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Research Article

Analysis of Flour Dust Exposure to Lung Capacity of Flour Mills Workers

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ABSTRACT

Introduction: Optimal lung capacity is essential for worker health and productivity. A dusty work environment can increase the risk of inhaling particles that affect workers' health. Workers in flour mills are at risk of respiratory problems due to exposure to flour dust in the work environment.
Objectives: This study aims to analyze the effect of exposure to flour dust on lung capacity in flour mill workers.
Methods: This type of research is quantitative research with an analytical observational approach using a cross sectional study design, conducted in October-December 2024. The research sample was 96 respondents consisting workers in the production and non-production department. Data were collected through measurements and questionnaires, then analyzed using univariate, bivariate, and multivariate analysis.
Results: The study showed that 80.2% of workers had abnormal lung capacity. Exposure to flour dust (p=0.001), history of lung disease (p=0.006), working department (p=0.003), smoking habits (p=0.004), and use of personal protective equipment (p=0.000) were significantly associated with lung capacity ($p<0.05$). The variables of age (p=0.865) and lenght of work (p=0.486) are not significant ($p>0.05$). Multivariate analysis showed that among all the variables studied, the use of personal protective equipment (PPE) and exposure to flour dust had the most influence on lung capacity.
Conclusions: The use of personal protective equipment and exposure to flour dust are the variables that most significantly affect the lung capacity. Therefore, we recommend the need to implement occupational safety and health programs such as the provision of adequate ventilation systems, provision of appropriate personal protective equipment (PPE), and periodic assessment of workers' lung capacity.
Keywords: Flour Dust Exposure; Lung Capacity; Flour Mills Workers.

INTRODUCTION

Exposure to dust in the workplace can cause inflammation and damage to lung structures that can result in decreased lung capacity and other dust-related lung diseases, including respiratory irritation and chronic obstructive pulmonary disease (COPD), which are recognized as serious public health problems [1]. Work related lung diseases are a public health problem, accounting for nearly 30% of all work-related diseases and reaching 50% in workers employed in high dust-producing industries [2].

In Indonesia, according to data from the Guidelines for Diagnosis and Management of COPD in Indonesia published by the Indonesian Lung Doctors Association (PDPI) in 2023, it is estimated that the number of people with COPD is 4.8 million people with a prevalence of 5.6% [3]. This number is expected to continue to increase along with the increasing number of smokers and air pollution, which comes from motor vehicle exhaust gases and industrial air pollution [4].

Work-related lung diseases can be caused by the deposition of dust in the lungs, which is influenced by the type of dust, the period of exposure, the concentration of dust and size of airborne dust in the breathing zone [5]. Particle size plays an important role in determining the percentage of dust that enters and where it settles in the respiratory tract of workers. Coarse particles ≥ 10μm in diameter settle on the upper airway surface while fine particles between 5 and 10μm in diameter are more likely to reach the lower respiratory tract and cause adverse respiratory health effects [6].

One industry that generates dust in the workplace during the activity process is flour mills [7]. Epidemiologic studies suggest an association between flour dust exposure and respiratory health problems and decreased lung capacity among flour mill workers [8]. Workers in flour mills face an increased risk of respiratory problems and reduced lung capacity due to exposure to dust in the workplace. The workplace atmosphere significantly impacts workers' health [9]. Flour milling produces dust as long as industrial activities, such as cleaning, milling, packaging,

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and loading. These processes produce flour dust that is released into the air and then inhaled by workers. Workers are susceptible to inhaling flour dust during the mixing and packaging process of the flour milling process, which can cause respiratory symptoms [10].

Flour dust has a bimodal distribution that peaks around 5µm for fine dust particles and around 15-30µm for coarse particles. It has been reported that inhaled flour dust particles smaller than 5µm can potentially cause hypersensitivity pneumonitis and particles between 5 and 10µm in size can trigger asthma [6].

