmonary Function

The measurement of pulmonary function status of workers in the production and administration was done on July 1, 2019. The first measurement was done on the production group and next on the administration group. The measurements were conducted by a team from HSE Unit at Surabaya and assisted by researchers by using Spirometry test.

The measurement results showed that the pulmonary function status of the production group with impaired pulmonary function were 9 workers (26.5%), while 15 (44.1%) of workers had normal pulmonary function. In the administration group, worker with impaired pulmonary function was 1 worker (2.9%), and workers who had normal pulmonary function were 9 workers (26.5%).

The differences of pulmonary function status on production group and administration group had a value of p = 0.215 which means that no significant difference on pulmonary function status between production group and administration group.

The impaired pulmonary function occurred when there was a decrease in spirometric parameters FEV1 of ≤ 75% and FVC of <80%. The FEV1 in the production group and administration group was p = 0.000, showing that there were significant differences between the two groups. Meanwhile, the FVC value in production group and administration group showed p = 0.001 which means that there were significant differences between the two groups.

The mean value of FEV1 in production group was significantly lower than the value of FEV1 in administration group. Similarly, the value of FVC in production group was significantly lower compared to the administration group.

The Correlation Characteristics between Workers Status and Pulmonary Function Status

The analysis on the relationship characteristics of workers with pulmonary function status was done by using Chi-Square test or Fisher's test. Its characteristics included age, length of employment, degree of smokers, the habit of using PPE, and

Table 9. The Cross Tabulation of Worker Characteristics and Pulmonary Function Status in Livestock Feed Industry Surabaya, 2019

Characteristic	Pulmonary Function Status				*p-value*
	Normal		Abnormal		
	n	%	n	%	
Age					
< 31 years	16	47.1	1	2.9	0.008
≥ 31 years	8	23.5	9	26.5	
Total	24	70.6	10	29.4	
Tenure					
< 7 years	16	47.1	1	2.9	0.008
≥ 7 years	8	23.5	9	26.5	
Total	24	70.6	10	29.4	
Degree of Smokers					
Non smoker	21	61.8	1	2.9	0.000
Light smoker	1	2.9	5	14.7	
Moderate smoker	1	2.9	3	8.8	
Heavy smoker	1	2.9	1	2.9	
Total	24	70.6	10	29.4	
PPE Use Frequency					
Never	12	35.3	4	11.8	0.890
Seldom	8	23.5	4	11.8	
Always	4	11.8	2	5.9	
Total	24	70.6	29.4	29.4	

nutritional status. According to Ostrowski and Barud, (2006), the pulmonary function might be influenced by many factors such as gender, nutritional status, degree of smoking, and air pollution (occupational and environmental exposure).

Based on cross-tabulation of age with pulmonary function status (Table 9), it is addressed that workers with age <31 years and ≥ 31 years on the same amount. From a total of 34 workers, 29.4% of the workers had abnormal pulmonary function status and 26.5% of the workers had abnormal pulmonary function status who were worker at the age of ≥ 31 years. The result of the relationship of age with pulmonary function status declares that there was a relationship between age and pulmonary function with p-value = 0.008. Normally, age is a factor that naturally decreases pulmonary capacity.

The analysis of tenure relationship with pulmonary function status showed p-value = 0.008 which means that there was significant relationship between tenure and pulmonary function status. According to Suma'mur (2014), the longer the employees worked in a dusty industry, the higher the risk of impaired pulmonary function.

Based on the analysis of the relationship degrees of smokers against pulmonary function status, it indicated p-value = 0.000, which means that there was a relationship between smoking and pulmonary function status.

Based on the analysis of the use of PPE relationship with pulmonary function status, the result was p-value = 0.890 which means that there was a significant relationship between the use of PPE with pulmonary function status. In cross-tabulation, the habit of using PPE to the status of pulmonary function addressed that workers with impaired pulmonary function were workers whom were rarely wearing PPE, but the worker with a normal function were workers whom did not wear PPE (35.3%). The workers who did not wear PPE were clerical workers who were working in a closed room and away from the exposure of dust's factory and they were not required to wear PPE.

