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ANALYSIS OF WORKERS CHARACTERISTIC AND HISTORY OF DISEASE WITH PULMONARY FUNCTION STATUS IN LIMESTONE BURNING INDUSTRIAL IN TUBAN REGENCY EAST JAVA INDONESIA

[1]Ning Gusti Ramadiani,[2]* R. Azizah, [3]AriskaMidya Fahmita

ABSTRACT--*Limestone industry is one of the industries that contributes to the occurrence of considerable air pollution. Limestone dust burning has a major effect on workers such as pulmonary function disorders both acute and chronic. To analyze workers characteristic and history of disease with pulmonary function status in limestone burning industrial in tuban regency east java indonesia This research was an observational study with cross sectional design. The sample size in this study was 18 workers. The measurement of pulmonary function status in workers was done using a spirometer. Data analysis was perfomed descriptively from crosstab results by looking at coefficient contingency dengan melihat nilai coefficient contingency value:There were 11.1% of workers who had abnormal pulmonary function status, with details of 1 worker (5.55%) had pulmonary function impairments with light restriction and obstruction categories, 1 another worker (5.55%) had pulmonary function impairments with moderate restriction and obstruction categories. From the results of cross tabulation, there was less means correlation between working period with pumonary function status (0,039), there was weak correlation between nutritional status with pumonary function status (0,186), age with pumonary function status (0,205), smoking habits with pumonary function status (0,271). There was very strong correlation between history of disease with pulmonary function status with coefficient contingency (0,707). Workers who experienced abnormal pulmonary function status are workers who have a history of the disease, followed by workers who have smoking habits. Even though the workers relatively young (<50 years)and has a normal nutritional status, did not guarantee pulmonary function status was also in normal conditions. This was seen from the presence of one of the factors which was smoking habits and history of disease that triggered abnormal pulmonary function status. Recommended to worker to have routine medical check up at least once a year , reduce smoking habits, regular watering around the work environment to reduce the amount of dust produced and increase humidity. Also using PPE in accordance with the work needs and standards.*

Keywords: *Workers Characteristic, History of Disease, Pulmonary Function Status*

[1]Department of Environmental Health, Faculty of Public Health, Airlangga University, CampusC Mulyorejo, Surabaya, East JavaIndonesia

*[2]*Department of Environmental Health, Faculty of Public Health, Airlangga University, CampusC Mulyorejo, Surabaya, East JavaIndonesiaCorresponding Author:R.**Azizah**E-mail:azizah@fkm.unair.ac.id*

[3]Department of Environmental Health, Faculty of Public Health, Airlangga University, CampusC Mulyorejo, Surabaya, East Java, Indonesia

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I. INTRODUCTION

Limestone industry is one of the industries that contributes to the occurrence of considerable air pollution. Limestoneis a sedimentcontainsmany dead marine organisms that turn into calcium carbonate. In the past time, limestone was used as a wall hardener, but in modern industry it is used as a material for making cement. Lime is used in the agricultural sector, in order to be used as a fertilizer mixture, limestone must be burned to produce calcium oxide (CaO). Theoretically, this process emitted combustion gases such as NO_2, SO_2 and CO which increase air pollution(1). Occupational inhalation exposure to cement dust is likely to induce minor degree of restrictive ventilatory impairment (2).

The composition of limestone containing 95% $CaCO_3$ and 11% $MgCO_3$, crystalline silica by 1-20% when exposed in a long time (time and average weight measurement) with a weight up 2-5 mg/m^3 can cause an inflammation reaction (3). Limestone contains up to 40% of crystalline silica in some cases. Silica dust exposure occurs more in certain occupations, such as mining, sandblasting, stone cutting, surface drilling, silica flour mill operations, etc. Exposure to silica may decrease resistance to infection by facilitating viral and bacterial contamination through the respiratory tract (4). Bioaccumulation of some specific components as chromium and silica present in the respiratory tract may lead to delayed hypersensitivity reaction and chronic inflammation and hence impaired respiratory function (5).

The limestone industry has polluted the air with dust and gases resulting from the processing stage(6). The smoke and dust produced by some industries cause various types of pathogenesis. The unhygienic exposure of the smoke and dust are linked with an increased risk of chronic obstructive pulmonary diseases (7).Work environment full of dust, fumes, and other gases besides disruptingproductivity and health, it also often causesrespiratoryimpairment which is often accompanied by a decrease in pulmonary function capacity(8).Lime or limestone dust burning has a major effect on workers such as pulmonary function disorders both acute and chronic. Acute pulmonary function disorders such as respiratory tract irritation, increased mucus production, respiratory tract narrowing, release of cilia and mucous membrane lining and difficulty breathing(9).