Flour dust particles are easily suspended in the air due to their very fine texture. When inhaled by workers, these particles have the potential to cause irritation to the respiratory system, leading to conditions such as asthma and rhinitis. Inhaling flour dust can trigger immediate symptoms such as coughing, sneezing and wheezing. Prolonged exposure to flour dust can also lead to decreased lung function, resulting in decreased lung capacity, impaired lung growth in younger workers, and impaired overall respiratory health [11].

Inhaling flour dust can cause workers to develop a variety of respiratory illnesses with different symptoms and severity. Symptoms of respiratory disorders range from mild ones such as simple irritation to severe ones of allergies and chronic respiratory diseases, including asthma. With continued exposure, respiratory health problems among flour mill workers can lead to worker disability[12] .

Continuous exposure to even low concentration levels of flour dust components including enzymes, proteins and additives can cause allergic and non-allergic reactions resulting in various respiratory disorders and reduced lung function capacity[13]. Pulmonary function disorders in workers are influenced by various factors, both the work environment and the workers themselves. worker factors that can affect lung function are age, lenght of work, smoking habits, and nutritional status [14].

Respiratory disorders are associated with factors including socio-demographic factors such as gender, education, type of employment, history of respiratory disease; behavioral factors such as smoking habits; work-related factors such as length of exposure, working section, use of personal protective equipment, and effective exhaust ventilation [2].Spirometry has been widely used to detect lung capacity in workers exposed to dust in the workplace. It provides important information on lung capacity parameters, such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC% percentage ratio, and is also used to evaluate changes in lung capacity in workers [15].

OBJECTIVES

Previous studies have shown a relationship between exposure to flour dust and lung capacity in workers, therefore it is deemed necessary to conduct further research on factors that affect lung capacity in flour mill workers. This study aims to analyze the influence of flour dust exposure, sociodemographic factors (age, history of lung disease), work-related factors (length of work and working department) and behavioral factors (smoking habits and use of PPE).

METHODS

Study design, area, and period

A cross-sectional study design was used to assess lung capacity in flour mill workers. This study aimed to analyze the effect of flour dust exposure on lung capacity. The independent variables in this study were flour dust exposure, age, history of lung disease, lenght of work, working department, smoking habits and use of PPE, while lung capacity was the dependent variable. This study was conducted in Makassar City, South Sulawesi, Indonesia, from October to December 2024.

Study population

A total of ninety-six flour mill workers who had worked for at least three months became respondents in this study. Participants consisted of permanent employees, non-permanent employees, and daily workers in the production and non-production department.

Data collection procedure

Questionnaire

Data of the respondents was collected through personal interview by using structured questionnaires. The components of the questionnaires were socio-demographic characteristics of respondents (sex, age, education), behavioral of workers (smoking habits and use of PPE), work-related variables (lenght of work and working department), and history of lung disease.

Anthropometric measurements.

Each respondent in this study was measured for height and weight. Height was measured using an upright height measuring device and converted into centimeters. Body weight was also measured using digital scales.

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Spirometric measurement
Lung capacity is assessed using spirometry. In a standing position, the respondent is asked to inhale and exhale into the disposable spirometer mouthpiece. This maneuver is repeated three times and the best result of the three readings is taken and interpreted. The measured parameters were FVC, FEV1, and the percent age ratio (FEV1/FVC%). Normal lung capacity is defined as ≥ 80% of the predicted FVC value, ≥ 80% of the predicted FEV1 value, and ≥ 0.7 FEV1/FVC ratio. Meanwhile, abnormal lung capacity consists of two categories: restrictive disorders and obstructive disorders. Restrictive disorders are characterized by normal FEV1/FVC with decreased FVC and normal or reduced FEV1. Obstructive impairment is characterized by decreased FEV1/FVC with reduced or normal FVC, and decreased FEV1[16].

Dust measurement
Environmental flour dust sampling at the factory was carried out by the technical staff of the environmental laboratories non goverment. Respirable Suspended Particulates (PM10) sample was measured using the air scanner tool at seven different locations in production and non production department. The procedure for measuring environmental dust refers to SNI 77119.15-2016.

