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Original Research

THE INTERNAL FACTORS AFFECTING LUNG CAPACITY OF PEOPLE LIVING IN AREAS AROUND THE CEMENT INDUSTRY, INDONESIA

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ABSTRACT
Background: Some internal factors have both positive and negative effects to people's health, especially those who live in a polluted area. The area around the cement industry is an example of polluted area in which the lung capacity will be harmed.
Aim: This research aimed at finding out internal factors affecting lung capacity of people living in the area around the cement industry.
Methods: This research used a cross sectional study plan by measuring lung capacity (FEV1 and FVC) of people living in four different locations. The locations were based on wind directions and within 3 km from the cement industry. The study plan was also done by connecting the measurement with other factors, such as age, physical activities, nutrition status and passive smoking or environmental tobacco smoke (ETS).
Results: Based on the calculation of lung capacity 241 respondents obtained 123 respondents (51%) had a normal lung capacity, 105 respondents (43.6%) had a restricted lung capacity, 4 respondents (1.7%) had an obstructed lung capacity and 9 respondents (3.7%) had a combination of a restricted and obstructed lung capacity. The age ($p=0.977$) and physical activities ($p=0.087$) of respondents had no effect on the lung capacity. However, nutrition status ($p=0.011$) and passive smoking or ETS ($p=0.003$) do.
Conclusion: The nutrition status and the presence of a passive smoker were the internal factors affecting people's lung capacity, especially for those who live around the cement industry. Thus, in order to avoid the impairment of lung capacity, people need to improve their nutrition and to avoid people smoking around them.

Key words: Lung capacity, age, physical activities, nutrition status, passive smoking

INTRODUCTION

PT Semen Tonasa is one of eight largest cement industries in Indonesia, located in Desa Biringere, District of Bungoro, Pangkep Regency, South Sulawesi Province. The area of limestone mining of the industry is only 1.7% or around 750 Ha of Karst Area of Maros and Pangkep which covers a total of 43,750 Ha. The production capacity of this industry is around 5,98 million tons of cement per year.[1]

Production capacity of PT Semen Tonasa has both economic and environmental impacts. Cement industries release around 5% of global carbon dioxide, the greenhouse gas.[2] In their production, cement industries release 5-6% of all carbon dioxide produced by human activities, or around 4% of global warming.[3] Furthermore, cement industries also contribute to the emission of SO_2, NO, PM and CO that has a negative impact to the environment, such as global warming and acid rain, and to human health, such as respiratory problems, chronic inflammation, irreversible structural changes on lungs, bronchitis, cancer, or even death.[4]

Epidemiological study shows a strong relation between exposure of air pollution and cardiovascular or respiratory diseases to people living around the cement industry. Cement industries are contributing to air pollution. It can be seen by the amount of NO_2 around the area of the industries in which the lowest amount is during winter with NO_2 around 83 $\mu g/m^3$.[5] Inhalation is the common way of pollutants getting to a human body and harming the respiratory system. Exposure of air pollution can burden and break the body's natural immune mechanism. It can also contribute in respiratory diseases such as lung cancer, asthma, chronic bronchitis and emphysema. Moreover, it has a negative impact on cardiovascular and the central nerve system.[6]

Some case studies show that people working in the area around the cement industry are at greater risk of pulmonary function impairment. The longer time they spend working or being in that area, the greater risk they get from the exposure of dust.[7,8] In India, people living within 2 to 3 km from the cement industry have health problems. In that area, the concentration of SO_2 and NO_2 is 115.2 $\mu g/m^3$ and 117.09 $\mu g/m^3$ in site 1 and 28.13 $\mu g/m^3$ and 19.46 $\mu g/m^3$ in site 2. This high concentration causes ISPA, bronchitis, asthma, emphysema, and irritation to the eyes and skin.[9]