According to research by Sucipto (2007) in Septyaningrum (2014), in Karangdawa, Margasari, Tegal Regency East Java Province, stated that there is a significant correlation between exposure to dust particles with a decrease in pulmonary function capacity (10).Pulmonary function impairment not only occurs in developed countries, but also occurs in developing countries and poor countries. According to WHO in 2000 - 2012 pulmonary function impairment is the third deadliest disease in the last decade. In 2012, around 3.1 millions died due to impaired pulmonary function of COPD (Chronic Obstructive Pulmonary Disease)(11).Based on the Basic Health Research (2013) report, COPD in Indonesia is included in the Non-Communicable Disease (NCD) group which is a chronic disease that is not transmitted from person to person. The prevalence of COPD based on interviews in Indonesia found 3.7% with a higher frequency in men. In Central Java the prevalence of COPD was 3.4% and in Sragen was 2.4% (12).

Pulmonary function can be not optimal due to extrinsicfactors such assources of exposure/factory type, duration of exposure, smoking behavior, personal protective equipment (PPE) and ergonomic principles. Whereas intrinsic factors such as age, sex, nutritional status, pulmonary defense mechanisms, immunological

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factors, pulmonary anatomy and physiology. To find out early, the diagnosis enforcement cases of pulmonary declining capacity must be done routinely, at least once a year by measuring pulmonary capacity(1,13).

One of thelimestone burningindustrial centers is CV. Indah Lestari owned by Nurhadi in Kesamben Village, Plumpang Kabu Sub-district, Tuban Regency. The limestone burning industry owned by Nurhadi has been established since 2007. The land area of the industry is 200 m^2 with a building area of 80 m^2 . There are 42 permanent employees consisting of 18 employees in burningsection, 15 employeesin packing section and9 lifting laborers. These employees originated from local residents in Kesamben Village, Plumpang Sub-district, Tuban Regency. Every day, this industry can produce tens of tons of mature limestone or so-called limestone, which is deposited in several industries such as paper making industry, cement production and other building materials.

Basically, limestone burning process is done by burning limestone in the furnace or also called tobong. The limestone burning industry has two operating furnaces. Limestone is crushed to a smaller size, then put in a furnace and burned using sawdust fuel. In the burning process (calcination) at a temperature of 900-1000°C, $CaCO_3$ isbroken down into CaO and CO_2($CO_2$is released into the air). The burning process is carried out for 24 hours. Workers are divided into 3 work shifts. Fuel is given once every 3 hours and the burned stone can be taken once every 27 hours. After the limestone is burnt, the next step is watering. If there is a demand that the limestone is broken down again to a smaller size, then the workers will break down the limestone which has been burned to a smaller size again and the last process carried out is the packaging process so that the limestone is ready to be deposited to the paper making industry, cement production and also other building materials. This industry still uses traditional methods and does not pay attention to emissionsprocessingaspects resulting from the burning activity. Air emissions arising from burning limestone are immediately disposed off with chimneys that are approximately 4-5 meters high.

II. RESEARCH METHODS

This research was an observational study in which the researcher made direct observations aimed at describing situations and events in the population. The research design used was*cross sectional*, which is a research that studies the correlation between risk factors (*independent*) and effect factors (*dependent*), when observations and measurements of variables were done at the one time. The population in this research was all workers in the burning processsection. The sampling technique used is *total sampling* which is the number of samples taken is equal to the population. The sample size in this study was 18 workers. The study was conducted in the Limestone Burning Industry CV. Indah Lestari owned by Nurhadi in Kesamben Village, Plumpang Sub-district, Tuban Regency. The time of the study was conducted in December 2018 until August 2019.

The dependent variable in this study was the pulmonary function statusin workers in the limestone burning processsection. While the independent variables in this study were the characteristics of workers such as working period, nutritional status, age, smoking habits and history of disease. Data collection technique used questionnaire sheets for variables of worker characteristics. Meanwhile, to determine the pulmonary function status in workers, measurements was done using a *spirometer*. Data analysis used descriptive analysis methods and cross tabulation analysis (crosstab). Descriptive analysis used to identify the characteristics of workers, the level of dust inhaled by workers, and pulmonary function status. Cross tabulation analysis is used to determine the strength of

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correlation between the level of dust inhaled by workersand the workers characteristic with pulmonary function status to workers in Limestone Burning Industrial,Tuban Regency.