Table 10. Correlation Pulmonary Function Status and Respirable Dust Concentration in Livestock Feed Industry Surabaya, 2019

Pulmonary function Status	Dust Concentration				*p-value*
	Mean	SD	Min	Max	
Normal	0.911	0.92	0.013	3.92	0.000
Abnormal	3.24	1.65	0.013	6.45	

Table 11. Correlation Status of Pulmonary Function and Concentration of Bacteria in Animal Feed Industry Surabaya, 2019

Pulmonary function Status	Mean	SD	Min	Max	*p-value*
Normal	808	571	197	1895	0.000
Abnormal	2159	854	197	2628	

Table 12. Correlation Pulmonary Function Status and Concentration of Fungi in Animal Feed Industry Surabaya, 2019

Pulmonary function Status	Mean	SD	Min	Max	*p-value*
Normal	561	344	205	1118	0.000
Abnormal	811	234	205	1118	

The Correlation of Respirable Dust Concentration and Pulmonary Function Status

The exposure of pollution in the working environment was the biggest cause of decreased health. The relationship between environmental exposure and health effects was difficult due to the limited environmental monitoring that normally should be conducted by company.

The correlation between respirable dust concentration and pulmonary function status showed value of p = 0.000 which means that there was a significant correlation between pulmonary function status and concentration of respirable dust. The concentration of respirable dust in the production area and the administration area showed an average value above TLV-TWA on the circuitry of worker's abnormal lung status as 3.24 mg/m3. According to the regulation of the minister of manpower Number 5 of 2018, reference value of TLV-TWA for respirable dust is less than 3 mg/m3. On the status of workers with normal pulmonary function, the average concentration of exposed dust was 0.911 mg/m3.

The Correlation between Microorganisms Concentration (Bacteria and Fungi) and Pulmonary Function Status

In the statistical test of correlation between respirable dust concentration and the concentration of bacteria and fungi, it showed strong results

assuming that they were correlated. The presence of microorganisms in large amounts could affect workers' health.

The concentration of bacteria on workers with abnormal function has exceeded the TLV-TWA (2159 CFU/m3), while the concentration of bacteria with a value below TLV-TWA (808 CFU/m3), and pulmonary function status of workers showed normal result.

The results on analysis of bacterial concentration correlation with pulmonary function status showed p-value of 0.000, which means that there was a significant correlation between the concentrations of bacteria in pulmonary function status. The concentration of bacteria varied at different points of its measurement. The maximum value of bacteria concentration in working environment has exceeded the TLV-TWA that potentially harmed the health of workers. The mean value of bacteria that exposed worker with abnormal pulmonary function was higher than normal pulmonary function. The result had similarity in minimum value. Both pulmonary function status had minimum value below TLV-TWA.

The results on analysis of fungal concentration relationship with the direct pulmonary status obtained p-value of 0.000, which means that there was a significant correlation between the concentrations of fungi with pulmonary function status.

The concentration of fungi varies at different points of its measurement. The maximum value of fungi concentration in working environment has exceeded the TLV-TWA. At some points, it could potentially harm workers' health. The workers with abnormal pulmonary function has a fungi concentration measurement that exceeded the TLV-TWA (811 CFU/m3), while workers with normal pulmonary function had a concentration measurement results of fungi under TLV-TWA (561 CFU/m3).

DISCUSSION

Respirable Dust Levels

The production area had higher respirable dust levels because the production activities were in direct contact with the raw material which was respirable dust. Based on observations, the production area becomes one with the rest room and has poor ventilation. This is different from the administrative area which is away from the dust exposure. The difference in dust concentration is in accordance with the Iyogun, Lateef and Ana, (2019) research stating that there were differences in dust concentration between the production and administration areas.

The Concentration of Bacteria and Fungi

The results of the analysis of differences in bacterial and fungal concentrations in both areas were different significantly. This can be caused by the concentration of dust in the production area which was higher than the administration. The research also proved that the concentration of dust had a correlation with the concentration of bacteria and fungi.

The Characteristics of Respondents

In the analysis of respondents' characteristics, it was found that the age group of the production group was dominated by older workers, the length of service of the production group and administration showed that the working period of the production group was longer than the administration. This was due to the higher turnover rate of administrative workers than production workers, which results in a lot of new employees coming in so that the age and administrative work period was shorter. Based on the analysis of the degree of smokers, it was obtained the results that the production workers have more smoking than the administration. Smoking habits can be influenced by the level of education of workers. Workers with lower levels of education have more smoking habits according to Suma'mur, (2014). Production groups were dominated by workers with lower levels of education than the administration group.