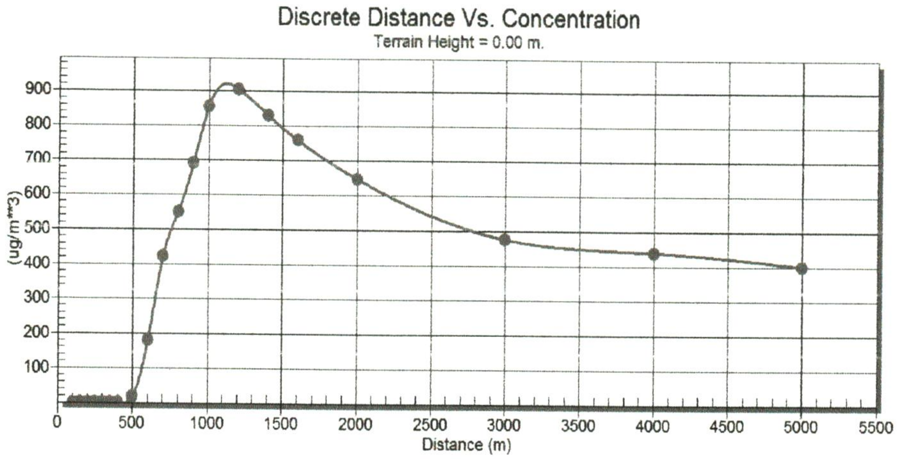
Previous studies try to correlate air quality of a cement industry to the lung capacity.[10] However; no one has studied about the internal factors affecting lung capacity in a polluted area or the area around the cement industry. The body has an internal defense system in respiratory tract; filtration of air, mucociliary clearance; local humoral secretion, and phagocytosis.[11] In an unhealthy environment, by taking care of the internal factors, it can decrease the risk of health. Those internal factors are age,[12,13]physical activities,[14] nutrition status,[15] environmental tobacco smoke (ETS).[16,17] This paper aimed to give a detailed review regarding the internal factors affecting lung capacity of people living in the area around the cement industry.

METHODS

Research Location

The research was undertaken around PT Semen Tonasa, Pangkep Regency, Indonesia. There were four different locations used in this research and they were based on the four wind directions using the application of *Screen View 3.5.0* (Screening Air Dispertion Model by Lakes Environmental Software) as seen in Picture 1.

Picture 1. Temporary Analysis Grafic of Emission Dispersion Level of PT Semen Tonasa



According to Picture 1, the high level of emission dispersion occurs within 1 km, and the level significantly decreases within 3 km. This is in line with a research conducted by Mehraj et al. (2013) in which people living within 2 to 3 km from the cement industry have higher health risk. Most of the health risks are ISPA, brochitis, asthma, emphysema, and irritation on eyes and skin.[9]

Based on the previous researcher's findings, it was decided that there would be four locations to measure people's lung capacity and the ambience of the air; they were Macinna Village, Sub-district of Bontoa, District of Minasatene (S:4°48'2.86"; E:119°37'13.05), Sela Village, Sub-district of Mangilu, District of Bungoro (S:4°46'51.92"; E:119°37'59.46), Boronguntia Village, Sub-district of Biringere, District of Bungoro (S:4°47'32.85"; E:119°36'13.12), dan Gattagattareng Village, Sub-district of Taraweang, District of Labakkang (S:4°46'12.93"; E:119°36'54.45).

Population and Sample

The population existed out of 609 respondents and 241 respondents were used as a sample using *Slovin's Formula.* The samples were divided into 44 respondents from Macinna Village, Sub-district of Bontoa, District of Minasatene or Location I; 51 respondents from Sela Village, Sub-district of Mangilu, District of Bungoro or Location II; 75 respondents from Boronguntia Village, Sub-district of Biringere, District of Bungoro or Location III; and 71 respondents from Gattagattareng Village, Sub-district of Taraweang, District of Labakkang or Location IV. Samples and population were taken by using simple random sampling method.