III. RESULTS AND DISCUSSION

PULMONARY FUNCTION STATUS

Pulmonary function measurement of workers in the limestone burning industry was carried out using a spirometry device. Measurements were done by officers fromEnvironmental Health Laboratory, Faculty of Public Health, Airlangga University. Based on the results of spirometry measurements that have been done, the following results are obtained:

Table 1: Interpretation of Assessment Results Pulmonary Function Impairments byAmerican Thoracic Society

Restriction (% FVC)	Interpretation	Obstruction (% FEV1)
≥80	Normal	≥75
60-79	Light	60-74
30-59	Moderate	30-59
<30	Severe	<30

Source : *American Thoracic Society* , 2006.

Based on Table 1 above, it is known thatthere are 2 categories of pulmonary function impairments according to the American Thoracic Society (2006), namely restriction and obstruction. It said restriction if% FVC <80 and obstruction category if % FEV1<75 (14).

Table 2: Distribution of Workers Based on Pulmonary Function Impairments in the Limestone Burning Industry in Tuban Regency

Pulmonary Function Impairments	**Amount (n)**	**Percentage (%)**
Normal	16	88.9
Light Restriction and Obstruction	1	5.55
Moderate Restriction and Obstruction	1	5.55
Total	**18**	**100**

Based on Table 2 above, it is known that there was 1 worker (5.55%) who has pulmonary function impairments in categoriy of light restriction and obstruction and 1 other workers (5.55%) has pulmonary function impairment in category of moderate restriction and obstruction. Restriction and obstructive (mixed) impairment occurs when FEV1/FVC <75% and FVC <80%.

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Table 3: Distribution of Workers Based on Pulmonary Function Status in Limestone Burning Industry in TubanRegency

No.	Name	Sex	Section	% FVC	% FEV1	Pulmonary Function Status	
						Normal	Abnormal
1	Workers 1	Female	Burning	89.9	88	v	
2	Workers 2	Male	Burning	91.4	88	v	
3	Workers 3	Male	Burning	100.2	79.3	v	
4	Workers 4	Male	Burning	104.1	94.2	v	
5	Workers 5	Male	Burning	89.7	78.7	v	
6	Workers 6	Male	Burning	60.2	60.1		v
7	Workers 7	Male	Burning	104	90	v	
8	Workers 8	Male	Burning	97.5	94	v	
9	Workers 9	Male	Burning	115	85	v	
10	Workers 10	Male	Burning	109	90	v	
11	Workers 11	Male	Burning	108	79	v	
12	Workers 12	Male	Burning	50.3	50.5		v
13	Workers 13	Male	Burning	114	88.7	v	
14	Workers 14	Male	Burning	115	94.6	v	
15	Workers 15	Male	Burning	100.8	90.1	v	
16	Workers 16	Male	Burning	105.1	87	v	
17	Workers 17	Male	Burning	88.9	85.9	v	
18	Workers 18	Male	Burning	93.7	89	v	

The decrease in the FEV1 and FVC and FEV1% in the exposed community is suggestive of lung function impairment (15).The inhalation of gases and particulates may initiate local inflammatory processes in the airways and lungs, which lead to conditions such as chronic bronchitis, small airways disease, and emphysema. Long-term consequences are pulmonary hypertension and systemic inflammation. Chronic airflow obstruction (or limitation) is the main defining characteristic of COPD. Chronic obstructive pulmonary disease (COPD) represents serious morbidity and has emerged as a leading cause of death worldwide (16).