Data Analysis
Statistical Package for the Social Sciences 24 was used to analyze the data, which consisted of three stages: univariate, bivariate, and multivariate. Univariate analysis was conducted to describe the frequency distribution of each variable studied. Bivariate analysis to determine the relationship between one independent variable and the dependent variable using the Chi-Square test with a 95% confidence level ($\alpha = 0.05$). Multiple logistic regression was used in multivariate analysis to determine the most influential variable on the dependent variable by selecting variables that had a p value ≤ 0.05.

RESULTS

Socio-demographic characteristic of respondents
This study involved 96 respondents from wheat flour factory workers, consisting of 85 respondents (88.5%) male and 11 respondents (11.5%) female. The age of the respondents varied from 18 to 51 years old. The number of respondents in the ≤ 30 years age group was 59 respondents (61.5%), while in the > 30 years age group there were 37 respondents (38.5%). The majority of respondents in this study were high school graduates, as many as 67 respondents (69.8%). The majority of respondents did not have a history of lung disease, namely 66 respondents (68.7%), while 30 respondents (31.3%) had a history of lung disease (Table 1).

Flour dust exposure
The results showed that the highest flour dust exposure was in the mill department and the lowest dust exposure was in the flour warehouse department. The average flour dust exposure concentration in mill workers was 13 μg/m³ ranging from 10.40 – 17.77 μg/m³ (Figure 1).

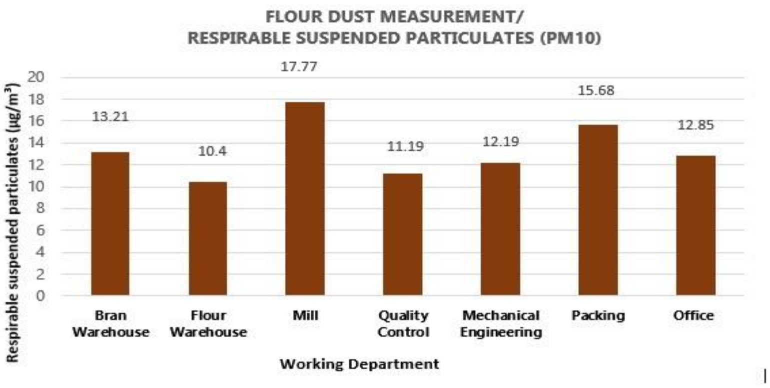

***Figure 1**. Flour dust exposure by working department*

Table 1. Socio-demographic characteristics of respondents in the flour mills workers

Variables	Frequency (n)	Percentage (%)
Sex		
Male	85	88.5
Female	11	11.5

Age (year)		
≤ 30	59	61.5
>30	37	38.5
Level of education		
Middle school	4	4.2
High school	67	69.8
College or university	25	26.0
History of lung disease		
Yes	30	31.3
No	66	68.8

Workplace and behavioral characteristics of respondents

Most of the respondents have been working for more than 3 years, namely 59 respondents (61.5%), while 37 respondents (38.5%) have been working for less than 3 years. For working department, the largest number of respondents in this study were those working in the production department, namely 54 respondents (56.3%), while 42 respondents (43.8%) worked in the non-production department. 58 respondents (60.4%) are smokers, while 38 respondents (39.6%) do not smoke. More respondents did not use PPE, namely 67 respondents (69.8%), while only 29 respondents (30.2%) used of PPE (Table 2).

Table 2. Workplace and behavioral characteristics of respondents in the flour mills workers

Variables	Frequency (n)	Percentage (%)
Lenght of work (year)		
≤ 3	37	38.5
> 3	59	61.5
Working Department		
Production (Exposed)	54	56.3
Non Production (Unexposed)	42	43.8
Smoking Habits		
Smoking	58	60.4
Not smoking	38	39.6
Use of PPE		
Not using	67	69.8
Using	29	30.2

Distribution lung capacity based on working department

Table 3 showed lung capacity of flour mills workers based on working department. Among the total respondents, 80.2% had abnormal lung capacity. Respondents who experienced the most abnormal lung capacity were respondents who worked in the packing department (production departement). Out of a total of 28 respondents working in the packing department, there were 27 (28.1%) respondents who had abnormal lung capacity while only 1 (1.1%) respondent had normal lung capacity.

