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# Lung Function Analysis of Marble Home Industry Workers in Tulungagung Regency

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## ABSTRACT

This study analyzes the effect of dust exposure and worker characteristics on lung function. This type of research was observational with a cross-sectional design. The population was 20 marble home industry workers in Tulungagung. The total population technique determined the sample. Data analysis was carried out using Smart PLS software. The study results found that sociodemography, including age, nutritional status, and years of service, affected lung function with a t-statistic of 2.604. Dust exposure, which includes respirable dust content and duration of exposure, impacted lung function with a t-statistic of 2.522. Marble artisans in Tulungagung with the age of ≥35 years and a long working period of >5 years with a level of exposure to silica dust >3 mg/m$^3$ and supported by a long working period of >7 hours had great potential for lung function. The recommendation was for home industry entrepreneurs to provide masks according to standards. The role of public health center officers was to monitor the work environment and regularly check home industry workers' health.

*Keywords:* Long exposure, lung function, nutritional status, respiratory complaints, silica dust

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## INTRODUCTION

Marble is one industry that contributes to high foreign exchange for the country. The largest marble-producing area in Indonesia is found in the Besole sub-district, Tulungagung Regency, East Java Province. Marble-making materials contain chemicals such as $CaCO_3$, silica, iron, aluminum oxalate, $MgCO_3$, and others (Kurniawati & Titisari, 2019). Making marble uses water and produces liquid waste containing lime and other chemicals (Videsia et al., 2017). Not only is liquid waste generated from the manufacture of marble but making marble that contains chemicals can also be a health threat that is dangerous for workers.

A previous study explained that marble home industry workers in Tulungagung mostly used Personal Protective Equipment from used cloth to substitute for masks. The cloth used as masks was not washed. The work time was more than 7 hours per day, but if the number of orders for marble increased, the working time was more than 9 hours. The working period was more than five years (Dewanti, 2019).

A preliminary survey conducted by interviewing six workers obtained data that workers had never had a regular pulmonary function test. The type of work was informal home industry (self-help). Moreover, if the workers bear the cost of this pulmonary physiology test, it will not be easy to implement. No Personal Protective Equipment or masks were available according to standards for occupational risks of exposure to marble dust. There were also respiratory problems and eye irritation (red eyes). Silica dust was exposed in mining, industry, construction, and granite workers using raw materials containing silica, causing health problems for workers (Roney et al., 2019). The total silica average of 0.61% to the research result (Kurniawati & Titisari, 2019).

One dust that causes occupational diseases is silica dust from marble because it contains $SiO_2$, around 28.35-45% (Murat & Malak, 2012). Marble is a metamorphic rock or a change from the original rock, namely the limestone tab. This dust is fibrogenic and can cause restrictive lung disorders. The primary reaction to dust exposure in the lungs is fibrosis (Susanto, 2011). Based on the Minister of Manpower Regulation Number No. 5/MEN/2018, the Indonesian government regulates the threshold value of silica dust in the work environment at 3 $mg/m^3$ (Kemenaker, 2018). Previous researchers stated lung function and respiratory symptoms were found due to exposure to dust and chemicals inhaled through inhalation in 85 iron foundry workers in Sweden (Andersson et al., 2019).

The research result (Sahri et al., 2019) showed that 42.6% of respondents have an unsafe risk level of exposure to c-silica dust and potential health problems due to c-silica dust. Based on the estimated calculation of chronic exposure risk, the risk level tends to increase over the next 20 years. Silicosis is still present in workers who die exposed to silica dust between 0.05–0.1 $mg/m^3$. The result of the measurement of c-silica dust in the working environment by using a personal sampler on each respondent got a result that exceeds the limit value based on Indonesia regulation (Ministry of Manpower and Transmigration No.

PER.13/MEN/X/2011) amounted to 55.3%. The value of concentration is very influential on the value of intake in workers; the higher the concentration of dust c-silica in the work environment, the higher the intake value, so the risk value will also increase.

