

Lung function reduction among welders

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ABSTRACT

Welding is associated with regular exposure to dust and fumes. Many studies have proven that there is a decrease in lung function due to exposure to this agent. This study aimed to quantitatively analyze the risk factors of impaired lung function among welders in Binong, Tangerang, Indonesia. This was a cross-sectional study design. The lung function of 30 welders is measured by spirometry using the parameters of vital capacity (VC), forced vital capacity (FCV), forced expiratory volume in one second (FEV1), and the ratio of FEV1/FVC. Chi-square analysis was performed and showed that 20 respondents (67%) had impaired lung function, while 10 respondents (33%) had normal lung function. Another factor contributing to impaired lung function among welding workers was their nutritional status, whereby respondents with abnormal nutritional status (body mass index (BMI) 18.4 or ≥ 25.1) were at 2.15 times higher risk of suffering from impaired lung function compared to respondents with normal nutritional status. Additionally, respondents who did not exercise regularly were at 1.22 times higher risk of impaired lung function compared to those who exercised regularly. Therefore, it is necessary to collaborate with the local community health center to monitor the health of the welders. It is recommended to carry out regular health checks, specifically pulmonary examination, at least once at a year to keep track of the health development of the workers. It is important to equip the workspace with a good ventilation system, and to have the welder work with appropriate personal protective equipment.

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1. INTRODUCTION

Welder and welding operators are those who operate electric or gas welding and cutting equipment. Gas and particulates from the welding process can pose health risks. Fumes formed during the welding process consist of alloy particulates such as iron (Fe), manganese (Mn), chromium (Cr), and nickel (Ni). Waste from welding also contains harmful gases such as carbon monoxide, carbon dioxide, ozone, nitrogen monoxide, and nitrogen dioxide. The resulting respiratory effects on welders include bronchitis, airway irritation, metal smoke fever, and changes in lung function [1]. Welding fume exposure also causes nausea and fatigue [2]. There are several million full-time welders worldwide. Indonesia alone needs around 45,000 welders within five years because welding is an integral part of industrialization [3]. Their numbers are likely to increase, and they work to unclear workplace safety standards. Meanwhile, there are chronic risks and side effects of welding, including on lung function [4].

Deaths, injuries, and occupational diseases are common in developing countries, including Indonesia. Workers in the construction sector are at risk of exposure to hazardous substances such as chemicals or radiation [5]. Many studies experience difficulties in performing comparisons due to differences

in worker populations, industrial settings, welding techniques, duration of exposure, and exposure to other occupations other than welding fumes. Epidemiological studies have shown that a large number of welders experience several types of respiratory diseases among full-time welders, including bronchitis, airway irritation, changes in lung function, chronic obstructive pulmonary disease (COPD), and possibly an increased incidence of lung cancer. Pulmonary infections were also found to be increased in severity, duration, and frequency among welders [6], [7]. The hazardous welding environment not only disrupts work productivity but also causes ill health. These ill effects often manifest in respiratory problems or interfere with lung functions [8]. One of the most common jobs related to the lungs is welding [9]. Spirometry is a lung function test used routinely to help measure the amount and speed of air that a person can inhale and exhale. The results obtained can be used to determine lung function and assist in diagnosing certain respiratory disorders. Spirometry is an important screening test for general respiratory health in the same way as blood pressure [10], [11].

Industrial welding is associated with lung disease, and welding techniques continue to produce many potential exposures to particulates and gases, leading to different bodily responses. However, few studies had been done to examine the relationship between impaired lung function, impairment, and welding dust. There are differences of opinion among these studies. A research conducted in an Iranian shipbuilding industrial factory that exposure to smoke and welding gas is associated with decreased lung function [12]. There was a significant relationship between age, work period more than five years, and duration of smoking with impaired lung function [13]. Another study found a significant relationship between dose, time of exposure, and composition of welding fume's affect lung injury [14]. Age, length of exposure, length of work, smoking habits, amount of smoking consumption, and welding fume are significantly associated with lung function disorders in Surabaya [15]. Similarly, working experience and age showed a significant relationship on welders in the steel industry [16].

