

Risk Analysis of Crumb Rubber Dust Exposure against Lung Physiological Disorder of XXX Crumb Rubber Industry Inc. Workers in Palembang City, 2016

By Mohammad Zulkarnain

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Abstract

Crumb rubber dust is organic dust causing respiratory health risk in crumb rubber industry worker. This study aimed to analyze the risk of crumb rubber dust exposure against lung physiological disorder of crumb rubber industry company worker. The study used cross sectional design. As many as 156 people were randomly taken from 450 people and 25 samples of occupation environment dust. The data collected using Minato As 507 Spirometry, IOM Dust Sampler Cat. 225-79A SKC and ATS-DLD78A questionnaire. *Chi square* analysis showed correlation between dust concentration (p 0.001), age (0.020), work duration (p 0.001), exposure duration (p 0.010), nutritional status (p 0.052), smoking habit (p 0.001), mask utility habit (p 0.002), and exercise habit (p 0.001). Companies should provide occupational health and safety facilities such as masks and provide periodical counseling for workers every 3 months.

Keywords: crumb rubber dust exposure, lung physiological disorder

INTRODUCTION

Crumb rubber industry performed its production activities by processing raw materials derived from raw natural rubber, clumping into chunks rubber in the form of slab and further mechanical process including crushing, milling, and packing into rubber crumbs and produce dust as byproducts. (Suma'mur, 2009; Lestari, 2009). Natural rubber dust is complex organic groups derived from plants²². The workers exposed to organic dust have a high risk to develop respiratory problems. Crumb rubber dust can be classified into *Particulate Not Other Specified* (PNOS), the permitted dust limit is PNOS *inhalable* 10 mg/m³ and *respirable* 3 mg/m³.²¹. Respiratory tracts disorder associated with workplace occurred in 6-30% workers who had a high exposure to organic dust such as rubber wood dust^{8,20}. Preliminary surveillance to 20 workers of XXX Crumb Rubber Industry Inc. showed that 35% were complaining cough, 20% were experienced sputum production, and 25% had wheezing. Spirometry test result showed 20% of workers had abnormal FVC lung function, 30% had abnormal FEV₁ lung function, and 25% had abnormal FEV₁/FVC lung function. This study measured the risk of various factors to pulmonary function disorders in XXX Crumb Rubber Industry Inc. workers.

METHODOLOGY

Study Design and Sampling Procedure

This study was an observational analytic study using cross sectional method and 450 workers of XXX Crumb Rubber Industry Inc. as the population study. Sample were randomly taken and sample size was determined using Lemeshow (1977) formula which result 156 workers in production division as sample. The inclusion criteria of this study were willingness to follow the research, has worked for at least 1 year and working on the production division. Meanwhile, the exclusion criteria included history of respiratory disorder and did not suffer from respiratory illness at the time of the study. Determination of air sampling points were based on National Standard of Indonesia No.7230 year 2009 and NIOSH which resulting 25 measurements points in production area.

Instrument Development and Data Collection Procedure

Data were collected using questionnaire which had 3 parts including information about (1) Age, Gender, education, working period, working division, working time, and anthropometry measurement (Body Weight and Height), (2) Respiratory symptoms and medical history, (3) Working history and smoking history. Crumb rubber dust concentration in working area (drying area and crumb rubber) was measured using IOM Dust Sampler SKC Cat. 225-76A, whereas respondent's lung capacity was measured using Minato AS 507 spirometry.

Ethical Considerations

Research proposal addressed to the examiner team of Postgraduate Environmental Study, Universitas Sriwijaya Indonesia. Ethical clearance was obtained from Public Health Faculty, Universitas Diponegoro, Semarang, Indonesia. Written informed consent was gained from the respondent before data collection and confidentiality was ensured.

Data Processing and Analysis

We asked 156 respondents to fill the questionnaire, then measured crumb rubber dust concentration, and assessed these respondents' lung function followed by data entry, data purification, and all missing value were calculated with standard manner. Univariate analysis was performed to gain descriptive information, whereas Chi-square test was used to find the relation between dependent and independent variables.

Result

The characteristics of respondents were included age, working period, exposure length, smoking habit, and lung physiological state. The distribution of workers in ≤ 30 years old age group were 62.5%. The characteristics distribution can be seen in Table 1.

Table.1 The distribution of respondent in production division of XXX Crumb Rubber Industry Inc., year 2016.