Silicosis is a pulmonary fibrosis disease caused by silica crystals' inhalation, retention, and lung reaction. Silica particles are deposited in the lungs, digested by alveolar macrophages, and activate proinflammatory cytokines and fibrogenic factors that cause lung damage and decrease lung function. Fibrosis is a Th2-mediated disease, and IL-13 is one of its components. Many studies report an increase in IL-13 rates of pulmonary fibrosis. Symptoms of silicosis develop 5 to 30 years after exposure (Jasminarti & Winaniarni, 2019).

Fibrosis is a Th2-mediated disease, and Th2, IL-4, IL-13, and IL-5 cytokines are essential in regulating tissue remodeling and fibrosis. In fibroblast subtypes, receptors for IL-4 and IL-13 were found, and in vitro studies showed that extracellular matrix protein synthesis and myofibroblast differentiation were induced by IL-4 or IL-13 stimulation (Esmaeil et al., 2014).

By seeing the magnitude of health problems due to exposure to ceramic makers' dust, it is necessary to carry out a strategy to prevent, control, reduce, and eliminate occupational risks due to occupational hazards on an ongoing basis. It is done considering the costs incurred due to health problems and work accidents caused by the work environment are significant with the harm it causes (ILO, 2008). The exposure can also develop into autoimmune disorders, chronic kidney disease, and others (Baron et al., 2002; De Maria et al., 2020). Studies in China showed that 10 million workers contracted silicosis, with 5000 reported deaths (Natural Stone Institute, 2018). Widajati's research (Armaeni & Widajati, 2017) revealed that ceramic makers in East Java, from 30 respondents studied, found a measurement of the level of health risk of 13.3% RQ > 1 (risk quotient), which means workers have an unsafe risk of exposure to dust in a safe work environment causing risk for health problems. Exposure to silica dust causes occupational disease silicosis.

In Indonesia, similar research on the impact of silica dust levels on marble artisans has not been widely carried out; therefore, it is necessary to investigate the presence of respiratory disorders through lung function tests and biomarkers of inflammatory and fibrogenic responses in the body, such as Interleukin-13. Similar researchers on exposure to silica dust in the workplace cause pulmonary tuberculosis. The work environment produces silica dust, namely construction, mining, and sand digging (Kootbodien, 2019).

This research refers to the concept by Kootbodien et al. (2019) and Tavakol et al. (2017). Tuberculosis is influenced by gold dust exposure, smoking, body mass index, and disease history. Furthermore, Tavakol et al. (2017) explain that respiratory function status is influenced by silica exposure, measured by vital lung capacity (FEV1/FVC). The most significant exposure to construction workers. In contrast, this study assessed pulmonary function disorders using indicators of respiratory complaints and lung function as measured

using an autospirometry due to exposure to dust, interleukin-13, and worker characteristics. The characteristics of the nutritional status of workers are assumed to have an effect on lung function and have not been carried out by previous researchers.

Therefore, it is essential to conduct this study to assess and analyze the effect of dust exposure and worker characteristics on the lung function of marble home industry workers in the Tulungagung Regency. The research hypotheses were determined as follows: (1) characteristics affect lung function, (2) dust exposure affects IL-13, (3) dust exposure affects lung function, and (4) Il-13 affects lung function. Proving the research hypothesis helps prevent the prevalence of respiratory disorders in-home industry workers and recommends improving the work environment.

## MATERIALS AND METHODS

### Research Design

This type of observational research used a cross-sectional design. The study was conducted on three marble home industry workers in Tulungagung Regency. Data collection was carried out at 3 locations/work units: (1) packing and finishing, (2) lathe and scrub polishing, and (3) cutting and craft operators. The population is 20 workers. The total population technique determined the sample.