By completing this research, further supporting evidence regarding prevention of exposure to welding fumes can be established. Despite the multitude of studies among welders, studies related to lung function disorders had never been done in Binong District, Tangerang. Moreover, the work programs related to workers' health and safety are not yet available. As a result, there are only a few follow-up studies on respiratory function among welders. Therefore, this study aimed to address the gap by examining risk factors to lung dysfunction among welders in Binong District, Tangerang, Indonesia.

2. RESEARCH METHOD

This study employs quantitative methods using a cross-sectional approach, which epidemiologically examines prevalence, distribution, and the relationship between disease and the exposure of research factors by observing exposure status, disease, or other health-related characteristics simultaneously among a population sample at one point in time. Cross-sectional studies allow for the assessment of exposure and the magnitude of the outcome. This study was done in February 2020 in a primary health care setting in Binong, Tangerang. The population in this study was welders who live in Binong Village, Tangerang with a sample size of 117 male welders. Based on the results of sample calculations using the Lemeshow formula, the minimum number of samples is 30 male welders were recruited, met the eligibility criteria, and agreed to participate in the study. In this study, researchers aim to analyze the risk factors for dysfunction among welders in Binong, Tangerang. Independent variables in this study include age, nutritional status, history of lung disease, working house, work duration, use of personal protective equipment (PPE), smoking, and physical exercise and variable dependent include lung function reduction (the lungs are unable to adequately oxygenate or excrete carbon dioxide with restrictive or obstructive pulmonary features):

- a. Impairment: key-value pair (KVP) value $>80\%$, forced expiratory volume in one second (FEV1) $\geq 75\%$
- b. No impairment:
 - Restrictive: KVP value $<80\%$, FEV1 $>75\%$
 - Obstructive: KVP value $>80\%$, FEV1 $\leq 75\%$

The data was collected over two days, consisting of spirometry tests performed by laboratory staff as well as a questionnaire on demographic information, exercise habits, smoking habits, diseases related to lung function, and the use of PPE and the measurement of nutrition status (weight and height). Respondents were given explanation about the purpose of the study and signed the informed consent. Inclusion criteria were welders who were currently residing in Binong district and agreed to be the participants of the study. The exclusion criteria were welders with known history of asthma and COPD at the time of the study, workers suffering from asthma due to hereditary factors and those who were not present at the location of the study. Univariate and bivariate analyses were performed to explain respondent characteristics and the relationship between their characteristics and lung function by using chi square test. This study was reviewed

and approved by the ethics committee of Faculty of Nursing Universitas Pelita Harapan and Mochtar Riady Institute for Nanotechnology Ethics Committee (MRIN EC) with protocol number 04.1804186.

3. RESULTS AND DISCUSSION

3.1. Correlation of individual factors with lung function reduction among welders in Binong, Tangerang

Binong Village is located in Banten Province, consisting of five villages. In this area, there are several welding, where one welding consists of two to five welders. Based on the research, it was found that 20 respondents (67%) had impaired lung function, and ten respondents (33%) had normal lung function. The analysis of correlation between lung function reduction with age, nutritional status, working hours, work duration, and history of lung disease were summarized in Table 1.

Table 1. Correlation of individual factors with lung function reduction among welders in Binong, Tangerang

Variable	Lung function				Quantity		OR (95% CI)	p-value
	Impairment present		No impairment present		n=100	%		
	n	%	n	%				
Age								
High risk	13	65	7	35	20	66.7	0.79 (0.15-4.08)	1.0
Low risk	7	70	3	30	10	33.3		
Nutritional status								
Abnormal	7	77.8	2	22.2	9	30	2.15(0.35-13.04)	0.67
Normal	13	61.9	8	38.1	21	70		
Working hours								
>40 hours/week	19	65.5	10	34.5	29	96.7	1.52 (1.17-1.98)	1.0
≤40 hours/week	1	100	0	0	1	3.3		
Work duration								
High risk	9	64.3	5	35.7	14	46.7	0.81 (0.17-3.74)	1.0
Low risk	11	68.8	5	31.2	16	53.3		
History of lung disease								
History present	6	66.7	3	33.3	9	30	1.0 (1.19-5.24)	1.0
History not present	14	66.7	7	33.3	21	70		