The Correlation between the Respirable Dust and the Concentration of Microorganisms

Dust concentration and microorganism concentration showed a significant correlation. This was confirmed by Haltensen, (2013) research which stated that dust concentration had a strong correlation with bacterial and fungal concentrations. The higher the concentration of dust, the higher the concentration of bacteria and fungi. Microorganisms such as bacteria and fungi need organic material contained in grains as a food source. Microorganisms multiply faster when food needs are fulfilled.

The Status of Pulmonary Function

Based on the cross tabulation, there was no difference in the number of workers who experience pulmonary physiology. However the FVC and FEV1 values were different significantly. The FEV1 value and FVC of the production group were lower than the administration. This was due to the production group which was being exposed to more environmental factors such as dust and microorganisms which can cause pulmonary physiology disorders (Iyogun, Lateef and Ana, 2019).

The Correlation between Workers' Characteristic Factors and Pulmonary Function Status

Production group that had older age (≥ 31 years) had higher risk than administration group. From a total of 34 workers, 29.4% of the workers had abnormal pulmonary function status and 26.5% of workers had abnormal pulmonary function status who were workers at the age of ≥ 31 years. This is consistent with a research conducted by Katherine (2014) on the Rice Mill workers, showing that the most dominant workers with impaired pulmonary function aged > 31 years. This study is also consistent with a research project conducted by Azizah (2019) on exposed workers to organic dust, stating that workers at older age had more experienced in pulmonary function disturbance.

The result of the relationship between age and pulmonary function status declared that there was a relationship between age and pulmonary function with p-value = 0.008. Normally, age is a factor that naturally decreases pulmonary capacity. The respiratory system will change the anatomy and immunology in accordance with age. The increased age was expected to slow down the development of the lungs, respiratory muscle strength vital capacity, FEV1, FVC, and liquid antioxidants as well as epithelial (Sharma and Goodwin, 2006). Thus, the increased age often becomes a risk factor of Chronic Obstructive Pulmonary Disease (COPD) as it relates to the accumulation of exposure during life (Gold, 2017).

Production group had longer tenure (≥ 7 years) than administration group. The analysis of tenure relationship with pulmonary function status showed that there was significant relationship between tenure and pulmonary function status. According to Suma'mur (2014), the longer the employee worked in a dusty industry, the higher was the risk of impaired pulmonary function. In an official report of the American Thoracic Society documented the relationship between occupational exposures and increased risk chronic cough, lower FEV1, and lower FEV1/FCV ratio. The dust exposed length may be associated with impaired pulmonary function since long-term exposure (Qian et al., 2016).

Production group had higher degree of smoker than administration. Based on the analysis of the relationship degrees of smokers against pulmonary function status, it indicated that there was a relationship between smoking and pulmonary function status. It is in-line with a research conducted by Azizah (2019) which showed that there was a significant association between smoking and pulmonary function disorders. Smoking is one of the factors that influences pulmonary function disorders. Based on the tabulation, the majority of nonsmoker workers have normal pulmonary function status (61.8%) and abnormal physiological status of the light smokers (14.7%).

According to Minister of Health Regulation (2008), it happened because the workers were passive smokers. Passive smokers have increased risk for Chronic Obstructive Pulmonary Disease (COPD) due to the chemicals of cigarette smoke inhalation which is higher as compared to major smoke of cigarette, because tobacco burns at a lower temperature when cigarettes are not smoked. There also happens a case of incomplete combustion and it can release more chemicals. Cigarette smoke caused lung disruption in the form of damage respiratory tract, namely the loss of silia to dispel foreign matter so that dust, bacteria, and fungi would more easily enter the lungs. The entry of dust and microorganism into the lungs causes infection and inflammation of bronchus, bronchioles and alveoli. That causes occurrence of pulmonary obstruction (Tageldin, Gomaa and Hegazy, 2017).

Based on the analysis of the use of PPE relationship with pulmonary function status, the result showed that there was a significant relationship between the uses of PPE with pulmonary function status. In cross-tabulations, the habit of using PPE to the status of pulmonary function addressed that workers with impaired pulmonary function were workers whom were rarely wearing PPE, but the worker with a normal function were workers whom did not wear PPE (35.3%). The workers who were not wearing PPE were clerical workers who were working in a closed room and away from the exposure of factory dust and they were not required to wear PPE.

The use of masks can reduce the ingress of dust into the respiratory tract that can lower the risk of pulmonary disorders. A research project conducted by Nuraisyah, (2010) on the animal feed industry, has found an influence among the characteristics of workers (working age, smoking habits, use of PPE) to the pulmonary function status.