Variables	n = 156	%
Age		
> 30 yo	59	37.5
≤ 30 yo	97	62.5
Working Period		
> 10 years	65	41.8
≤ 10 years	91	58.2
Exposure length		
> 8 hours	114	72.8
≤ 8 hours	42	27.2
Lung Physiological State		
Disturbance	37	23.7
Normal	119	76.3
Nutritional state (BMI)		
Abnormal	45	28.5
Normal	111	71.5
Smoking habit		
Smoker	96	61.4
Not a smoker	60	38.6
Masker utilization habit		
Poor	68	43.7
Good	88	56.3
Exercise habit		
Poor	59	37.5
Good	97	62.5

The maximum working period in production division is 26 years, whereas the minimum working period was 5 years, and as much as 41.8% workers had >10 years working period with 5 years median. The average exposure was 8.6 hours per day. As much as 72.8% workers experienced exposure >8hours per day. Most of the workers (61.4%) in production division were smoker. Smoker defined as worker who smoke regularly as an active smoker. Of the total 156 respondents, 72.8% had normal BMI, 76.3% had normal lung function, 14.1% and 7.7% consecutively had obstructive and restrictive lung disorder, and 1.9% of respondents had both. As much as 43.7% respondents had poor mask utilization habit and 62.5% of respondents performed sufficient exercise.

Crumb rubber dust concentration was measured in working area including drying area and *crumb rubber* by Company Hygiene and Occupational Health (Hiperkes) Officer of South Sumatera Province. The measurement result of crumb rubber dust concentration can be seen in Table 2.

Table 2. The measurement results of crumb rubber dust concentration in production division of XXX Crumb Rubber Industry Inc., year 2016.

No.	Location/Area	*Dust concentration (mg/m ³)	Temperature (°C)	Humidity (%)
1.	Drying room	4.341	23	56
2.	<i>Crumb Rubber</i>	2.085	26	50
3.	Production area	3.213	24.5	53

Note: *Average Value

Crumb rubber dust concentration I production area was 3,213 mg/m³ which is above the safe threshold based on Permenakertrans No.13/Men/X/2011 about Threshold Value (NAB) of physics and chemical factor in working area. NAB stated that organic respirable dust was less than 3 mg/m³.

The relationship between workers characteristics, dust concentration, and lung physiological disorder was analyzed statistically using *crossstabs* and *Chi Square Test*.

Table 3. The relationship between dust concentration and lung physiological disorder of XXX Crumb Rubber Industry Inc., year 2016.

Variables	Lung Physiological State						<i>p value</i>	PR (95% CI)
	Disturbance		Normal		Total			
	n	%	n	%	N	%		
Age							8.182	
> 30 yo	32	54.2	27	56.8	59	100	0.020	1.691-3.659
≤ 30 yo	5	5.2	92	94.8	97	100		
Working period							0.001	8.454
> 10 years	30	46.2	35	53.8	65	100		2.194-32.155
≤ 10 years	7	7.7	84	93.3	91	100		
Exposure Length							0.010	6.473
> 8 hours	28	24.6	86	75.4	114	100		1.102-6.988
≤ 8 hours	9	21.4	33	78.6	42	100		
Nutritional state (BMI)							0.052	0.818
Abnormal	12	26.7	33	73.3	45	100		0.292-2.291
Normal	25	22.5	86	77.5	111	100		
Smoking Habit							0.001	4.583
Smoker	33	34.4	63	65.4	96	100		1.535-12.692
Not a smoker	4	6.7	56	44.0	60	100		
Mask utilization habit							0.002	6.718
Poor	31	45.6	37	54.4	68	100		1.875-8.763
Good	6	6.8	82	93.2	88	100		
Exercise habit							0.001	7.571
Poor	29	49.2	30	50.8	59	100		2.935-16.456
Good	8	8.2	89	91.8	97	100		
Dust Concentration							0.001	6.234
≥ 3 mg/m ³	31	39.7	47	60.3	78	100		(1.102-5.345)
< 3 mg/m ³	6	0.77	72	92.5	78	100		

As much as 54.2% of the respondents who were aged >30 years old had lung disturbance and there was significant relationship between impaired lung physiology and worker's age ($p=0.020$; *Confidence Interval* 95%; $\alpha \leq 0.05$). Ratio prevalence were 8.182 (CI = 1.691-3.659) which mean that worker aged ≥ 30 years old had 8 times higher risk to develop impaired lung physiology compared to those aged ≤ 30 years old. As much as 24.6% of the respondents who experienced >8hours exposure had impaired lung physiology. Chi square analysis showed significant relation between exposure length and lung physiological disorder with *ratio prevalence* 6.473 (CI = 1.102-6.988). As much as 26.7% of the respondents who had abnormal BMI were known to have lung physiological disorder. Chi square did not show significant relation between abnormal BMI and lung physiological disorder. As much as 34.4% smoker had impaired lung physiology and *chi square* showed significant relation between smoking habit and impaired lung physiology with ratio prevalence 4.583 (CI = 1.535-12.692) ($p=0.0001$). As much as 45.6% of workers with poor mask utilization habit experienced lung physiological disturbance and showed significant relation with ratio prevalence 6.718 (CI = 1.875-8.763). Respondent with poor exercise habit were as much as 49.2% had lung physiological disturbance and chi square showed significant relation between exercise habit and lung physiological disturbance with ratio prevalence 7.571 (CI = 2.935-16.456) which means poor exercise habit had 8 times higher risk to develop lung physiological disturbance compared to those with good exercise habit. Respondents who worked in the area with dust concentration $\geq 3 \text{ mg/m}^3$ as much as 39.7% was experienced impaired lung physiology and there was significant relation with ratio prevalence 6.234 (CI = 1.102-5.345) ($p=0.001$).

