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The Influence of Dust Exposure and Individual Characteristic on Lung Capacity in Labor in Production Unit of the Indonesian Ship Industry (Persero) in Makassar

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KEYWORDS
Dust exposure; individual characteristics; lung capacity; labor force

ABSTRACT:

Introduction: Exposure to pollutants carries the risk of upper respiratory tract infection. Respiratory tract disease is an occupational disease found globally in developing countries.

Objectives: This study investigated the effect of dust exposure and individual characteristic on lung capacity in labor in the production unit of the Indonesian ship industry in Makassar.

Methods: This cross-sectional study included 72 laborers who provided consent and fulfilled the inclusion criteria. Data analysis was performed using the chi-square and logistic regression models with a P value of 0.005, odds ratio (OR) with a 95% confidence interval (CI), pathway analysis to determine the direct and indirect effects. Statistical analysis was performed using descriptive statistics including frequencies, percentages, means and linear regression analysis for variables and data were analyzed using SPSS 25.0.

Results: Dust exposure (P=0.028), use of protective personal equipment (P=0.000), and a history of medical illness (P=0.000) affected the lung capacity of labor. The length of service (P=0.019), use of PPE (P=0.000), and history of medical illness (P=0.000) had significant effects on laborers' lung function. Work experience (P=0.267), smoking habits (P=1.000), and exercise habits (P=0.241) did not have a significant effect on lung capacity, whereas exposure to dust (P=0.115), smoking habits (P=1.000) and exercise habits (P=0.112) have not significant effect on lung function disorders on employee at the Indonesian ship industry (Persero) Makassar City.

Conclusions: Regular medical check-up and provision personal protective equipment (PPE) for labor in production units are needed to reduce the risk of lung capacity and lung function impairment.

1. Introduction

Dust is a solid chemical particle formed from organic or inorganic materials such as coal, wood, metal ore, limestone and stone as a result of natural or mechanical forces such as processing, crushing, grinding, rapid packing [1]. Dust exposure cause obstruction of air flow (obstructive disease), thickening of the bronchial walls, increased mucus secretion, decreased contraction and cough reflex thresholds, as well as increased susceptibility to respiratory tract infections and asthma symptoms [2].

Impact of pollutant exposure on the risk of upper respiratory tract infections. Respiratory tract disease is an occupational disease in industries found in developing countries (2-20%) [3]. International Labor Organization (ILO) in 2018 estimates more than 1.8 million work-related deaths every year in the Asia Pacific region. More than half of the work-related deaths worldwide occur in Asia. The Ministry of Health Government of Indonesia declared that the cases of occupational illness in Indonesia was high during 2011-2014 (2011 = 57,292 cases, 2012 = 60,322 cases, 2013 = 97,144 cases, 2014 = 40,694 cases) [4]. World Health Organization estimates about 3 million morbidity cases per year related to exposure to outdoor air pollutants in 2016, however indoor air pollutants could be deadly. It is estimated more than 6.5 million deaths worldwide (11.6%) are related to air pollution [5].

The results of Labor Force Survey (LFS) in 2017-2019 in the United Kingdom found 18,000 new cases of work-related lung disease categorized as occupational

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respiratory system diseases [6]. The lung capacity examinations carried out on 200 workers in eight companies of Health Occupational Safety Centre South Sulawesi in 1999 showed 45% experienced restrictive (lung narrowing), experienced obstructive (lung blockage) (1%), and a combination of restrictive and obstructive (1%) [7].

A study in Makassar Tene Industry showed 16 workers working in boiler areas and categorizing as heavy smoker had dust exposure above the maximum level were identified for abnormal lung capacity (45.7%) and normal lung capacity 19 (54.3%) [8]. The workers with length of service >26 – 31 years for 25 (6.6%) showed 10 (2.6%) had normal lung function, restrictive lung function 14 (3.7%), mixed lung function 1 (0.3%) [9].

The Indonesian ship industry (Persero) itself operates in the business of ship production, repair and modification. Direct observation in site area found the sandblasting production unit though a process of smoothing, forming, and cleaning hard surfaces by shooting particles at high speed onto the surface.

Sandblasting is known to cause potential dangers to the health and safety of workers. The identified hazard was dust exposure. The sand is the primary material used in the sandblasting process. The sand is sprayed at a high pressure towards the plate; therefore, the rust and dirt on the plate can disappear. During the sandblast process, a large amount of sand was used. Impact of pollutant exposure on the risk of upper respiratory tract infections [10].

