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Risk Factors Affecting Respiratory Symptoms and Impaired Lung Function of Palm Oil Mill Workers in the District of Kandis

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Abstract

Background: Air pollution that exposed to human have been a problem all over the world and caused a variety of lung disease. Gases and particles emitted from industry including sulfur oxide, nitrogen oxide, and particulate matter may lead to decreasing lung function. Sulfur dioxide is one of the highest causes of air pollution at the highest level. Workers exposure to gases were vulnerable to respiratory function abnormality.

Methods: A study on the effect of risk factors and sulfur dioxide exposure on lung function of palm oil workers in the district of Kandis was carried out in December 2019–January 2020. The research aim at describing sulfur dioxide air ambient in palm oil mill as well as respiratory state of palm oil workers and analyzing sulfur dioxide exposure and lung function relationship.

Result: The result showed that sulfur dioxide concentration in outdoor 25.7 $\mu\text{g}/\text{Nm}^3$ and indoor 20.6 $\mu\text{g}/\text{Nm}^3$. The result of spirometry showed obstruction in 13% of the workers. Breathlessness and productive cough are the most common symptoms. Several factors correlated with lung function namely as personal protective equipment ($P=0.001$), length of working ($P=0.003$), and smoking habit ($P=0.004$). From multivariate analysis, personal protective equipment has a significant correlation with lung function ($P=0.038$).

Conclusion: Increasing the concentration of sulfur dioxide may cause the decrease of lung function but other factors like personal protective equipment showed correlation is directly proportional with lung function. (*J Respirol Indones 2021; 41(3): 180–6*)

Keywords: lung function, pollution, sulfur dioxide

Faktor Risiko yang Mempengaruhi Keluhan Respirasi dan Gangguan Fungsi Paru Pekerja Pabrik Kelapa Sawit PT. X di Kecamatan Kandis

Abstrak

Latar Belakang: Polusi udara yang terpajan pada manusia merupakan masalah di seluruh dunia dan menyebabkan berbagai penyakit paru. Gas dan partikel yang dihasilkan industri seperti sulfur dioksida, nitrogen dioksida dan particulate matter dapat menyebabkan penurunan fungsi paru. Sulfur dioksida merupakan salah satu penyebab polusi udara tingkat tertinggi. Paparan gas toksik pada pekerja rentan menimbulkan kelainan fungsi paru.

Metode: Studi tentang pengaruh faktor risiko dan paparan sulfur dioksida terhadap fungsi paru pekerja pabrik kelapa sawit di kecamatan Kandis telah dilakukan pada bulan Desember 2019–Januari 2020. Studi ini bertujuan mengetahui gambaran udara ambien sulfur dioksida di pabrik kelapa sawit serta fungsi paru pekerja pabrik dan menganalisis paparan sulfur dioksida terhadap fungsi paru.

Hasil: Hasil penelitian menunjukkan bahwa konsentrasi sulfur dioksida pada outdoor 25,7 $\mu\text{g}/\text{Nm}^3$ dan indoor 20,6 $\mu\text{g}/\text{Nm}^3$. Pekerja pabrik yang mengalami gangguan fungsi paru sebanyak 13% (obstruksi) dari hasil pemeriksaan spirometri. Keluhan pernapasan yang paling banyak adalah sesak napas dan batuk berdahak. Terdapat hubungan bermakna antara fungsi paru dengan penggunaan alat pelindung diri (APD) ($P=0,001$), lama kerja ($P=0,003$) dan kebiasaan merokok ($P=0,004$). Dari ketiga variabel tersebut dilakukan analisis multivariat dengan hasil penggunaan APD memiliki hubungan signifikan dengan fungsi paru ($P=0,038$).