Table 3. Distribution of lung capacity respondents by working department

Working Department	Lung Capacity				Total	
	Abnormal		Normal			
	n	%	n	%	n	%
Bran Warehouse	3	3.1	2	2.1	5	5.2
Flour Warehouse	5	5.2	3	3.1	8	8.3
Mill	18	18.8	1	1.0	19	19.8
Quality Control	2	2.1	2	2.1	4	4.2
Maintenance Engineering	8	8.3	5	5.2	13	13.5
Packing	27	28.1	1	1.1	28	29.2
Office	14	14.6	5	5.2	19	19.8

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Table 4. Association socio-demographic, workplace and behavioral characteristic with lung capacity

Variable	Lung Capacity				Total		*P value*
	Abnormal		Normal				
	n	%	n	%	n	%	
Flour Dust Exposure							
>13,00 µg/m³	48	50.0	4	4.2	52	54.2	0.001
≤ 13,00 µg/m³	29	30.2	15	15.6	44	45.8	
Age (year)							
> 30	30	31.3	7	7.3	37	38.5	0.865
≤ 30	47	49.0	12	12.5	59	61.5	
History of lung disease							
Yes	29	30.2	1	1.0	30	31.3	0.006
No	48	50.0	18	18.8	66	68.8	
Lenght of work (year)							
> 3	46	47.9	13	13.5	59	61.5	0.486
≤ 3	31	32.3	6	6.3	37	38.5	
Working Department							
Production	49	51.0	5	5.2	54	56.3	0.003
Non production	28	29.2	14	14.6	42	43.8	
Smoking Habits							
Smoking	52	54.2	6	6.3	58	60.4	0.004
Not smoking	25	26.0	13	13.5	38	39.6	
Use of PPE							
Not using	61	63.5	6	6.3	67	69.8	0.000
using	16	16.7	13	13.5	29	30.2	

Table 4 shows a significant relationship between lung capacity and exposure to flour dust (p=0.001), history of lung disease (p=0.006), working department (p=0.003), smoking habits (p=0.004), and use of PPE (p=0.000), (p<0.05). While age (p=0.865) and length of work (p=0.486) were not significantly relationship to lung capacity (p>0.05).

Table 5. SPSS output of Multiple Logistic Regression Test

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1ᵃ	Flour Dust Exposure	.996	1.535	.421	1	.517	2.706
	Smoking Habits	-18.805	12549.379	.000	1	.999	.000
	Use of PPE	20.913	12549.379	.000	1	.999	1208666699.966
	History of Lung Disease	1.577	1.108	2.028	1	.154	4.842
	Working Department	.990	1.533	.417	1	.518	2.691
	Constant	-10.351	2.591	15.963	1	.000	.000
Step 2ᵃ	Flour Dust Exposure	1.878	.719	6.812	1	.009	6.538
	Smoking Habits	-18.832	12613.885	.000	1	.999	.000
	Use of PPE	20.820	12613.885	.000	1	.999	1101446812.915
	History of Lung Disease	1.574	1.107	2.021	1	.155	4.827
	Constant	-10.027	2.506	16.004	1	.000	.000
Step 3ᵃ	Flour Dust Exposure	1.958	.711	7.595	1	.006	7.088
	Use of PPE	2.169	.666	10.626	1	.001	8.753
	History of Lung Disease	1.448	1.103	1.723	1	.189	4.255
	Constant	-10.269	2.499	16.884	1	.000	.000
Step 4ᵃ	Flour Dust Exposure	2.185	.701	9.721	1	.002	8.890
	Use of PPE	2.435	.652	13.959	1	.000	11.414
	Constant	-8.377	1.792	21.852	1	.000	.000

Table 5 is the result of multiple logistic regression analysis, which shows that there are 4 stages in the partial testing of all variables tested. In step 1, the work unit variable has a Sig. value of 0.518 so it is removed in the next test stage. In step 2, the smoking habit variable has a Sig. value of 0.999 so it is removed in the next test stage. In step 3, the variable history of lung disease has a Sig. value of 0.189 so it is removed in the next test stage.