Instrument of Data Collection

The instruments used to collect data were *Spirometri Analyzer SN 42942 Kent MEI12AZENGLAND* to measure lung capacity; digital and manual scale to weigh body; *microtoise* to measure the respondents' height; and questionnaires for the interview.

Quality Control

A quality control is needed to maintain all aspects of the operation of the research, starting from the preparation, data collection to data analysis, so that the research is valid and reliable. The quality control for this research was:

a. Standardization of the Measuring Instruments

The measuring instruments for air parameter were certified and validated by Balai Besar Kesehatan Paru Makassar or BBKPM

b. Standardization of Experts
In collecting and analyzing the data, the experts were from Balai Besar Kesehatan Paru Makassar or BBKPM. They consisted out of of a pulmonologist and three graduates of the public health department to interview the respondents.

RESULTS

Lung Capacity

Lung capacity is determined by two indicators, the value of FVC and FEV1. Both can be obtained by using a spirometer.

Table 1 Distribution of Respondents Based on the Value of FEV1 and FVC around the Cement Industry

Lung Capacity	n	Mean	Std. Deviation	Minimum	Maximum
FVC	241	1.9352	0.45578	0.41	3.26
FEV1	241	1.7486	0.43874	0.21	2.68

Table 2 Distribution of Respondents' Lung Capacity around the Cement Industry

Lung Capacity		n	Percentage (%)
Normal		123	51.0
Abnormal	Restriction	105	43.6
	Obstruction	4	1.7
	Mix	9	3.7
Total		241	100.0

Age

In this part, an independent variable–the respondents' age and the dependent variable–lung capacity are connected. However, the test result showed that P Value (0.977) > 0.05 (*pearson chi square value*). It indicates that the age of respondents has no relation to their lung capacity.

Table 3. Test Result of Variable of Respondents' Age with the Condition of Lung Capacity

Age (year)	Lung Capacity				Total		P Value
	Normal		Abnormal				
	n	%	n	%	n	%	
< 25	8	44,4	10	55,6	18	100	0.977
26-35	29	52,7	26	49,1	55	100	
36-45	41	52,6	37	47,4	78	100	
46-55	27	51.9	25	48,1	52	100	
> 56	19	50	19	50	38	100	
Total	124	51,5	117	48,5	241	100	

Nutrition Status

This is the part where an independent variable–the respondents' nutrition status (Body Mass Index or BMI) and the dependent variable–lung capacity are connected. Furthermore, the test result of chi square showed that P Value (0.011) < 0.05 (*pearson chi square value*). It indicates that there is a relation between respondents' BMI and the condition of lung capacity.

Table 4. The Test Result of Variable of Respondents' BMI with the Condition of Lung capacity

IMT Responden	Lung Capacity				Total		P Value
	Normal		Abnormal				
	n	%	n	%	n	%	
Thin	2	33,3	4	66,7	6	100	0,011
Ideal	38	40,4	56	59,6	94	100	
Obesity	84	59,6	57	40,4	141	100	
Total	124	51,5	117	48,5	241	100	

ETS

This is the part where an independent variable–the presence of a smoker in the respondents' home and the dependent variable–lung capacity are connected. Furthermore, the test result of chi square showed that P Value (0.003) < 0.05 (*continuity correction value*). It indicates that there is a relation between the ETS and the lung capacity.

Table 5. The Test Result of the Variable of the ETS with the Lung Capacity

ETS	Lung Capacity				Total		P value
	Normal		Abnormal				
	n	%	n	%	n	%	
No	70	61,9	43	38,1	113	100	0.003
Yes	54	42,2	74	57,8	128	100	
Total	124	51,5	117	48,5	241	100	

Physical or Sport Activities

This is the part in which an independent variable–the respondents' physical or sport activities and the dependent variable–lung capacity are connected. However, the chi square test result showed that P Value (0.087) > 0.05 (*continuity correction value*). It shows that the physical or sport activities of respondents have no relation to lung capacity.