The relationship between age and reduced lung function shows no significant relationship. Despite that, among participants at higher risk (aged ≥ 30 years), there is a higher percentage experiencing reduced lung function (65%) compared to those who do not experience lung function reduction (35%). Age is one of the main factors in the evaluation of lung function [17]. The lungs mature around the age of 20-25, and lung function will decrease starting at age 35, such that breathing becomes more difficult. The natural changes in the body that occur due to aging can lead to reduced lung capacity, as muscles such as the diaphragm start to weaken, the loss of elasticity in lung tissue, leading to airways decreasing in size. Additionally, the ribs can change and become smaller, leaving less room for lung expansion [18]–[20]. The data in this study indicate that there is a higher percentage of respondents (65%) within the high-risk age range (aged ≥ 30 years) experiencing reduced lung function. This finding is consistent with a UK study which found that lung function declines between the ages of 35-45 years [21].

The relationship between nutritional status and reduced lung function was also not significant. However, based on the OR, respondents with abnormal nutritional status (body mass index (BMI) ≤ 18.4 or ≥ 25.1) are 2.15 times higher risk of lung function reduction compared to respondents who have normal nutritional status. Inadequate nutrition leads to low body weight and is associated with decreased respiratory muscle strength and increased mortality [22]. Malnutrition is one of the risk factors for impaired lung function [23], [24]. Abnormal BMI has a significant relationship with decreased lung function. In obese people, the tidal volume is greater than those with a normal body mass index and the frequency of breathing will be faster, which can lead to a larger number of particulates inhaled [25]. Healthy eating and regular exercise are recommended to increase lung health [20]. However, the data from this study did not find a significant relationship (p-value=0.67) between nutritional status and reduced lung function among welders, as most of the respondents have good nutritional status.

Similarly, there is no significant relationship between working hours and reduced lung function but based on the OR, respondents working >40 hours/week are 1.52 times higher risk of lung function reduction compared to respondents who work <40 hours/week. Working hours is the length of time a person is present in the environment work in a day. The working hours were categorized into two groups ≤ 40 hours and >40 hours in a week. Workers who work longer hours are presumed to be exposed to dust for longer periods

through breathing and will be at higher risk for pulmonary disorders. A study of 13 traders in Gresik explained that there was a relationship between the length of exposure and the status of lung function [26].

There was also no significant relationship found between work duration and reduced lung function. However, among those who have worked more than five years, a higher percentage (64.3%) were found to experience reduced lung function, while 35.7% were unaffected. The data showed that among respondents who have worked more than five years, nine respondents (64.3%) experience reduced lung function. This is consistent with the findings of a study on 50 welders in Pakistan where respondents who had more than nine years of exposure displayed significant reductions in spirometry results, impaired lung function even among non-smoking welders. Results from stratification of welding doses over many years also showed different degrees of damage to lung function, which was attributed primarily to an obstructive pattern of airway disease [27]. Working period is an important indicator for evaluation of lung function status among welders [28]. The results showed that of 14 respondents who worked more than five years (at risk), there were five respondents who did not experience impaired lung capacity (normal). In this study, it was difficult to evaluate the relationship between work duration and lung function reduction because of the complexity of the occupational history of the welder. Furthermore, this can be caused by other factors, including the habits of some respondents to not smoking, to meet the needs of good nutrition, and to use masks or personal protective equipment while working [29].

There is no significant relationship between history of lung disease and lung function reduction. However, based on the OR, those with a history of lung disease (asthma, bronchitis, and pulmonary TB) are at one time higher risk of lung function reduction compared to respondents without a history of disease. The data showed that respondents with a history of disease (asthma, bronchitis, and pulmonary TB) are one times at higher risk of reduced lung function compared to those without prior history of disease. Family history of asthma, and the presence of respiratory tract infections in childhood are risk factors for lung function reduction [30], [31]. Childhood asthma is associated with decreased lung function, which may begin in infancy or before birth, persisting into childhood and adulthood. However, most studies in children and adults with asthma are brief enough to explain the true incidence [32]. Hence, those who have a history of lung disease will be more susceptible to experiencing diseases affecting the lung function when exposed to pollutants in the work environment such as dust [33].