Preliminary survey results on laborers in the Indonesian ship industry (Persero) showed respiratory system disorders such as coughing, sore throat, and difficulty breathing while working. Additionally, several laboratories were identified that did not use adequate personal protective equipment, such as masks, to protect themselves from dust exposure, thereby increasing the risk of dust exposure due to the sandblasting process. This study focused on the influence of dust exposure and individual characteristics on lung function disorders in workers in the production unit at the Indonesian shipbuilding industry Makassar.

2. Materials and Methods

This was a cross-sectional study conducted on information obtained from laboratory results and interview using questionnaire tools. Direct observation was held in production unit at the Indonesian ship industry Makassar.

A total of 100 employees in production unit the Indonesian ship industry Makassar City as population. The minimum sample size with a case–control design was formulated using the Lemeshow design, resulting in a minimum of 65 samples. Out a total of 10% of the total was added to prevent a sample bias. In total, 72 employees fulfilled the inclusion criteria and provided their consent to participate in this study. The length of service more than one year and worked in the six of site area in the industry as inclusion criteria in this study, whereas the exclusion criteria are the length of service less than one year, not working at 6 of site of selected place and no consent.

Dust exposure measurements were carried out within 3 minutes at six locations in the production section of the Indonesian ship industry (Persero) Makassar, including the front right center of the ship, rear of the ship, left and right bottom of the ship, and left front of the ship. While measuring lung capacity, the labor sample included those who met the criteria were assigned to the six locations where dust exposure was measured.

The independent variables were dust exposure, length of service, smoking habits, exercise habits, using protective personal equipment, and history of medical illness, whereas the intervening variable was the lung capacity, and lung function disorder as the dependent variables.

The dust exposure was assessed using a Dust Truck measuring instrument and were categorized (1). Meets health requirements (<55 μg/nm3) (2). Does not meet health requirements (≥55 μg/nm3). The lung capacity parameter was assessed using the parameters forced vital capacity (FVC) and forced expiratory in one second (FEV1) per FVC. Normal lung function was defined as % predicted FVC ≥ 75% FEV1/FVC ≥ 75%, restriction disorders = % predicted FVC and obstructive disorders = FEV1/FVC [11], this variable was categorized (1). Disturbance: If the respondent's spirometer measurement results show a restriction or obstruction. (2). Normal: If the respondent's spirometer measurement results show normal lung function.

The Lung function disorders were assessed using a questionnaire based on the Gutman scale and were categorized (1). The symptoms of impaired lung function were as follows: the percentage of respondents' answers was ≥ 50%. (2). No symptoms of lung function disorders:

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the percentage of respondents' answers was <50%. The length of service was categorized as (1). Short service: < 5 years, (2). Long service duration: > 5 years. Workers' smoking habits were categorized (1). Yes, if the employee ever had smoking habit, (2). No, if the employee has never had smoking habit.

The custom of regular physical exercise was assessed using a questionnaire with the Gutman scale and categorized (1). There is a routine (workers have a habit of exercising): if the percentage of respondents' answers is ≥ 50%. (2). Not routine (workers do not have a habit or never exercise): if the percentage of respondents' answers is <50%. Personal protective equipment (PPE) conformity was categorized (1). Utilizing (PPE): If the worker uses a mask while working. (2). Not utilizing: If the worker does not wear a mask while working.

History of medical illness before or during a worker's work has an impact on respiratory problems or is aggravated by lung function disorders, such as asthma, tuberculosis, pneumonia, acute respiratory infection (ARI), and chronic obstructive pulmonary disease (COPD). This variable was assessed using a questionnaire based on Gutman scale (1). Has a history of medical illness (the worker experienced or currently has asthma, tuberculosis, pneumonia, ARI or COPD): if the percentage of respondents' answers is ≥ 50%. (2). Does not have (if the worker does not have a history of the disease): if the percentage of respondents' answers is never <50%.

Statistical analysis was performed using the SPSS (Statistical Program for Social Science) version 25.0. The Univariate, bivariate and multivariate analysis were performed in this study. Univariate analysis provides descriptive statistics, including frequencies, percentages, and means, were calculated for variables. Bivariate analysis aims to test the hypothesis of the relationship between independent and dependent variables in the form of a cross tabulation (crosstab) with the chi-square statistical. Multivariate analysis has determined the effect of two variables, by controlling other variables and finding out the significant effect of the variables. A P value = 0.005 was obtained to select variables for the multivariable analysis. The OR with a 95% confidence interval (CI) was reported, and all independent variables that were found significant at a P value of 0,05 were considered the effect to the intervening and dependent variable [12].