### Measurement

Characteristics data were collected using a questionnaire: age, years of work, duration of exposure to dust, and nutritional status measured by anthropometry (height and weight). Serum interleukin-13 data was measured using a sample of the respondent's blood serum, as much as 1 ml of blood serum. The level of IL-13 was measured using the ELISA (Enzyme-Linked Immunosorbent Assay) test technique. Measurements were taken using the personal dust sampler installed near the worker's breathing and during the worker's activities during working hours. The lung function test was measured using autospirometry. Furthermore, the condition of lung ventilation was assessed using FVC (Forced Vital Capacity) and FEV1 (forced expiratory volume in one second) parameters. Normal if FVC > 80%; FEV1 > 70%, restriction if FVC < 80%; FEV1 > 70%, Obstruction if FVC > 80%, FEV1 < 70%. Respiratory complaints data was measured using a questionnaire containing respiratory complaints felt by workers.

### Data Analysis

Analysis of the data used is path analysis. The advantage of this analysis is that the relationship patterns of 4 variables (characteristics of marble craftsmen, levels of respirable dust, IL (interleukin) 13, and lung function were studied directly or indirectly. The

hypothesis was tested based on the significance level of 0.05 and t-statistics of >1.96; the hypothesis was accepted.

## RESULTS

The results of the data analysis on the characteristics of research respondents, including age, nutritional status, and length of employment, are shown in the frequency distribution in Table 1.

Table 1
*Characteristics of research respondents*

| Characteristics | Total | Percentage (%) |
|---|---|---|
| Age | | |
| < 35 | 4 | 20 |
| ≥ 35 | 16 | 80 |
| Length of Employment | | |
| < 5 years | 6 | 30 |
| ≥ 5 years | 14 | 70 |
| Nutritional Status (BMI) | | |
| Normal | 12 | 60 |
| Excess weight | 4 | 20 |
| Obesity | 4 | 20 |

*Source*. primary data, 2019

Table 1 shows that most research respondents aged > 35 years were 16 people (80%), based on most working years five years as many as 14 people (70%). The term of service category was more than five years. Nutritional Status (BMI) was dominated by normal in 12 (60%) respondents, based on Body Mass Index in the overweight category in 4 (20%) respondents, and obesity in 4 (20%) workers.

Table 2
*IL-13 levels in the workers*

| IL-13 Levels | Frequency | Percentage (%) |
|---|---|---|
| Normal (≤ 3 pg/mL) | 17 | 85 |
| Not normal (> 3 pg/mL) | 3 | 15 |
| Total | 20 | 100 |

*Source*. primary data, 2019

Table 2 shows that as many as 17 workers (85%) had IL-13 levels within normal limits, and three (15%) had abnormal IL-13 levels. IL levels in 13 abnormal categories were found in workers over 35 years. Table 3 describes the distribution of respirable dust measurements during work.

Table 3

*Frequency distribution of respiratory dust exposure by work unit*

| Measurement Results of Respiratory Dust Exposure | Frequency | Percentage (%) |
|---|---|---|
| Location 1: Packing and Finishing 1.683 mg/m$^3$ | 4 | 30 |
| Location 2: Lathe and Polish scrub 1.101 mg/m$^3$ | 3 | 15 |
| Location 3: Cutting and crafting operators 5.160 mg/m$^3$ | 13 | 65 |
| Total | 20 | 100 |

*Source*. primary data, 2019

The highest exposure to respirable dust is in the cutting work unit and craft operators, which is 5.160 mg/m$^3$, and there are 13 workers at that location (Table 3). The work unit with the lowest exposure to dust was the lathe and polishing location, which was 1.101 mg/m$^3$, and there were three workers in the work unit. On the other hand, workers at packing and finishing locations were exposed to the dust of 1.683 mg/m$^3$; there were four workers. Based on the results of measurements of respiratory dust exposure that had been carried out on marble home industry workers, there were 13 workers (65%) exposed to dust above the Threshold Value (TV) and seven workers (35%) exposed to dust below the TV level, the TV standard is determined in a Ministerial Regulation Manpower and Transmigration Number 5 of 2018.