3.2. Correlation of behavioral factors with lung function reduction among welders in Binong, Tangerang

Table 2 shows the correlation of use of PPE, smoking, exercise habits with the lung function reduction to welders in Binong, Tangerang. The data showed that nine respondents (69.2%) who did not use PPE experienced reduced lung function. Welders' adherence to using personal protective equipment is also different from other welders even in their working time [28]. PPE is used to prevent occupational accidents and subsequent health problems. Wearing masks when welding will minimize the amount of exposure and inhalation of aerosolized particles. Apart from the amount of exposure, the particle size which can pass through the masks will likely be smaller. A study of 37 workers in Semarang, Indonesia showed that the use of personal protection equipment (mask) has a significant effect on acute respiratory symptoms infection, where workers who did not wear masks were at 4.8 times higher risk of experiencing acute respiratory tract infection symptoms compared to those who did [34]. Similarly, there was a relationship between the use of PPE and reduced pulmonary function. This shows that lack of PPE usage and smoking habits while working can increase the risk of reduced lung function [35].

This is also no significant relationship between smoking and reduced lung function. However, among those who smoked 201-600 cigarettes a year, nine respondents (64.3%) experience lung function disorders and five respondents (35.7%) did not. Symptoms of chest disease show a relationship with smoking habits [2]. Smoking can also cause disruptions in lung ventilation because of the irritation and excessive mucus secretion in the bronchi. These effects reduce the effectiveness of the mucociliary function to carry dust particles. Consequently, cigarette smoke can narrow airways and cause difficulty breathing, chronic inflammation, or swelling in the lungs, eventually leading to chronic bronchitis. Additionally, cigarette smoke can also destroy lung tissue and trigger changes that may develop into cancer. Smoking can also damage the lungs and increase the effects of aging [20]. Decreased lung function in welders showed a greater effect in those who smoked [4], [9]. Men who smoked one pack per day experience decreased FEV1 by an average of 12.6 ml per year while women who smoke one pack per day experience decreased FEV1 by an average of 7.2 ml per year [36], [37]. Furthermore, this study also found that a majority of respondents who smoked 201-600 cigarettes in a year experienced lung function reduction.

The data also showed no significant relationship between physical exercise and reduced lung function. However, using the OR, it was found that those who did not exercise regularly (2-3 times a week in the last six months) are at 1.22 times higher risk of experiencing reduced lung function reduction compared

to respondents who exercised regularly. Physical exercise can help keep lungs healthy as well as improving the health of muscles, lungs, and heart. Regular exercise will improve the vital capacity of the lung, even if only slightly, at the same time decrease the residual volume or the amount of immovable air or out of the lungs [20]. Basic physical exercise is related to cardiovascular health [38]. The level of physical activity has a positive impact on the capacity of human's pulmonary function. A person with a higher exercise routine has a better lung function's capacity. However, the smoking habit of the respondents can have a negative impact on lung function. It has been proven from several studies that people who smoke have worse lung function's capacity [39]. A study in Libya showed that being physically active is associated with healthy lungs and less chance of abnormal lung function [40].

Table 2. Correlation of behavioral factors with the lung function reduction to welders in Binong, Tangerang

Variable	Lung function						OR (95% CI)	p-value
	Impairment present		No impairment present		Quantity			
Use of PPE								
Without PPE	9	69.2	4	35	13	43.3	0.22 (0.26-5.73)	1.0
With PPE	11	64.7	6	35.3	17	56.7		
Smoking								
Heavy	0	0	1	100	1	3.3	-	0.67
Medium	9	64.3	5	35.7	14	46.7		
Light	11	73.3	4	26.7	15	50		
Exercise habits								
Insufficient	11	68.8	5	31.2	16	96.73.3	1.22 (0.26-5.59)	1.0
Sufficient	9	64.3	5	35.7	14			

4. CONCLUSION

The analysis showed that 20 respondents (67%) had impaired lung function and 10 respondents (33%) had normal lung function. The findings in our study demonstrated lung function impairment in a majority of the participants. However, no variables were found to be significantly associated with lung function impairments among our participants. Nevertheless, various efforts must be made to reduce the risk of reduced lung function among welders in Binong District. To monitor the health of the welders, it is recommended to hold routine medical check-up, especially regular pulmonary examinations, at least once a year to monitor the health development of workers. Furthermore, it is necessary to equip the workspace with a good ventilation system, and to have the welder work using appropriate personal protective equipment. The limitation in this study this was a cross-sectional study whereby causal relationships cannot be established.

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