Based on the results of the analysis, it can be seen that the variable of PPE use is the most significant variable that partially affects the lung capacity variable with a Sig. value of 0.000, and an OR value of 11.414, which means that workers who do not use PPE properly will have an 11 times higher risk of lung capacity abnormal than workers who use PPE properly.

DISCUSSION

The Effect of flour dust exposure on lung capacity.

The dust measurement results show that the highest dust concentration is found in the milling (17.77 μg/m³) and packing (15.68 μg/m) compared to other working depertments. The results of the bivariate analysis in Table 4, was found that exposure flour dust had a relationship with lung capacity (p value = 0.001 < 0.05). Respondents who were exposed to dust above the average measurement results or more than 13 μg/m³ experienced abnormal lung capacity as many as 48 respondents (50%), while respondents exposed to dust below the average measurement results who experienced abnormal lung capacity were only 29 respondents (30.2%).

The dust measurement results show that flour dust exposure in all work sections is still far below the threshold value based on the Indonesian Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health. The indoor air quality threshold value for the Respirable Suspended Particulate Matter (PM10) parameter is <180 μg/m³ [17]. Although the measurement results were far below the NAB value, most respondents experienced impaired lung capacity. This indicates that although dust exposure is still below the threshold value, inhaled dust still provides a high risk for workers to experience impaired lung function. This needs to be a concern because dust inhaled daily can accumulate and settle in the lungs[18].

The risk of adverse health effects to workers is closely linked to the level of exposure to flour dust in the work environment [19]. Flour dust generated during the cleaning, milling, packaging, and transportation processes is released into the air and can be inhaled by workers[20].

The results of lung capacity measurements also showed that workers exposed to dust above the average measurement results (>13μg/m³) were more likely to experience abnormal lung capacity. Multiple logistic regression analysis showed that workers exposed to dust >13 μg/m³ had an 8 times greater risk of experiencing abnormal lung capacity (Sig. 0.002, OR = 8.890).

The Effect of Age on Lung Capacity

The age group of less than 30 years experienced more abnormal lung capacity, namely 47 respondents (49%) compared to the age group of more than 30 years, which was only 30 respondents (31.2%). Based on the results of bivariate analysis of the effect of age on lung capacity, the p value is 0.865 (p>0.05), this means that age does not significantly affect the lung capacity of respondents.

Lung function declines throughout adult life, and healthy people are no exception. Aging has been shown to have a significant correlation to lung changes [21]. Age is historically one of the main factors in the evaluation of lung function. The most affected variables are forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1)[22].

As we age, FVC decreases due to increased chest wall stiffness, loss of lung tissue elasticity, and weakening of the respiratory muscles. There is an average reduction of about 20-25 ml in FVC after the age of 40. FEV1 also decreases, progressively faster with age. It is reported that the annual decline in FEV1 is about 20-35 ml between age 25-40 years. When reaching the age of 70 years or older, the annual decline is about 40-60 ml [23].

In this study, respondents with age groups above 30 years and below 30 years both experienced abnormal lung capacity. This indicates that age is not the only factor that causes a decrease in lung capacity. Increasing age does not mean that the risk of abnormal lung capacity also increases. There are other causes that lead to impaired lung capacity such as exposure to dust, smoking, and the use of personal protective equipment.

The Effect of History lung disease on lung capacity.

More respondents who did not have a history of lung disease experienced abnormal lung capacity, namely 48 respondents, compared to respondents who had a history of lung disease, namely only 29 respondents (30.2%) out of a total of 77 respondents (80.2%) who experienced abnormal lung capacity.