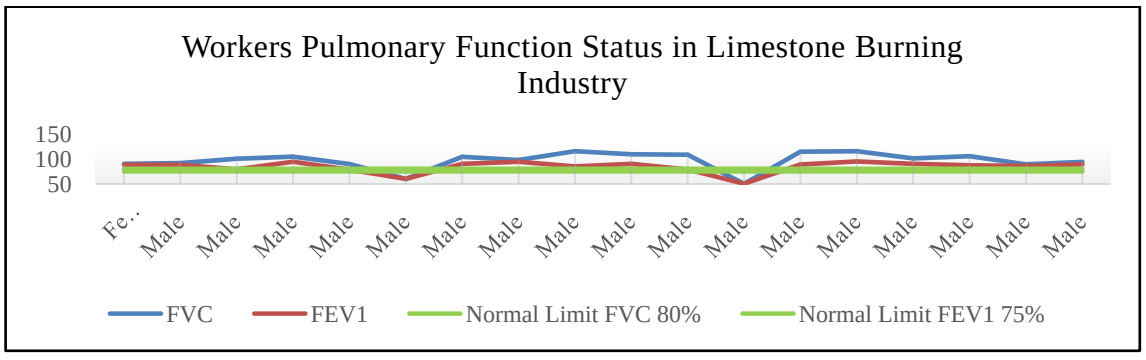

Figure 1: Workers Pulmonary Function Status in Limestone Burning Industry

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Oneof pulmonary function is ventilation, the process of exiting and entering air into the pulmonary and the release of carbon dioxide from alveoli into ambient air. Ventilation abnormalities included in the common pulmonary function impairmentsare restriction and obstruction impairments(17). Respiratory diseases associated with inhalation of airborne dust are the most vital group of occupational diseases. Previous study subjects with chronic obstructive pulmonary disease advocate that workplace exposures are powerfully linked with an increased risk of chronic obstructive pulmonary disease (7).Pulmonary function impairment generally can be classified into obstructive pulmonary disorders and restrictive pulmonary disorders. Obstructive pulmonary disorder is a narrowing of diameter of the airway so that it is more difficult to let out air (expiratory). While restrictive pulmonary disorders are a decrease in the ability to enter air into the pulmonary(inspiration) and a decrease in the normal pulmonary volume(11).

CROSS TABULATION OF WORKERS CHARACTERISTIC WITH PULMONARY FUNCTION STATUS

Working Period with Pulmonary Function Status

Table 4: Cross Tabulation Between Working PeriodwithPulmonary Function Status

Variable	Pulmonary Function Status			
	Abnormal		Normal	
	n	%	n	%
Workng Period				
≥5 years	1	12.5 %	7	87, 5%
<5 years	1	10 %	9	90 %

Based on the results from Table 4 above, it was known that most of the limestone burning industry worers have a working period of <5 years as much as 10 people (55.56%). From the results of the cross tabulation between working period with pulmonary function status of limestone burning industry workers, it is known that the abnormal pulmonary function status experienced by workers with <5 years of working periodas much as 1 person (10%) and ≥5 years as much as 1 person (12, 5%). Working period is a risk factor for pulmonaryfunction impairments, workers with a working period of>5 years has the potential to experience greater pulmonary function impairment compared to workers who work <5 years (10).This is due to the nature of dust when entering into a person's pulmonary will be accumulative and piled up in one's pulmonary, will eventually have a chronic impact on one's health(18). A higher prevalence was recorded for all the respiratory symptoms among quarry workers who have worked for duration of 1 - 5 years in the quarries. Although this association was not statistically significant, this finding contrasted a study in India which showed that exposure duration of more than 15 years was associated with silicosis and many more respiratory problems among sand stone quarry workers (19).

In the cross tabulation between working period with pulmonary function status obtained*coefficient contingency*value of 0.039, which means the strength level of the correlation between these variables were

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categorized as less means. This can be due to most of the workers in the limestone burning industry are dominated by workers who have a working period of <5 years (55.56%) . This result is in line with the research of Yulaekah (2007), that stated there is no correlation between working period and pulmonary function impairments in the limestone industry workers. When viewed by proportion, the categories of working years <5 years and ≥5 years have the same risk of developing pulmonary disfunction, although the results of statistical tests do not show a significant correlation (1). Also, it could be that the workers who have worked for a longer duration in the quarries would have developed tolerance to the effect of quarry dust over time (19). However, the longer working period of a person also shows the long exposure to a source of danger to someone so as to increase the risk of health problems caused by long-term exposure(20). The level of cumulative cement dust exposure estimated (11.41-423.98 mg/m3 - year) is a high risk factor for developing chronic respiratory symptoms when working for many year in adverse condition (2). Workers who had less than five years of occupational exposure to the cement dust had a significantly higher FVC, FEV1 and PEF than the workers who had more than 15 years of exposure (21).