Table 4

*Frequency distribution of lung function based on autospirometry test and marble workers*

| Lung Function | Frequency | Percentage (%) |
|---|---|---|
| Lung function | | |
| Not normal | 5 | 25 |
| Normal | 15 | 75 |
| Respiratory complaints | | |
| Yes | 10 | 50 |
| None | 10 | 50 |

*Source*. primary data, 2019

Table 4 shows the results of the pulmonary function test using autospirometry. There were five categories of abnormal lung function (25%), and it was found that ten people had respiratory complaints (50%).

Figure 1 describes the pulmonary function analysis model for marble workers in Tulungagung using pathway analysis.

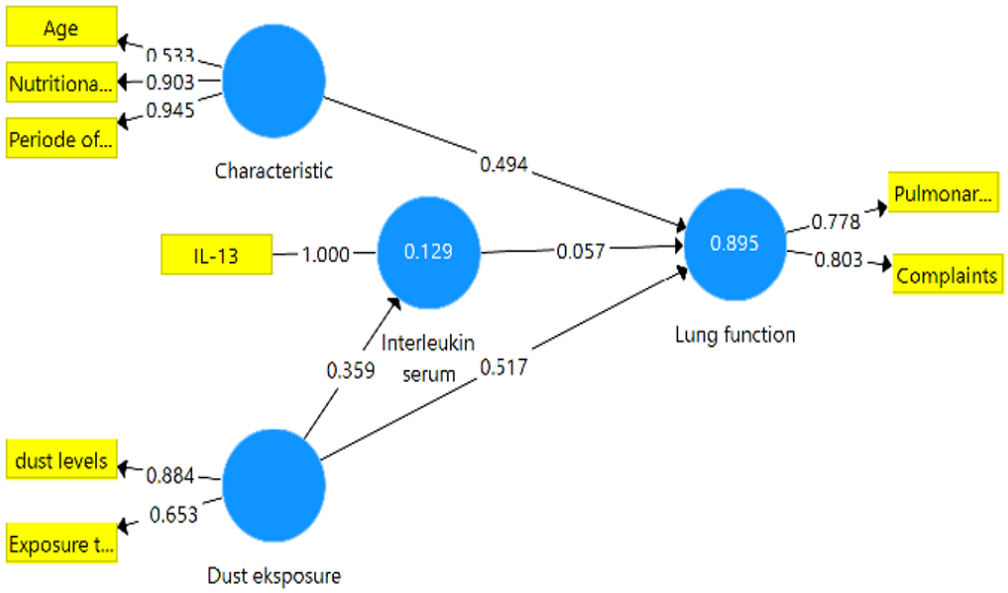


*Figure 1.* Lung function pathway analysis marble workers in Tulungagung

Pathway analysis model on the outer model variable characteristics, exposure to dust, interleukins, and lung function showed a loading factor greater than 0.50. Therefore, it was concluded that all research variables indicators were suitable for use as research instruments. The subsequent analysis is the inner model, as shown in Table 5.

Table 5

*Hypothesis test*

| Variables | Original sample | Sample mean | Standard deviation | t-statistic | p-value |
|---|---|---|---|---|---|
| Characteristics → Lung function | 0.494 | 0.445 | 0.190 | 2.604 | 0.009* |
| IL-13 → Pulmonary function | 0.057 | 0.130 | 0.244 | 0.232 | 0.817 |
| Dust exposure → IL-13 | 0.359 | 0.469 | 0.255 | 1.412 | 0.158 |
| Exposure to dust →Lung function | 0.517 | 0.448 | 0.205 | 2.522 | 0.012* |

*Source*. Primary data, 2019. (*sig, p-value < 0.05)

Table 5 shows two variables that affect lung function: the worker's characteristic variable significantly affects lung function of the t-statistic value (2.604) and the p-value (0.009). Dust exposure significantly affected lung function t-statistical values (2.522) and p-value (0.012). Two variables had no effect: the IL-13 and the p-value (0.817) did not affect lung function. In addition, the dust exposure variable did not affect the IL-13 p-value (0.157).