The results of the bivariate analysis show that there is a significant influence between the history of lung disease and the lung capacity (p value = 0.006 < 0.05) However, in the multivariate analysis, the variable history of lung disease has a significance value above 0.05, which is 0.189, so it is not included in the next stage of the test. This indicates that based on the multivariate test, history of lung disease does not have a significant effect on lung capacity.

A previous history of respiratory disease may affect the normal function of the respiratory system by causing airway obstruction and respiratory sensitization. These changes may lead to an increase in chronic respiratory symptoms.

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Pre-existing respiratory diseases can disrupt the defense mechanisms of the respiratory tract, leading to increased susceptibility to symptoms related to respiratory disorders [24]. Flour dust can also act as an irritant and cause short-term respiratory symptoms, or can trigger asthma attacks in individuals with a pre-existing history of the disease [25]. The history of lung disease in this study is not the result of a diagnosis from a doctor, but based on the symptoms experienced by respondents describing the presence of lung disease disorders assessed through the questionnaire using a guttman scale.

The Effect of Lenght of work on Lung Capacity

Respondents with more than 3 years lenght of work experienced more lung capacity disorders, namely 46 respondents (47.9%), while respondents with less than 3 years lenght of work experienced fewer lung capacity disorders, namely 31 respondents (32.3%) out of a total of 77 respondents who experienced abnormal lung capacity. The results of the bivariate analysis show that there is no significant influence between lenght of work and lung capacity in flour mill workers (p value = 0.486 > 0.05).

Lenght of work will have a positive effect on the workforce. The longer a person works, the more experienced they will become in doing the job. On the other hand, the longer lenght of work for individuals working in dusty environments, the more negative impact it can have on their health, especially respiratory tract health [26]. The longer a worker is exposed to dust concentrations that exceed the threshold in the work environment, the faster the worker will experience a decrease in lung capacity [27].

A long working period in a work environment exposed to flour dust allows employees to experience continuous exposure to dust. This has the potential to exacerbate or accumulate dust exposure that can damage the respiratory tract and ultimately lead to impaired lung capacity. However, this study shows that the lenght of work does not significantly affect the incidence of abnormal lung capacity in flour mill workers. This may be because respondents with a lenght of work more than 3 years and respondents with lenght of work less than 3 years, both had more abnormal lung capacity than respondents who had normal lung capacity.

The Effect of Working Department on Lung Capacity

The total of 77 respondents who experienced abnormal lung capacity, respondents who worked in production units experienced more abnormal lung capacity, namely 49 respondents (51%), while respondents who worked in non-production units experienced less abnormal lung capacity, namely 28 respondents (29.2%).

The results of the bivariate analysis show that there is a significant influence between the working department and lung capacity (p value=0.003 < 0.05). After the multivariate test, it was found that the significant value was above 0.05, which was 0.518. This indicates that based on the multivariate test, working department and lung capacity do not have a significant.

Dust produced from the production process in flour mills is released into the air and then inhaled by workers during processes such as cleaning, grinding, packaging, and transportation. The highest level of dust exposure occurs in the mixing and packaging areas of flour mills [28].

The observation findings in this study show that flour dust accumulates on the floors and machines in the production working department, namely in the mill, packing and bran warehouse. Dust accumulates in the flour milling and packaging sections because fine organic flour dust spreads into the air in the indoor environment of the flour factory. Exposure to flour dust in various working department in this study varies greatly. Flour factory workers who work in the production department, especially the milling department, are exposed to higher levels of flour dust than other departments.

This study is in line with a study conducted on flour mill workers in Addis Ababa, Ethiopia. The results of the analysis showed a significant association between respiratory symptoms and working departement. Workers in the milling and packaging departments were 3.24 and 2.42 more likely to be at risk of chronic respiratory distress than those in the machine operation department. This could be because workers in the packaging and milling department are directly exposed to fine flour products, which can be easily inhaled by workers in these department [29]. In the production department, workers are directly exposed to flour dust compared to workers in non production department.

Direct exposure to dust can lead to decreased lung function. Occupational lung diseases are mostly related to the inhalation of dust by workers and its deposition in the lungs [16].