Nutritional Status with Pulmonary Function Status

Table 5: Cross Tabulation Between Nutritional Status with Pulmonary Function Status

Variable	Pulmonary Function Status			
	Abnormal		Normal	
	n	%	n	%
Nutritional status				
Thin	0	0%	2	100 %
Normal	2	14.3 %	12	85.7 %
Overweight	0	0%	2	100 %

Based on the results from Table 5 above, it was known that most of the limestone burning industry workers have normal nutritional status as much as 14 people (77.78%). From the results of cross tabulation between nutritional status with pulmonary function status of limestone burning industry workers, it was known that abnormal pulmonary function status was experienced by workers with normal nutritional status as much as 2 people (14.3%). Nutritional status variables are seen through the Body Mass Index (BMI) for Asian populations, with the thin category having BMI < 18.5, normal with BMI 18.5-25, overweight with BMI 25-30 and obesity with BMI> 30(18).Nutritional status can affect the durability of the respondents against the effects of dust, so that someone with good nutritional status, the possibility of suffering the respiraroty disease is smaller than someone who has a poor nutritional status. One of the result of malnutrition can lower the immune system and antibodies so that people easily suffers infections such as coughs, colds, diarrhea and also decreasing the body's ability to detoxify against foreign particles such as dust into the body(17). Nutritional status also affects in person's lung capacity. People has posture high skinny usually has vital lung capacity power greater than those with stubby stature. It can be concluded that the physiologically of someone with less and more nutritional status has decreased in their lung vital capacity which may turn affect in the occurrence of pulmonary function impairment (3).

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In the cross tabulation between nutritional status with pulmonary function status obtained coefficient contingency value of 0.186 which means the strength level of the correlation between these variables were categorized as weak. This result was in line with the Cahyana's research (2012), where there is no significant correlation between nutritional status and pulmonary function impairments in coal miners in Kalimantan (22).In addition, in Permatasari's research (2017), it is also known that there is no correlation between nutritional status and pulmonary function impairments in wood processing workers in Semarang. This study was unrelated because more workers with normal nutritional status had pulmonary function impairments compared with abnormal nutritional status(23).Although statistically it did not have a significant meaning, but epidemiologically, nutritional status and food intakerelated to a person's nutritional needs, these are related to the anatomical and physiological body development, especially the respiratory tract, which will affects the strength and endurance of the respiratory muscles to pump oxygen optimally throughout the body, controlling the respiratory rate and the formation of immunological mechanisms in the body for the prevention of other pulmonary diseases (17). Body mass index was not significantly associated with pulmonary function tests in previous study similar (24). However, some studies show that in obese subjects there is a significant negative correlation between BMI and lung function parameters though this correlation is absent in non-obese individuals (25).

Age and Pulmonary Function Status

Table 6: Cross Tabulation Between Age with Pulmonary Function Status

Variable	Pulmonary Function Status			
	Abnormal		Normal	
	n	%	n	%
Age				
30-39 years	1	20%	4	80%
40-49 years	1	10%	9	90%
>50 years	0	0%	3	100%

Based on the results from Table 6 above, it was known that most of the limestone burning industry workers had an age range of 30-39 years as much as 5 people (27.78%) and ages 40-49 years as much as 10 people (55.55%). From the results of cross tabulation between age with pulmonary function status of limestone burning industry workers, it was known that abnormal pulmonary status was experienced by workers with age of 30-39 years as much as 1 person (20%) and 40-49 years as much as 1 person (10%). The age factor affects to physical conditions and associated with pulmonary function (3).Age plays important role in lung function test, as maximum lung growth appears in after the 20s or 30s, hence, will slowly decline the lung function forced vital capacity (FVC) and forced expiratory volume-one second (FEV1). However, lung will remain stable around 5-10 years or more and start declining in later adulthood (26). The respiratory system will change anatomically and immunologically according to age. Increasing age will decreases pulmonary development strength, respiratory muscle strength, vital capacity, FEV1, FVC, and antioxy and epiteal fluids(27).

The age factor may affecting in pulmonary function impairment due to aging affects lung elasticity as other organ tissues. It will be oldest a person, greater lung function decline will be occur to them. The decreaselung

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vital capacity generally occurs after the age of 30 years, but the decline will be fast after the age of 40 years (3).This was in line with the statement of Suma'mur (2009), which stated that workers aged 15–25 years will experience decreased work capacity when exposed to dust, whereas for workers aged 25-35 when exposed to dust will have coughing and decreased FEV1 values. The occurrence of FEV1 devaluation is one of the indications that a worker has pulmonary function impairment. In addition, at the age of 25-65 years workers will experience a gradual decrease in FVC and FEV1 (28,18).