The ethical approval was granted by Public Health Faculty, Hasanuddin University (Number:350/UN4.14.1/TP.01.02/2024). Prior to the data collection and interview, the researcher explained the purpose of study, method and written consent were obtained.

3. Results

The results of the research activities consisted of three (3) data analysis sections for univariate, bivariate, and multivariate analyses.

Table 1. Distribution frequency table for characteristic of respondents in the Indonesian ship industry in Makassar.

Characteristic	n	%
Age (years)		
17-25	7	9,7
26-35	14	19,4
36-45	4	5,6
46-55	43	59,7
56-65	4	5,6
Unit site		
Ship and Land Electricity	9	12,5
Facilities	10	13,9
Dock	13	18,1
Engine and shaft	10	13,9
Repair and Welding	20	27,8
Hull	10	13,9
Tolerance level of dust exposure		

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Meet minimum health standard	0	0,0
Did not meet minimum health standard	72	100,0

Source: Primary data, 2024

Table 1. showed that the age category 46 – 55 had the highest proportion (59.7 %, n = 43), whereas repair and welding unit site area had the highest number of workers (27.8%, n = 20). All employee (100%, n = 72) who worked in the Indonesian ship industry (Persero) in Makassar were exposed to dust on above the threshold level.

Table 2. Distribution frequency table of dust exposure based on measurement location site in theIndonesian ship industry in Makassar.

Location site	Detail of site area	Result
Site 1	Starboard Front of the Ship	1860*
Site 2	Middle Starboard of the Ship	2480*
Site 3	Rear side of the ship	367*
Site 4	Bottom right of the ship	3720*
Site 5	Front left of the ship	540*
Site 6	Bottom left of the ship	5400*

* The measurement using Particulate Matter (PM) with µg/nm3 as international unit

Table 2. shows the six sites (bottom left of the ship) with the highest concentration of dust exposure. The air temperature during measuring was 35.00C with an air pressure of 759.0 mmHg. Dust exposure was measured using Particulate Matter ($PM_{2.5}$) in µg/nm3 international units by direct reading during measurements carried out for 3 min.

Table 3. Analysis of effect dust exposure on lung capacity and lung function findings on Labor in the Indonesian ship industry in Makassar.

Finding	n (%)	Mean	SD	Median	P value
Lung capacity					
Abnormal	53 (73,6)	2884,45	1787,22	2480,00	0,028
Normal	19 (26,4%)	1895,47	1445,69	1860,00	
Lung function disorder					
Symptoms found	44 (61,1%)	2829,59	1640,69	2480,00	0,115
No symptoms	28 (38,9%)	2299,57	1893,83	1860,00	

Source: Primary data, 2024

Table 3. display that analysis result using Mann Whitney test have *P* -value (0,028) < 0,05. The hypothesis of the effect of dust exposure on lung capacity is acceptable, when the labor experience lung function, the dust exposure is 2884,45 higher compared to the labor whose normal lung capacity. However, the analysis of effect dust exposure to lung function show *P*-value (0,115) > 0,05 means the hypothesis is accepted, when the symptoms of lung function disorders in labor, dust exposure is 2829,59 higher rather than those with symptoms of impaired lung function.

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Table 4. Analysis of effect length of service, smoking habits, exercise habits, history of medical illness, using PPE on lung capacity and lung function findings on Labor in the Indonesian ship industry in Makassar.

Variable	Lung capacity		*P*-Value	Lung function		*P*-Value	Total
	Symptomatic	Normal		Symptomatic	Normal		
	n(%)	n(%)		n (%)	n(%)		n(%)
Length service							
Long	43 (70,5)	18 (29,5)	0,267	41(67,2)	20 (32,8)	0,019	61 (100)
New	10 (90,9)	1 (9,1)		3 (27,3)	8 (72,7)		11 (100)
Smoking habit							
Yes	29 (74,4)	10 (25,6)	1,000	24 (61,5)	15 (38,5)	1,000	39 (100)
No	24 (72,7)	9 (27,3)		20 (60,6)	13 (39,4)		33 (100)
Exercise habit.							
Not routine	29 (74,4)	14 (32,6)	0,241	30 (69,8)	13 (30,2)	0,112	43 (100)
Routine	24 (72,7)	5 (17,2)		14 (48,3)	15 (51,7)		29 (100)
Using PPE							
No	46 (97,9)	1 (2,1)	0,000	36 (76,6)	11 (23,4)	0,000*	47 (100)
Yes	7 (28,0)	18 (72,0)		8 (32,0)	17 (68,0)		25 (100)
History of medical illness							
Yes	40 (90,0)	4 (9,1)	0,000	44 (100,0)	0 (0)	0,000*	44 (100)
No	13 (46,4)	15 (53,6)		0 (0)	28 (100)		28 (100)