The Effect of Smoking Habits on Lung Capacity

Respondents who smoke experience more abnormal lung capacity, namely 52 respondents (54.2%) compared to respondents who do not smoke, namely 25 respondents (26%) out of a total of 77 respondents who experience abnormal lung capacity.

The results of the bivariate analysis show that there is a significant influence between the smoking habits and lung capacity (p value=0.004 < 0.05). After the multivariate test, it was found that the significant value was above 0.05 (p = 0.999). This indicates that based on the multivariate test, smoking habits do not have a significant influence on lung capacity. This study is in line with research conducted by Ulanga et.al (2021) which shows that smokers have a 42.4% higher prevalence of pulmonary obstruction defects (FEV1 / FVC <70%) than respondents who do not smoke (20.7%), p <0.05[30].

Smoking is the most important risk factor for accelerating the decline of lung function and can cause chronic obstructive pulmonary disease [31]. Cigarette smoke contains harmful substances such as nicotine, tar, and thousands of chemicals, including those with toxic and carcinogenic effects. The particles inhaled from cigarette smoke and deposited in the respiratory tract depend on their size. Larger particulates settle in the upper airways and smaller particulates settle in the alveoli causing chronic inflammation, infection, oxidative stress and damage to the airways and gas exchange in the lung area [32].

The results of this study show that workers who are active smokers are more likely to have abnormal lung capacity. This study confirms that smoking behavior affects the decrease in lung capacity. Workers who do not smoke also experience more abnormal lung capacity compared to workers who have normal lung capacity. This could be because some workers who do not smoke are also still exposed to cigarette smoke or become passive smokers.

The Effect of Use of PPE on Lung Capacity

Respondents who did not use personal protective equipment (masks) at work experienced more abnormal lung capacity, namely 61 respondents (63.5%) compared to respondents who used personal protective equipment (masks) at work, namely 16 responses (16.7) out of a total of 77 respondents who experienced abnormal lung capacity.

The results of the bivariate analysis show that there is a significant influence between the use of PPE and vital lung capacity (p-value = 0.000 <0.05). After conducting a multivariate test, a significant value below 0.05 was obtained, namely 0.000. This shows that based on the multivariate test, the use of PPE has a significant effect on lung capacity.

Workers who handle dusty materials such as flour, wearing a face masks will protect the lungs from inhaled dust [33]. The use of respiratory protective equipment such as masks can minimize exposure of workers to flour dust [11]. Lack of awareness in using personal protective equipment may increase the likelihood of respiratory symptoms among factory workers[12].

Multivariate analysis show that the use of personal protective equipment has a significant effect on lung capacity. Based on the results of the analysis, it can also be seen that the use of personal protective equipment is the most significant variable that partially affects the lung capacity variable with a Sig. value of 0.000, and an OR value of 11.414, which means that workers who do not use PPE at work will have an 11 times higher risk of experiencing impaired lung capacity than workers who use PPE properly at work.

To reduce the negative impact of flour dust on workers' health, proper operation of the ventilation system should be ensured. In addition, in working department such as production department with high exposure to flour dust, it is recommended to use personal protective equipment such as masks [34].

CONCLUSION

Based on the result PPE use variable is the most significant variable that partially affects the lung capacity variable with a Sig. value of 0.000, and an OR value of 11.414, which means that workers who do not use PPE properly will have an 11 times higher risk of lung capacity impairment than workers who use PPE properly (completely). The dust exposure variable is also a variable that partially and significantly affects lung capacity with a Sig. value of 0.002, and an OR value of 8.890, which shows that workers exposed to dust above the average measurement result or > 13 μg/m³ have an 8 times higher risk of lung capacity impairment than workers who use PPE properly. 0.002, and an OR value of 8.890, which shows that workers exposed to dust above the average measurement result or > 13 μg/m³ have an 8 times higher risk of experiencing impaired lung capacity than workers exposed to dust below the average measurement result or < 13 μg/m³.

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