In the cross-tabulation between age with pulmonary function status was obtained *coefficient contingency* of 0.205 which means the strength level of the correlation between these variables were categorized as weak. Although pulmonary function decreases while age increases, it has never been directly associated with the occurrence of pulmonary function abnormalities(10).This result was in line with the Armaeni's research (2016), where the correlation between age and pulmonary function is very low among limestone workers in Pakis Village, Tuban Regency. Age is not the only causative factors to the decrease of normal pulmonary function, there are other factors that can cause pulmonary function impairments. According to Suma'mur (2009), the effects of health impairments due to chemicals particle exposure are due to several factors, such as chemical properties, port of entry, physical properties of particles and the workers factor itself. Factors include age, habituation (adaptation), endurance (tolerance), and degree of health(28,9). The relatively young workers in the production had a higher prevalence of acute respiratory symptoms compared to the older, low exposed guards. The prevalence of respiratory symptoms in some cases is assumed to increase with age, thus supporting the suggestion that there is a strong association between cement dust exposure and acute respiratory symptoms (29).

Smoking Habits with Pulmonary Function Status

Table 7: Cross Tabulation Between Smoking Habits with Pulmonary Function Status

Variable	Pulmonary Function Status			
	Abnormal		Normal	
	n	%	n	%
Smoking Habits				
Not Smoking	0	0%	7	100%
Smoking	2	18,2%	9	81,8%

Based on the results from Table 7 above, it was known that most of the limestone burning industry workers had a smoking habit as much as 11 people (61.11%). From the results of a cross tabulation between smoking habits with pulmonary function status of limestone burning industry workers, it was known that abnormal pulmonary function status were experienced by workers with smoking habit as much as 2 people (18.2%). The smoking habits of the workers researched were the number of cigarettes smoked every day and the smoking period in years. Based on the Brinkman Index (BI) to determine the classification of smokers known by the average number of cigarettes smoked a day (sticks) multiplied by smoking period (years). BI ≥600 is categorized as heavy smoker, IB 200-599 is categorized as moderate smoker, while 0-199 is categorized as light smoker. From the results of the research, 4 workers (36.36%) were included in the heavy category with IB> 600, 4

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workers (36.36%) were included in the category of moderate smokers and 3 workers (27.27%) others were included in the category of light smokers (18).

Thepulmonary vital capacity does not change significantly due to smoking, however organic dust exposure is synergistic with smoking habits. Based on a research in the United States stated that 50% of workers who produce organic dust by smoking showed symptoms of obstruction and 25% of workers who do not smoke will increase susceptibility to organic dust(30).When smoking, there is a tobacco burning process occurs by releasing pollutants of solid and gases particles. Cigarette smoke stimulates mucus secretion while nicotine will paralyze cilia so that the airway cleansing function is inhibited and consequently there is a accumulationof mucus secretion which causes coughing, lots of phlegm, and shortness of breath. These symptoms can be caused by exposure to these tobacco burning particles and gases (17). Smoking habits will accelerate decline in lung function. Cigarette smoke can irritate and damage the respiratory tract, it's causing various respiratory problems such asdifficulty for breathing and other diseases such as bronchitis and emphysema (3).

In the cross tabulation of smoking habits with pulmonary function status obtained *coefficient contingency* value of 0.271, which means the strength level of the correlation between these variables were categorized as weak.Lung function levels were not consistently decrease over-age either among the smokers and non-smokers, whereas 40% shows a significant slope either positive or negative (20).This was in line with Luthfiah's research (2011), that stated there is no meaningful correlation between smoking habits with pulmonary function impairments on limestone industry workers in Padalarang Village, West Bandung Regency(31).In addition, in the Fatmaulida's research (2013), it was also known that there is no significant correlation between smoking consumption with pulmonary function impairments in limestone workers in Tamansari Village, Karawang Regency. However, epidemiologically, workers diagnosed with pulmonary function impairments are workers who have a habit of consuming cigarettes(17).The combined effects of respirable dust exposure and smoking on the loss of FEV1 were found to be additive (15). Moreover, those exposed workers suffered significantly lower ventilator function (VC, FVC, FEV1, FEV1/FVC and PEF). It was found also that the inhalation of cement dust causes irritation of the respiratory epithelium and smoking aggravates this effect (24).

History of diseasewith Pulmonary Function Status

Table 8: Cross Tabulation BetweenHistory of Diseasewith Pulmonary Function Status

Variable	Pulmonary Function Status			
	Abnormal		Normal	
	n	%	n	%
History of Pulmonary Disease				
Dont Have	0	0%	16	100%
Have	2	100%	0	0%

Based on the results from Table 8 above, it was known that most of the limestone burning industry workers did not have history of disease as much as 16 people (88.89%). The history of disease referred to in this research was a history of pulmonary disease. The basis used in looking at the history of pulmonary disease have been