Kesimpulan: Peningkatan konsentrasi sulfur dioksida dapat menyebabkan penurunan fungsi paru tetapi faktor lain seperti penggunaan APD menunjukkan korelasi berbanding lurus terhadap fungsi paru. (*J Respirol Indones 2021; 41(3): 180–6*)

Kata kunci: fungsi paru, polusi, sulfur dioksida

INTRODUCTION

Sources of air pollution can be divided into indoor air pollution and outdoor pollution. Air pollution in urban areas is a serious problem. Increased use of motor vehicles and energy consumption, if not controlled, will exacerbate air pollution. Based on the World Health Organization (WHO) data, air pollution in Indonesia has experienced an alarming level compared to WHO standards. The cause of air pollution 80% comes from the transportation sector and 20% from industry and domestic waste. Increased air pollution in urban areas will increase the risk of lung cancer, respiratory system infections, chronic obstructive pulmonary disease (COPD), and trigger asthma attacks.^{1,2}

Based on WHO data in 2018, the current high level of air pollution in the world is an environmental issue that is disturbing to the wider community, causing a high incidence of several diseases caused by air pollution, namely diseases related to the respiratory system. Various pollutants, especially from industrial fuels and motor vehicles, such as nitrogen oxides (NO), sulfur oxides (SO), ozone (O₃), and particulate matter (PM), are risk factors for acute respiratory infections (ARI), lung cancer, COPD and asthma triggers.³ Sulfur dioxide (SO₂) is one of the causes of air pollution at the highest level. Sulfur dioxide causes respiratory problems, especially in children and the elderly, and triggers pre-existing heart and lung diseases. Injury to the larynx, trachea, bronchi, and alveoli occurs in significant exposures above 50 parts per million (ppm).¹

The result of a survey by the Directorate General of Infectious Disease Eradication and Environmental Health, Ministry of Health Indonesia in 2015 showed ARI and lung infections, especially tuberculosis and pneumonia, are contribute to morbidity (35%).⁴ In 2017, respiratory diseases such as tuberculosis, pneumonia, and ARI are 10 infectious diseases in Siak Regency. In addition, asthma and COPD rank second and fifth out of 10 non-communicable diseases in Siak Regency.⁵ The

purpose of this study was to obtain an overview of respiratory symptoms and lung function of palm oil mill workers and ambient SO₂ concentrations at PT. X Kandis district.

METHODS

This research is a descriptive-analytic study using a cross-sectional research design. The research has been conducted at the palm oil mill of PT. X Kandis sub-district, Siak district in December 2019–January 2020. The materials and tools in this study were the European Community Respiratory Health Survey (ECRHS) questionnaire, spirometer, spectrophotometer, disposable mouthpiece, weight scale, height meter, stationery, and digital camera.

The research inclusion criteria were the workers of the palm oil mill of PT. X in the Kandis sub-district with a minimum working period of 2 years. The exclusion criteria were the workers of the PT. X in the Kandis sub-district has Post Tuberculosis Obstruction Syndrome, which is concluded from data history and chest x-rays in the last 6 months.

The types of data used were quantitative and qualitative. The data used in this study came from primary data through filling out a modified ECRHS questionnaire and measuring the value of the VEP₁ and KVP ratio using a spirometer for factory workers at the specified location. Furthermore, measurements of SO₂ concentration were carried out using a spectrophotometer at the location of the factory workers doing activities (outdoor) and the palm oil mill office space (indoor). Determination of the location of the measurement of SO₂ concentration was carried out by purposive sampling, namely by considering the characteristics of the area's activities, namely in the palm oil mill area (outdoor) and the palm oil mill office space (indoor).

The population in this study were workers at the palm oil mill of PT. X Kandis sub-district in 2019 as many as 104 people. The sample in this study were factory workers who met the inclusion criteria and did not have the exclusion criteria from the

population. Based on the calculation of the Slovin formula, the minimum sample size to be studied is 48 people. A multivariate test will be carried out in this study, and there are 6 variables for which statistical analysis will be carried out. Each variable has a minimum of 10 samples so that the total sample in this study is at least 60 people. In this study, the sampling technique used a stratified random sampling technique. Sampling was divided into two groups according to the activities of the factory workers, namely, the factory area (outdoor) and the office space (indoor) of the PT. X Kandis sub-district using the proportional allocation formula.