*) Significant level P<0,005 means an association with the dependent variable

Table 4. display that the result Chi-square test between the group labor with symptoms and with the no symptoms (normal), using PPE (*P* =0,000) and history of medical illness (*P* =0,000) have *P*-value < 0,05 that means have significant effect on the lung capacity and lung function. The length of service (*P* = 0,019) had a significant effect to the lung function, whereas the length of service didn't have significant effect to the lung capacity (*P* =0,267).

Table 5. Logistic regression analysis results for the risk factor affecting lung capacity and lung function on labor in the Indonesian ship industry in Makassar.

	B	*P* -value	OR	95% C.I. for OR	
				Lower	Upper
Lung capacity					
Exercise habits (1)	-3.151	0.062	0.043	0.002	1.166
History of medical illness (1)	2.605	0.046	13.528	1.043	175.533
Using PPE (1)	5.168	0.001*	175.569	8.623	3574.777
Dust exposure	0.001	0.115	1.001	1.000	1.001
Constant	-1.570	0.106	0.208		
Lung function					
Length of service (1)	-2.187	0.024	8.912	1.340	59.251
Using PPE (1)	2.638	0.000*	13.982	3.697	52.889
Exercise habits (1)	0.837	0.265	2.310	0.530	10.062
Dust exposure	0.000	0.277	1.000	1.000	1.001
Constant	-1.757	0.051	0.173		

*) Significant level P<0,005 means an association with the dependent variable

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Table 5. show that variable using PPE (OR = 175,569; *P* = 0,001) has 176 times higher for the lung capacity, whereas for the lung function, variable using PPE (OR = 13,982; *P* = 0,000) has 13,9 times higher rather than exercise habits, history of medical illness when the labor had dust exposure.

The end stage of the multivariate analysis was path analysis. The path analysis method was developed by Wright to study the direct and indirect effects of variables [13]. Path analysis was used to analyze the associate between the cause and effect of one variable and another variable.

Table 6. Estimation direct and indirect total effect of the risk factors to lung capacity and lung function on labor in the Indonesian ship industry in Makassar.

Variable Y		Variable X	Estimate Effect
Lung capacity	<---	Length of services	-0.163
Lung capacity	<---	Smoking habits	0.013
Lung capacity	<---	Exercise habits	-0.114
Lung capacity	<---	History of medical illness	-0.385
Lung capacity	<---	Using PPE	0.625
Lung capacity	<---	Dust exposure	-0.155
Lung disorder	<---	Length of services	0.037
Lung disorder	<---	Smoking habits	-0.045
Lung disorder	<---	Exercise habits	-0.075
Lung disorder	<---	History of medical illness	0.813*
Lung disorder	<---	Using PPE	-0.123
Lung disorder	<---	Lung capacity	-0.019
Lung disorder	<---	Dust exposure	0.058

*) Rx coefficient pathway (variable influencer)

Table 6. show the history of medical illness on lung function disorders on labors in Indonesian Ship Industry (Persero) Makassar with a value of effect 0.813 means that labors with history of medical illness have prevalence of 0.813 times that they were affected by lung function disorders.

4. Discussion

The laborers in production units have risk of impaired lung capacity because exposure to dust originating from work activities is a major risk factor impaired lung capacity. The hypothesis in this study was analyzed by using the Mann Whitney test, the results showed the effected of dust exposure on lung capacity p-value < 0,05 (P = 0,028) in labor at the Indonesian ship industry (Persero) Makassar; when the lung function disorders occur in labor, the dust exposure was higher 2884.45 times compared to normal lung capacity in labors, this study is in line with previous study that show there was a relationship between dust exposure and the lung capacity of coal workers [14]. The impaired lung capacity might lead to Chronic Obstructive Pulmonary Disease (COPD) has been proven as a strong predictor of all-cause mortality case by respiratory diseases, because impaired lung capacity can cause breathing difficulties and decrease the quality of life [15].