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suffered by workers was using the American Thoracic Society (ATS) questionnaire standard guides. History of pulmonary disease are pulmonary impairments before 16 years old, bronchitis pneumonia, chronic bronchitis, emphysema, and asthma (18). In the cross tabulation between the history of pulmonary disease with pulmonary function status obtained *coefficient contingency* value of 0.707, which means the strength level of the correlation between these variables were categorized as very strong. This result can be caused by abnormal pulmonary functionstatus experienced by workers who had history of disease as much as 2 people (100%), with the history of disease, namely asthma. While the abnormal pulmonary function status of workers was included in the category of light and moderate restriction and obstruction pulmonary function impairments (mixture). This result was also supported by research that has been done on workers in the Cecek home industry in Katerungan Village, Sidoarjo Regency, there is a correlation between history of respiratory disease and pulmonary function, because all workers who have history of disease have abnormal pulmonary function(32).

Obstructive lung diseases consist of chronic obstructive pulmonary disease (COPD) and bronchial asthma; restrictive pulmonary abnormalities include interstitial lung disease (ILD) and other extrinsic restrictive diseases (33).Generally the diagnosis of asthma and chronic obstructive disease can be easily established because patients usually have typical symptoms and signs such as shortness of breath, chronic cough, sputum production, with a history of exposure to dangerous gases or particles, accompanied by examination of pulmonary function. However, if the patient is not in a hyper responsive airway, physical examination and spirometry may not show abnormalities so the diagnosis is difficult to establish even though anamnesically shows asthma. Exposure to mineral dust such as coal, copper and others is known to cause typical changes in respiratory mechanics and pulmonary volume with a restructive pattern. While exposure to organic dust such as fungi, bacteria, vegetables and animals, can cause asthma with obstructive work patterns with reversible patterns (17).

History of pulmonary disease can present a risk that is 2 times greater for the occurrence of pulmonary function impairments (34).Someone who has had pulmonary disease will reduce perfusion ventilation so that the alveoli will slightly exchange air and cause a decrease in oxygen levels in the blood (35). Work-related respiratory conditions can have long latency periods. Once the disease process has begun, the worker continues to be at risk for many years, even after exposure ceases. In addition, once these conditions have developed, they are usually chronic and may worsen, even after avoidance of the risk factors. Occupational respiratory diseases include a spectrum of conditions caused by the inhalation of both organic and inorganic materials. The population attributable risk of asthma and chronic obstructive pulmonary disease arising from work exposure is estimated to be up to 15%. Worldwide, asthma is the principal disease caused by the inhalation of organic agents (36). A history of tuberculosis and asthma were important factors for lung function impairment (33).

Table 9: Strength Level of The Correlation Between WorkersCharacteristicwith Pulmonary Function Status in Limestone Burning Industry

Variable	Pulmonary Function Status	
	Coefficient Contingency	**Strength Level of The Correlation**
Working Period	0,039	Less Means
Nutritional Status	0,186	Weak

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Age	0,205	Weak
Smoking Habits	0,271	Weak
History of Disease	0,707	Very Strong

According to American Thoracic Society, lung function and airway inflammation are greatly influenced by age, weight, height and smoking status. Smoking habit and working duration could be among the factors that contribute to the increasing of time of exposure and respiratory health effects (26). When complete matching using weight, age and height was done, the lung function parameters (vital capacity and FEV1%) became less in the exposed group compared to the unexposed and the effect of cement dust exposure became apparent. This underscores the importance of matching subjects using anthropometric parameters in lung function studies (37).

Lime particles are irritants but not classified as carcinogens. The effects on the respiratory tract are the occurrence of respiratory tract irritation, increased mucus production, airway narrowing, loss of cilia and mucus membranes of cells lining as well as difficulty breathing. Early detection of the limestone mining industry workers should be earlier to prevent progression to Chronic Obstructive Pulmonary Disease (COPD) is irreversible