Respiratory protection was an important tool considering 90% of cases poisoning as a result of entry of hazardous materials through the respiratory tract. Respiratory protection equipment itself provides protection against sources of danger in the workplace air such as air, gas, pollution dust particle and smoke (Li et al., 2019).

The Correlation between Exposure Factors (Respirable Dust, Bacteria, and Fungi Concentration) and Pulmonary Function Status

Based on the measurement results, the average of dust concentration in a production group was 2.22 mg/m3 greater than the administration group of 0.09 mg/m3. According to the Regulation of (Minister of Manpower Regulation, 2018), the concentration of respirable dust in the production and administration groups were still under threshold limit value (TLV-TWA), which was 3 mg /m3.

There was a significant difference between the dust concentration of production and administration areas. The production group was mostly exposed to grain dust during production process. The activities included the production of dumping, grinding, mixing, palleting, and sacking off. The dumping area was an area of distribution of raw materials in the form of grains to the production machine. The raw materials that have entered and then milled on a grinding machine was the activity of raw material grinding grain into smaller-sized material. After the grinding process, the raw materials went through the process of mixing the raw materials with the mixture of other materials that can support the quality of feed. The materials were mixed and then formed through the palleting process. Then, the last option was the process of packaging or sacking off. Throughout the process, workers were directly exposed to the production of raw materials such as grain production for 8 hours of working.

The dust concentration amount at the production area was greater than the area of administration. The values of dust concentration in the administration area was smaller, because the area was a closed-area and was equipped with air conditioning (AC). The particulate within the area could be significantly reduced by the air conditioning. The concentration of microorganisms were likely to be greater found in rooms (area) without air conditioning. In the administrative area, the working process is merely on the administrative process that does not involve raw materials, so that the concentration of dust in the administration area is lower than in the production area.

Result of measurement on the concentration of bacteria showed the average concentration of bacteria in the production group 1479.1 CFU/m3 which was greater than the administration group 549.2 CFU/m3. According to the Minister of Manpower Regulation, (2018) the TLV concentration of bacteria in working environment was 700 CFU/m3. It showed that the threshold number of bacteria in the air (production area) has exceeded.

The results of dust concentration and the concentration of bacteria had strong correlation and positive correlation which means that the larger the concentration of dust, the greater the concentration of bacteria. The grain dust were organic materials that were potentially contaminated by microorganisms such as bacteria and fungi. The grain dust was variety. Not only the grain itself, but also microorganisms. The proportion of microbial components in the grain dust could vary in each workplace (Haltensen, 2013). In essence, microorganism did not live in the air, because air is not a natural habitat for microorganism. Microorganism was located in the air due to the wind along the dust particles (Sari, 2017).

There were other various factors that could affect the concentration of bacteria and fungi in the air such as temperature, humidity uv, and intensity of illumination according to Pudjadi et al., (2015). The high concentration of bacteria and fungi in the production area could be caused by temperature and humidity of the production area that tended to be high. In the production area, there were production machines when operating emit heat radiation that might cause the ambient temperature increased. A high humidity in the production area could be caused by the lack of adequate ventilation.

The presence of bacteria and fungi that contaminated working environment could also have negative effects on pulmonary function status. The differences of pulmonary function status on production group and administration group had no significant difference on pulmonary function status but the mean value of FEV1 in production group was significantly lower than the value of FEV1

in administration group. Similarly, the value of FVC in production group was significantly lower as compared to the administration group.

This is consistent with research by Iyogun et al (2019) that there was a decrease in FEV1 in the exposed group as compared to workers who were not exposed. It is also consistent with a study by Wagh (2006) which stated that there were significant differences on FEV1 as compared with the control group. In contrast, the study conducted by Hosseinabadi (2013) found that the differences in measurement results of FEV1 and FVC addressed significant difference. However, these studies use small number of samples, so it becomes a limitation towards the study that may lead to different result that clarifies there is no significant differences between exposed and control group.

The correlation between dust concentration and pulmonary function status showed significant correlation between pulmonary function status and concentration of dust. The concentration of dust in the production area and the administration area showed average value of the above TLV on the circuitry of workers' abnormal lung status of 3.24 mg/m3.