## DISCUSSION

Most of the characteristics of marble artisans are more than 35 years old. Most have more than five years of service and primarily normal nutritional status. The working period significantly contributes to lung function ($p = 0.000$), and 15.749% of lung function disorders are influenced by years of service, and other factors influence the rest. The longer the working period of marble artisans, the greater the risk for pulmonary function disorders. Workers with a working period of >5 years will be more likely to experience impaired lung function because dust particles are inhaled and have settled in the alveoli (Jonsson et al., 2019). Hochgatterer (Graff et al., 2020) explained that the duration of exposure to quartz dust had a significant effect ($p=0.000$) on the decline in workers' lung function. The risk of sarcoidosis increases in workers aged 20–65 due to dust exposure.

Characteristics of age, nutritional status, and years of service based on the external model show loading factors that meet the feasibility value of the characteristic variable indicator. The novelty of this study is that previous researchers did not use nutritional status as an indicator. Nutritional status affects a person's resistance to disease, so workers need to maintain nutritional status in normal conditions. Nutritional status based on anthropometry is directly related to disease (Thamaria, 2017). It was contrary to previous researchers who stated that nutritional status did not affect the lung function of wood industry workers (Rismandha et al., 2017).

Exposure to silica dust in the work environment, especially workers in the mineral mining industry, glassmakers, stone cutting, ceramics, and sand, must be aware of the risk of lung cancer. Silica dust is a carcinogenic and hazardous material that can cause lung cancer. Observations on 22 ceramic and glass-making industries in Egypt found that thousands of workers were exposed to silica dust exceeding the threshold value (Mohamed et al., 2018). The prevalence of silicosis is high in industrial mining countries. Respiratory damage, especially lung tissue for stone and sand mining workers due to the deposition of silica particles, reduces the quality of life and threatens death (Konečný et al., 2019).

Kozlowska et al. (2008) research results regarding age and lung function showed a significant relationship, maximum muscle strength at 20–40 years. They will decrease by 20% after 40 years, and the need for energy substances increases until it finally decreases after 40 years. The reduced need for energy is due to decreased physical strength. According

to Setiana et al. (2014), as a person's age increases, the ability of the body's organs will naturally decrease, which is no exception for impaired lung function. The condition of workers' lung function will worsen with dusty environmental conditions and other factors such as smoking habits, unavailability of masks, length of exposure, and history of the disease.

Based on the autospirometry test of Tulungagung marble home industry workers, of the 20 respondents, 25% of workers experienced pulmonary function disorders in the form of mild restrictions in 2 people and moderate restrictions in 3 people. Pulmonary restriction disorders are usually characterized by reduced lung volume caused by allergenic substances such as fungi, spores, and dust. In addition, the restriction is associated with limited lung expansion. It can occur due to changes in the chest wall, pleura, and neuromuscular apparatus (Kalamillah, 2018). Silica dust is the most common cause of lung disease in modern industrial countries such as Australia, Israel, and Turkey (Barnes et al., 2019).

In general, humans aged 30–40 years will experience a decrease in lung function, whereas, with increasing age, the disorders that occur are also increasing. Suyono (2001) also stated that the older a person ages, the greater the possibility of decreased lung function. In the elderly, several structural and functional changes occur in the thorax and lungs. At that age, it was found that the alveoli became less elastic and more fibrous and contained minor functioning capillaries; so, the utilization capacity decreased because the diffusion capacity of the lungs for oxygen could not meet the body's demands (Maryam, 2008). According to Fathmaulida (2013), a person's energy needs are related to the development and physiology of the body, especially the respiratory system so that it affects the work of the respiratory muscle strength in pumping $O_2$ throughout the body, controlling the respiratory rate and the formation of the body's immunological mechanism for the prevention of lung disease.