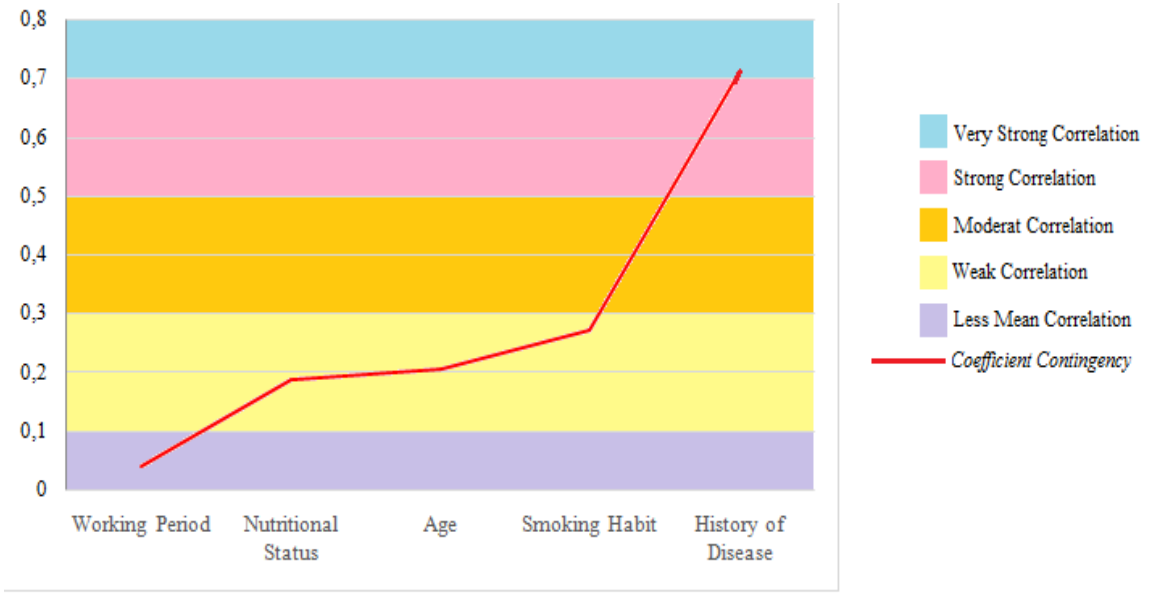

Figure 1: Strength Level of The Correlation Between WorkersCharacteristic with Pulmonary Function Status in Limestone Burning Industry

Based on Figure 1 above, it was known that the characteristic which had the most strong correlation with pulmonary function status was the history of disease. Pulmonary is one of the vital organs that functions as a place to exchange oxygen gas (O_2) which is used as a basis for metabolism in the body. The metabolic process will produce energy in the form of ATP (Adenosine Tri Phosphate) and carbon dioxide (CO_2) as metabolic waste products. If there is impairment with the pulmonary, the metabolism of body will be disrupted and will directly reduce the quality of human life(11).

Inhaled particles can penetrate and deposit in different parts of the human respiratory system, from the nose and mouth, to the bronchi and alveoli of the lung. Particles with a mass median aerodynamic particle size of 10 mm and geometric standard deviation of 1.5 are defined as the thoracic aerosol fraction and may penetrate into

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the lung (38).Continuous exposure with higher concentration of respirable dust will likely decrease the FVC%. The deposition of the unwanted particle such as PM2.5 in the bronchial tree restricts their lung to fully exhale by reducing their FVC thus declining the lung function status. The exposure to air pollutant in occupational setting and environment decline the lung function levels by predictors of FEV1 (26). The lung function indices were found to be reduced with increasing duration of exposure to cement dust (39).

It is advisable that health risk should be reduced by the collaboration between health officials, workers and the management of industry to adopt technical preventive measures, such as ventilated work areas and utilization of appropriate respiratory protective measures including dust preventive nose and mouth filters/masks and safety goggles. It is also suggested that workers must undergo pre employment and periodic medical examinations including lung function test (40).Someone'swith history of pulmonary disease can worsen health conditions if they are often exposed to sources of danger such as dust. In addition, if someone's physical condition is good, it will be less likely to be affected by pulmonary function impairments. This can be conditioned by healthy lifestyles such as maintaining a healthy diet and routine exercise(20).

IV. CONCLUSIONS

There were 11.1% of workers who had abnormal pulmonary function status, with details of 1 worker (5.55%) had pulmonary function impairments with light restriction and obstruction categories, 1 another worker (5.55%) had pulmonary function impairments with moderate restriction and obstruction categories. Based on the strength level of the correlation, the workers characteristic who had the strongest level of correlation with the pulmonary function status was histroy of disease with a *coefficient contingency*value of 0.707. This research gave meaning even though the age was relatively young <50 years and normal nutritional status, did not guarantee pulmonary function status was also in normal conditions. This was seen from the presence of one of the factors which was smoking habits and history of disease that triggered abnormal pulmonary function status.

To prevent the occurrence of pulmonary function impairments in workers, it is necessary to have routinemedical check up at least once a year and reduce smoking habits. Industrial owners can also do regular watering around the work environment of the limestone industry to reduce the amount of dust produced and increase humidity. One of workers protection is by obediently using personal protective equipment (PPE) in accordance with the work needs and standards.

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