Table 6. Test Result of Variable of Respondents' Physical or Sport Activities with the Condition of Lung capacity

Physical or Sport Activities	Lung Capacity				Total		P value
	Normal		Abnormal				
	n	%	n	%	n	%	
Yes	16	66,7	8	33,3	24	100	0,087
No	108	49,8	109	50,2	217	100	
Total	124	51,5	117	48,5	241	100	

DISCUSSIONS

The lungs undergo some development phases within the first twenty years of human life. The maximum function of the lungs occurs when a female is 20 years old and a male is 25 years old. Their function remains stable with minimum development when people are 20 to 35 years old and begin to decrease after that.[18,19] Age is one of confounding factors due to FEV1 and FVC also follow the development phases of the lungs. This fact is also supported by a previous research stating that 40% of adults aged under 34 years old have some pulmonary function impairment, while there are only 20% of adults aged 34 to 40 years old having similar problems.[20] The relation between age and pulmonary function is quite complex. The maximum function for different age is also determined by the genetic factor. There is also another research stating that there is a relation between FEV1 and FVC with chromosome of 4, 6 and 8. The plateau phase and the decreasing level of pulmonary function have relations with certain independent predictors of the decrease of FEV1 such as smoking, working, pollution dispersion, coughing, and malnutrition. [13]

The respondents' BMI is counted by using the height and weight of the respondents. The average height, weight, and BMI of the respondents are respectively 1.38 m, 94.4 kg, and 24.4. This level of BMI is considered overweight according to BMI standard for Indonesian female from Indonesian Health Ministry (2003). Statistical study test using *chi square* study (*person chi square* value) shows that there is a relation between BMI and lung capacity (p=0.011).

According to a cohort study, which was done for six years, weight increase of more than 10 kg has a significant effect to the value of FVC and FEV1. It is found that men experience more risks in their lung capacity than women. By using a multiple regression analysis, it can be concluded that with every one kilogram weigh increase, men will encounter a decrease of 26 ml FVC and 23 ml FEV, while women will face a decrease of 14 ml FVC and 9 ml FEV.[21] The significant difference in parameter of spirometer is counted as a percentage of prediction between male and female. Among all obesity subjects, the most significant relation is found between BMI and the values of pulmonary function; FEV1 (r = -0.531, p = 0.009); FEV1 / FVC (r = -0.603, p = 0.002). This significant relation is found between the BMI and pulmonary function of female, while the relation is not that significant in male respondents.[15]

According to the variable of the presence of a smoker in respondents' home, 53.1% respondents stated that there was a smoker living with them. The result of statistic study using *chi square* study (*continuity correction* value) shows that there is a relation between the presence of a smoker or the respondent being a passive smoker and lung capacity (p = 0.003).

The presence of a smoker living with the respondent in the same house is also known as as passive smoking. A passive smoker is a person who inhales the smoke of someone smoking cigarette. The other name for passive smoker is *Second-hand smoke or SHS* or also known with the term *Environmental Tobacco Smoke or ETS.*[21]

In the variable of physical or sport activities, there are only 10% of respondents whose routines are related to physical, such as daily job or occupation, or sport activities. The result of statistic study using *chi square* study (*continuity correction* value) shows that physical activities have nothing to do with lung capacity (p = 0.087).

A previous research regarding the impact of sport on the pulmonary function done on 30 people aging 18 to 27 years old with equal number of male and female shows that there was a significant change on pulmonary function after the respondent did a twelve week exercise. Before doing exercise, the value of FVC was 3.40 + 0.70 and FEV1 was 2.54 + 0.35. After doing the twelve week exercise, the value of FVC became 3.81 + 0.69 and FEV1 became 3.11 + 0.70.[22]

CONCLUSION

The nutrition status and the presence of a passive smoker were the internal factors affecting people's lung capacity, especially for those who live around the cement industry. Thus, in order to avoid the impairment of lung capacity, people need to improve their nutrition and to avoid people smoking around them.

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