RESULT

This research was conducted from December 2019–January 2020. The palm oil mill of PT. X was established in 2002 and is one of the largest factories in the Kandis sub-district, Siak district. There were 69 eligible subjects, 47 outdoor workers and 22 indoor workers. The dependent variable in this study was lung function. In contrast, the independent variables assessed in this study included SO₂ concentration, age, gender, length of work, smoking history, use of Personal Protective Equipment (PPE), respiratory symptoms, and history of respiratory disease. Subjects filled out the modified ECRHS questionnaire in a guided manner and a spirometry examination was performed. The measurement of SO₂ concentration using the spectrophotometer method was carried out in two places, namely the factory area (outdoor) and the office room (indoor).

The characteristics of subjects in this study are mostly under 40 years old (88.4%), male predominantly (97.1%). Most of the study subjects work less than 5 years (53.6%). Smoking history measured with Brinkman's Index (BI), most subjects are moderate-heavy smokers with BI more than 200 (31.9%). There are only a few subjects who did not wear PPE in this study (36.2%) and most of the subjects work in the outdoor area (68.1%). Based on the history of respiratory disease, 14 people (20.3%) had a history of respiratory illness. From the

lung function test, it was found that 13% had an obstruction. The characteristics of research respondents are described in Table 1.

Table 1. Characteristics of Palm Oil Mill Workers PT. X

Variable	n	%
Age		
>40 years	8	11,6
<40 years	61	88,4
Gender		
Male	67	97,1
Female	2	2,9
Length of Working		
≥5 years	32	46,4
<5 years	37	53,6
Smoking History		
BI ≥200	22	31,9
BI <200	47	68,1
Use of PPE		
No	25	36,2
Yes	44	63,8
Job Location		
Factory area (outdoor)	47	68,1
Office space (indoor)	22	31,9
History of Respiratory Disease		
Exist	14	20,3
None	55	79,7
Lung Function		
Obstruction	9	13
No Obstruction	60	87

This study showed, 76.6% of outdoor subjects experienced respiratory symptoms. Most indoor subjects (54.6%) had no respiratory complaints. From the results of the lung function test using spirometry, it was found that 17% of outdoor workers and 4.5% of indoor workers had obstructive diseases (FEV₁/FVC<75%). An overview of respiratory symptoms and lung function is presented in Table 2.

Table 2. Description of Respiratory Complaints and Lung Function of Factory Workers

Variable	Respondent Outdoor (n=47)	Respondent Indoor (n=22)
Respiratory Complaints		
Exist	36 (76,6%)	10 (45,4%)
None	11 (23,4%)	12 (54,6%)
Lung Function		
Obstruction	8 (17,0%)	1 (4,5%)
No Obstruction	39 (83,0%)	21 (95,5%)

Based on the results of research conducted by filling out guided questionnaires using modified ECRHS, it was found that the distribution of the characteristics of clinical respiratory complaints in both respondents. Shortness of breath complained most by outdoor respondents (70.2%). Some of the outdoor respondents experienced cough (17%) and productive cough (17%) but no wheezing symptoms found, while in indoor workers, as many as 2 people (9,1%).

Table 3. Factory Worker Respiration Complaint

Symptoms	Outdoor Respondent (n=47) (%)	Indoor Respondent (n=22) (%)
Cough	8 (17.0%)	2 (9.1%)
Phlegm Cough	8 (17.0%)	6 (27.3%)
Shortness of Breath	33 (70.2%)	6 (27.3%)
Wheezing	0 (0.0%)	2 (9.1%)

History of phlegm cough attacks experienced by as many as 8 people (17%) in outdoor workers and as many as 6 people (27.3%) in indoor workers. However, only a small proportion had wheezing (9.1%) in indoor workers. An overview of the characteristics of respiratory symptoms is presented in Table 3.