The results showed that the nutritional status of the respondents was primarily normal. Nutritional status is related to disease susceptibility in workers. IL-13 levels from the ELISA test showed that only three respondents (15%) had abnormal IL-13 above 3 pg/mL. It is supported by the statistical analysis results where IL-13 does not affect the lung function of Tulungagung marble artisans. Good nutritional status affects food intake in the body, which will be used as an energy source, where the primary energy source in the body is energy intake and carbohydrates, protein, and fat. If food intake is good, the digestive system will be good and affect the circulatory system throughout the body (Agustina et al., 2018). Exposure to silica dust can cause pulmonary fibrosis takes 5 to 30 years. It is also strongly influenced by the health status of the artisans, lifestyle, diet, PPE (masks) following the exposure used by artisans, and many factors that influence it (10). IL-13 is a pleiotropic cytokine produced by the chromosome 5 gene at q 31, produced significantly by Th2. Various evidence indicates that IL-13 is a mediator in the pathogenesis of asthma, airway hyperresponsiveness, mucus production, and airway subepithelial fibrosis. Fibrosis of the

lungs, liver, and kidneys is associated with the synthesis of IL-13 by T lymphocyte cells. IL-13 can trigger collagen synthesis independently of TGFβ and cause the proliferation and contraction of smooth muscle cells, leading to fibrosis formation. Overexpression of IL-13 in the lung triggers subepithelial airway fibrosis in mice without other inflammatory stimuli. IL-13 levels increase in pulmonary fibrosis (Jasminarti & Winaniarni, 2019; Kalahasthi et al., 2010).

This study showed that the dominance of workers exposed to dust produced by marble stone processing was seen in the >7 hours/day category, which was as much as 90%. The Tulungagung marble home industry had working hours from 08.00 to 16.00 with six working days in one week, so the total working hours at the Tulungagung marble home industry was 48 hours in one week. Working hours that exceed 7 hours/day or 40 hours/week as applied by the Tulungagung marble home industry were not following the Law of the Republic of Indonesia Number 13 of 2003 concerning Manpower Article 77, which states that the working time for six working days is 7 hours/day or 40 hours/week.

According to Suma'mur (2009) and Wulandari et al. (2015), a person can usually work well for 40–50 hours a week. If it is more than that, the possibility of various health problems for workers will be even greater. Many home industries have closed, and only a few are still running with a small number of workers, on average, under 20 workers. The duration of exposure and the intensity of dust exposure also determines dust exposure in the workplace. In this research, the measured dust is respirable dust with a TV (threshold value) of less than 3 mg/m$^3$ according to the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018. The results of the measurement of respirable dust showed that as many as 13 people from 20 craftsmen (65%) had a respiratory dust value exceeding 3 mg/m$^3$, and only seven people (35%) were still below 3 mg/m$^3$. The highest respiratory dust exposure measured in Tulungagung marble home industry workers was found in the cutting section and craft operators at 5,160 mg/m$^3$. The packing section's lowest respiratory dust exposure value was 1,101 mg/m$^3$. The statistical analysis showed that dust exposure to lung function was very significant (p=0.012).

The pulmonary function test results showed that five workers (25%) experienced mild and moderate restrictions. It is also supported by a relatively long employment length of more than five years, the age of the workers was more than 35 years, the working time mainly was more than 7 hours of work outside of resting hours (1 hour), special PPE (masks) according to the type of exposure does not provide, artisans only used a used cloth that was rarely washed. In addition, there had never been an HRA (health risk assessment) by the local Health Center Occupational Health Effort staff because the officers could not yet assess the hazards of the work environment and their impact on workers' health. It is also closely related to the lung function test of marble artisans who had never been carried out periodically at least once a year to protect workers' health and increase work productivity (BPK RI, 2003).

## CONCLUSION

Sociodemographics of marble artisans, including age, nutritional status, and years of service, have a significant effect on lung function disorders. In addition, nutritional status is related to disease susceptibility in workers. Dust levels, including respirable dust levels and duration of exposure in the workplace, also significantly affect lung function disorders of marble artisans. However, IL-13 did not affect lung function, and dust exposure did not affect IL (interleukin)-13. It is hoped that the Health Center will establish an occupational health post in its working area to monitor the health of home industry workers in the informal work sector and support the country's foreign exchange.

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