The percentage of labors in the production unit of the Indonesian ship industry (Persero) Makassar with a service period of more than five years is higher in which 70,5% of the total have impaired lung capacity. This indicates that the longer labor is exposed to dusty and polluted environments, the greater the risk of impaired lung capacity in labor. The hypothesis result using the chi-square found that the length of service variable P = 0.267 (P < 0.05) means no effect between length of service and lung capacity in Labor at the Indonesian ship industry (Persero) Makassar. Contrary finding from a study in Surakarta, west java Indonesia that showed association between length of service and lung function capacity [16]. People with impaired lung capacity often experience low quality of life and increase morbidity, due to declined lung capacity led to difficulty to engage physical activity and perform daily tasks [17].

The number of smoker laborers in the production unit at the Indonesian ship industry (Persero) Makassar 54.2%

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whereas 45.8% were non-smokers. The smoker laborers had impaired lung capacity 74.4%, the smoker laborers had normal lung capacity 25.6%. The chi-square test showed P =1,000 which means no-influence between smoking habits and lung capacity in labor in the Indonesian ship industry (Persero) Makassar, which in line previous study that found that no effect of smoking on the vital lung capacity [18]. Smoking habits highly affect lung capacity because non-smokers have higher lung capacity compared to the smoker. Damage on lung capacity will reduce alveoli function in the respiration process, causing a decrease in the function of the lung organs and a decrease in vital lung capacity [19].

A previous study showed no effect of good exercise habits on the lung capacity that with the results of this study (P = 0,241) [20]. However, another study found that exercise influenced the lung capacity (P = 0.014) [21]. Personal protective equipment should be available at the work site, because it reduces the risk of occupational accidents and avoids work-related diseases such as impaired lung capacity which synchronized with the finding in this result (P = 0,000).

Disorders of lung capacity are conditions that affect the ability of the lungs to fully expand, resulting in reduced lung capacity and difficulty breathing [17] especially in the labor production unit of the Indonesian ship industry (Persero) Makassar which was synchronized with the analysis results in this study (P=0,000). Historical medical illness is one of the risk factors influencing lung capacity in labor in the production unit of the Indonesian ship industry (Persero) Makassar. The high percentage of labor with a history of medical illness (61,1%) was synchronized with percentage of labor with problems with their lung capacity (73.6%).

The analysis results on the effect of dust exposure on lung function disorders in labor with symptoms of lung function disorders (P > 0.05) showed that dust exposure was 2829,59 higher that of labor with no symptoms of lung function disorders. Air pollution is an environmental issue due to its proven serious impacts on human health, premature deaths caused by PM2,5 and PM10 with average risk relative were about 6.35% and 6.76% of the total deaths [22]. Several labor with respiratory tract diseases, including lung function disorders and undiagnosed asthma were found as potential burden of disease that can be prevented by early detection and treatment [23]. The overwhelming consensus in environmental tobacco smoke also leads to high respirable particulate matter (PM2.5), tobacco toxin levels and exposures among gaming employees [24]. The labor with symptoms of impaired lung function (61.1%) when exposure to dust with impaired lung function is statistically analysed based on its effect, value from results obtained cannot be calculated (not detected) because the value is homogeneous.

This study showed an influence between the length of services and lung function disorders in labor on production unit of the Indonesian ship industry (Persero) Makassar (P =0,019). A potential risk factor that can cause lung function disorders is the duration of exposure to pollutants. The longer the working period, the longer the exposure time to pollutants [25]. The tobacco in cigarettes is known to be the main risk factor for lung function disorders. This study found no influence between smoking habits and lung function disorders on labors in the Indonesian ship industry (Persero) Makassar (P =1,000). Smoking habit might be a dominant role in smokers, therefore, additional exposure to air pollutants might not have greater impact compared to non-smokers [26].

Being less exercising is worse for smokers, therefore it is very important to have body exercise. The low of exercise frequency was found less (1.39 out of 5) among the labor who complied with preventive behaviours [27]. However, this study found no influence between exercise habits and lung function disorders on labor in the Indonesian ship industry (Persero) Makassar (P =0,112). The use of personal protective equipment was analyzed with lung function disorder showed a significance value (P =0.000). Personal protective equipment is respiratory protective equipment that is suitable for the job and can indirectly reduce dust deposits that infected the lung [28].

History of disease and impaired lung function in labor at the Indonesian ship industry (Persero) Makassar had influence on lung function disorder (P =0,000), this study result is diverse with the study on employee on the Train company in maintenance unit that found there was no significant relationship between history of disease and impaired lung function [28]. The healthy body might affect the quality of the labor's work performance and gradually develop into lifelong ailments [29].

5. Conclusion

Periodic medical check-up and enforce health and safety in working by using complete personal protective

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equipment in working environment can reduce risk factors for impaired lung capacity and symptoms of impaired lung function on the labor.

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