Table 4. The Relationship between SO₂ Concentration and Lung Function

Variable	Lung Function			P	OR (95% CI)
	Obstruction	No obstruction			
SO ₂ concentration in the factory area (outdoor) 25,7 µg/Nm ³	8 (17.0%)	39 (83.0%)		0.254	0.23 (0.03–1,98)
SO ₂ concentration in the office (indoor) 20,6 µg/Nm ³	1 (4.5%)	21 (95.5%)			

Table 5. Relationship of Age, Length of Work, History of Smoking, Use of PPE and History of Respiratory Diseases with Lung Function of Factory Workers

Variable	Lung Function			P	OR (95% CI)
	Obstruction	No obstruction			
Age				0.278	2.6 (0.4–15,3)
>40 years	2 (25)	6 (75)			
<40 years	7 (11.5)	54 (88.5)			
Length of Work				0.003	10.3 (0.26–0.46)
≥5 years	9 (24.3)	28 (75.7)			
<5 years	0 (0)	32 (100)			
Smoking History				0.004	10.5 (1.9–56.2)
IB Risk (≥200 cigarettes)	7 (31.8)	15 (68.2)			
No IB Risk (<200 cigarettes)	2 (4.3)	45 (95.7)			
The Use of PPE				0.001	20.2 (2.3–174.3)
No	8 (32)	17 (68)			
Yes	1 (2.3)	43 (97.7)			
History of Respiratory Diseases				0.373	2.3 (0.3–10.3)
There is	3 (21.4)	11 (78.6)			
There is no	6 (10.9)	49 (89.1)			

Measurements and observations were carried out at the palm oil mill of PT. X Kandis district. SO₂ concentration was carried out within 24 hours in the factory area (outdoor) and office space (indoor) using a spectrophotometer. Based on the Belfast Metropolitan Urban Area (BMUA) standard, SO₂ concentration in 24 hours should not exceed 365 µg/Nm³. The SO₂ concentration in the outdoor of the factory area is 25.7 µg/Nm³. Furthermore, in the indoor setting, the SO₂ concentration is 20.6 µg/Nm³.

Furthermore, bivariate analysis was carried out using the chi-square statistical test. Bivariate analysis statistically gave a significant value. Based on the results of statistical analysis of respondents who experienced obstruction disorders, 17% were outdoor respondents, and 4.5% were indoor respondents. Statistical tests showed, that there was no significant relationship between SO₂ concentration and lung function ($P=0.254$). The relationship between SO₂ concentration and lung function is presented in Table 4.

In this study, bivariate analysis using chi-square was performed to found the association between age, length of work, smoking habits, PPE, and history of respiratory disease the lung function. There was a significant relationship between the use of PPE ($P=0.001$), length of work ($P=0.003$) and smoking history ($P=0.004$) on lung function, which is presented in Table 5.

DISCUSSION

Based on the study results, 76.6% of outdoor/indoor subjects and 11% of outdoor/indoor subjects and 23.4% had no respiratory symptoms. In indoor respondents, 54.6% had no respiratory symptoms. This research is in line with Takeshi et al in 2017, a study conducted on 168 subjects who had a history of living in a mountain area and were exposed to volcanic eruptions. The study showed increased respiratory symptoms caused by higher risk exposure to toxic gasses.⁶

This study showed outdoor respondents showed more symptoms compared to the indoor respondents such as shortness of breath complaints of shortness of breath (70,2%), the cough was found to be higher in outdoor workers. History of coughing up phlegm was experienced by as many as 8 people (17%) in outdoor workers and as many as 6 people (27.3%) in indoor workers. Only a small portion of indoor respondents experienced wheezing (9,1%). This is similar to Wu et al that shortness of breath and coughing up phlegm were the most common symptoms, and there was a significant relationship between shortness of breath and an increase in SO_2 concentration 45.7 $\mu\text{g}/\text{Nm}^3$ with an odds ratio (OR) value are 4.1 (95% CI=1.2–19.9).⁷ Murgia et al in 2011 showed that factory workers had a high risk of experiencing complaints and limitations in the respiratory system with a hazard ratio (HR) value (HR=5.3; 95% CI=2.7–10.5).⁸

In this study, lung function test shows that 17% of outdoor workers had obstructive disorders ($\text{FEV}_1/\text{FVC}<75\%$) and 1 person (4.5%) indoor workers had obstructive disorders ($\text{FEV}_1/\text{FVC}<75\%$). Similar to Rantetampang et al,

the population of the Kurulu area is at risk of exposure to toxic gases that can cause a decrease in lung function. It was found that significantly 92.3% of subjects experienced a decrease of FVC.⁹