On the status of workers with normal pulmonary function, the average concentration of exposed dust was 0.911 mg/m3. This value was still below the threshold limit value (TLV-TWA) (Minister of Manpower Regulation, 2018).

One cause of pulmonary function status decrease was caused by the dust. The factors that affect including particle size, concentration, chemical properties, shape, power, and duration of exposure to dust (Aji, 2010). The most harmful size of dust to the respiratory tract was dust with a size of less than 4 μm or called as respirable dust. With its small size, it reached into bronchial area to alveoli (Suma'mur, 2014).

Generally, dust that reaches the alveoli will settle and be very dangerous when it is buried in the area of gas in the respiratory system. Particles that settle can cause deterioration in pulmonary function, and the static dust particles can cause a damage on the alveolar wall.

A continuous exposure of dust could cause macrophages undergo continuous destruction, causing the onset of collagen connective tissue and lead to pulmonary fibrosis. The pulmonary fibrosis could cause a decrease in lung elasticity and decreased respiratory function (Anderson and Wilson, 2012).

A research by Wagh (2006) has proven that there was an impairment of pulmonary function when an exposure to dust is increased. This statement was supported by (Korelia, 2018) who also mentioned that an exposure to dust causes the decreased pulmonary function values. Dust of animal feed raw materials containing LPS (Lipopolysaccharides) endotoxins which is potential to increase TNF-α as indicating inflammation and infection by microorganism.

A similar study conducted by Iyogun et al (2018) which stated that if the duration of exposure increases, the value of pulmonary function declines. There was a significant decrease in the value of FEV1 on the length of service in the industry with an exposure to dust for > 5 years.

A research conducted by Ekasari (2013) on feed mill, stated that there was a meaningful relationship between the exposure of dust and impaired pulmonary function. The concentration of bacteria on workers with abnormal function has exceeded the TLV-TWA (2159 CFU/m3), while the concentration of bacteria with a value below TLV-TWA (808.38 CFU/m3), and pulmonary function status of workers showed normal result.

The results on analysis of bacterial concentration correlation with pulmonary function status showed that there was a significant correlation between the concentrations of bacteria in pulmonary function status. The concentration of bacteria varied at different points of its measurement. The maximum value of bacteria concentration in working environment has exceeded the TLV-TWA that potentially harm the health of workers.

The results on analysis of fungal concentration relationship with the direct pulmonary status obtained that there was a significant correlation between the concentrations of fungi with pulmonary function status. The concentration of fungi varies at different points of its measurement. The maximum value of fungi concentration in working environment has exceeded the TLV-TWA. At some points, it could potentially harm the workers' health. The workers with abnormal pulmonary function had a fungi concentration measurement that exceeded the TLV-TWA (811.1 CFU/m3), while workers with normal pulmonary function had a concentration measurement results of fungi under TLV-TWA (561.04 CFU/m3).

The inhalation of microorganisms caused various respiratory diseases such as allergies alvelolitis, asthma, and organic dust toxic syndrome

(Widmeier and Hotz, 2007). The bacteria has endotoxins that cause inflammation in the respiratory tract that occurs after the exposure to grain dust. Respiratory tract inflammation causes a narrowing in the pulmonary tract and experiences obstruction (Hayleeyesus and Manaye, 2014).

Fungi has a role in health because it could be pathogens that cause illness as well as allergens. Mycotoxins from fungi also can cause negative effects on the respiratory system. The toxins are responsible for the acute toxicity of macrophages in the alveoli.

Fungi has the ability to produce and disseminate spores through the air. Generally, fungi infected the air spread through droplet infection mechanism, which is a process for distributing spores through grain dust or through droplets of saliva residue dried (Jawetz, Adelberg and Melnick, 2017).

Exposure to fungi in large numbers coupled with supporting factors like age, unhealthy body condition, smoking and work fatigue causes decreased immune response by activated inflammatory response. Inflammation of respiratory tract causes narrowing of the lung tract due to fluid that fills the airways and prevents the air from obstruction (Nielsen et al., 2012).

CONCLUSION

Correlation of age, tenure, and degree of smoking shows $p < 0.05$ which indicates that there is significant relationship between age, tenure, and degree of smoker and pulmonary function. The concentration of dust in a production and administration groups are <3 mg/m3 that are still below the Threshold Limit Values (TLV-TWA). The dust concentration has strong correlation with concentration of bacterial and fungi. There is significant correlation between the concentrations of dust, bacteria, and fungi in pulmonary function status.

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