From this study, SO_2 measurements in the factory area (outdoor) is 25.7 $\mu\text{g}/\text{Nm}^3$ within 24 hours. Meanwhile, in the office room (indoor), the SO_2 concentration is 20.6 $\mu\text{g}/\text{Nm}^3$. That was below the BMUA standard value. Based on the regulation of the State Minister of the Environment in 2010, the threshold value of SO_2 concentration for 24 hours of observation should not be more than 365 $\mu\text{g}/\text{Nm}^3$.¹⁰

From this study, there is no significant correlation between SO_2 concentration and lung function impairment ($P=0.254$). It may be due to the SO_2 concentration value was below the standard BMUA value. The concentration should not exceed 365 $\mu\text{g}/\text{Nm}^3$ in 24-hour observation.¹⁰

Based on research by Wu et al in 2016, an increase in SO_2 concentration with a value of 45.7 $\mu\text{g}/\text{Nm}^3$ caused the effect of clinical respiratory symptoms for example shortness of breath (OR=4.1; 95% CI=1.2–19.9).⁷ Rantetampang et al found a significant relationship with decreased lung function with SO_2 exposure above 25 $\mu\text{g}/\text{Nm}^3$; from the results of the study, it was found that 92.3% experienced a decrease in FVC ($P=0.0001$).⁹ Study by Wijarti et al from 60 subjects of street vendors at the Pulogadung bus terminal showed 31.67% had a risk of health problems, especially the respiratory system with SO_2 exposure of 133.78 $\mu\text{g}/\text{Nm}^3$ within Respiratory Quotient (RQ) = 1.0470.¹¹ Gao et al in 2018 found that acute SO_2 exposure can reduce vital lung capacity, especially in COPD patients.¹² Andersson found that exposure to toxic irritant gases increased the incidence of chronic bronchitis in factory workers (HR=32; 95% CI=2.0–5.2).¹³ Until now, there has been no study that explains the exact value of SO_2 concentration that can reduce lung function.

From the statistical test results, it was found that there was a significant relationship between the use of PPE ($P=0.001$), length of work ($P=0.003$), and smoking history ($P=0.004$) on lung function and multivariate analysis was performed. It was found

that the use of PPE had a significant relationship with lung function ($P=0.038$). In line with Awang et al that wearing PPE masks can affect the incidence of pulmonary function disorders. All workers must use respiratory personal protective equipment in industries that produce dust in the production process ($OR=12.15$; 95% $CI=1.14-102.62$).¹⁴ Sholikhah et al in 2015 found that the use of PPE affected lung function, and PPE must be used in all industrial workers.¹⁵

This research is cross-sectional, so it cannot clearly describe the causal relationship. Therefore, it is necessary to conduct a cohort study to obtain a more relevant analysis. In addition, this study used a questionnaire to ask several things such as respiratory symptoms and a history of respiratory disease, which was assessed only subjectively so that there were no clear parameters to measure prior lung function. The data obtained that SO_2 concentration does not have a significant relationship with lung function causes a bias in this study because the factors that affect lung function may be due to exposure to other toxic gases such as CO, NO, O_3 and PM. In this study, there are also limitations because a bronchodilator test was not performed to rule out COPD diagnosis. Nevertheless, this research can be used as primary data for further research in evaluating irritant toxic gas exposure.

CONCLUSION

This study concluded that the most respiratory symptoms were in the palm oil mill workers of PT. X Kandis sub-district, namely shortness of breath and productive cough in the factory area (outdoor) and office space (indoor). There were 13% with impaired lung function (obstruction). The SO_2 concentration in the factory area (outdoor) is $25.7 \mu g/Nm^3$ and in the office room (indoor) is $20.6 \mu g/Nm^3$.

The most influential risk factors on the lung function of workers at the palm oil mill PT. X Kandis sub-district, namely the use of PPE, length of work and smoking history. Multivariate analysis showed a

significant relationship between lung function and PPE use.

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