Discussion

The respondents were selected from production division of XXX *Crumb Rubber* Industry Inc. due to their risk of exposure to dust in working area. Dust created as byproduct from the process of chopping, grinding, crumbing, pressing, and packing crumb rubber. Most of workers with lung physiology abnormalities experienced combination (restriction-obstruction) disorder. Lung physiological abnormalities correlates with many factors either extrinsic from work environment or intrinsic from worker's habit. Intrinsic factor which correlate with lung physiological function including age, working period, exposure length, worker's habit related to healthy behavior. Dust particle can effect someone's health due to its physical and chemical character, *port of entry*, and from factor from the worker itself. Factor from the workers including age, adjustment, immunity, and self-health status.^{6,7} The results were in concordance with Marpaung study that there was relationship between $\text{PM}_{2.5}$ intake with lung function disturbance of hawker in the bus station. Hawker who had $\text{PM}_{2.5}$ intake more than reference concentration had 6.5 higher risk to develop lung function disorder⁸. Natural rubber originated from the farmers contain *immunoglobulin E (IgE)* protein which can increase respiratory tract sensitivity and elevate someone's risk to get asthma specifically population who are allergic to the protein⁵. Vital capacity disturbance due to dust exposure was related to dust concentration, immunity, and the way someone breath⁹. As one gets older it will affect body tissues such as decrease in lung tissue elasticity that cause reduction of breathing power. Adult aged more than 30 years old will have decrease in lung diffusion, ventilation, and other lung capacity.¹⁰ This study was consistent with Sumakmur's theory that lung physiological disorder can be caused by individual factor or other factor. Age was not directly related to lung physiological disorder, however it affects immunity against disease. The older the age, the immunity is decreasing. Workers either encountered working period ≤ 10 years or > 10 years had same risk to develop lung physiological disturbance. Workers with working period > 10 years in dusty environment were found to be more susceptible to impaired pulmonary physiology. The longer a person works in dusty environment specifically in rubber industry will increase the risk of impaired lung function¹². Workers either exposed >8 hours or ≤ 8 hours had similar opportunity to develop impaired lung physiology. There was significant relation between mask utilization habit and vital lung capacity. It was in concordance with other study which elucidated that there was significant relation between personal protective equipment and vital lung capacity^{13,14}. Workers compliance to use mask was related to utilization frequency, how to use the mask, and the type of the mask. The use of medical mask in coal handling worker was not comparable with the hazard that worker should had disposable respirator¹⁰. The education about importance of mask utilization increase worker habit to use mask in order to avoid impaired lung function⁹. Smoking habit had relation to impaired lung physiology which consistent with other study that smoking decrease vital lung capacity^{16,17}. Smoking changed lung structure and respiratory tract function. Smoking habit was risk factor for developing respiratory disorder in rubber industry worker besides the dust exposure itself¹⁸. Poor exercise habit generated impaired lung physiology. Good exercise habit increase *Forced Vital Capacity (FVC)* 30%-40%²⁰. Good exercise consists of warming up 5-10 minutes, core exercise for at least 20 minutes, and cooling down 5-10 minutes¹⁰. 30-60 minutes exercise had purpose to maintain immunity and physical fitness, whereas > 60 minutes exercise aimed to burn body fat. Exercise divided into aerobic and anaerobic. Aerobic exercise consumes less energy than anaerobic. Jogging, gymnastic, bicycling are aerobic exercise, whilst anaerobic exercise such as football, volley ball, martial sport, and etc. Good exercise for respiration is gymnastic and swimming²⁰.

Conclusion

As much as 23.7% of XXX Crumb Rubber Industry Inc. workers were developed impaired lung physiology and the average dust concentration in production area was 3.213 mg/m^3 . There were 62.5% respondents aged ≤ 30 years old and 58.2% had working period ≤ 10 years. The worker characteristics including age, working period, exposure length, smoking habit, exercise habit, and mask utilization were statistically showed relationship to impaired lung physiology, whereas nutritional state was not correlate. There was statistical correlation between dust concentration in working area and impaired lung physiology. The limitation of the study was we couldn't find the initial lung physiology data of the worker when join the company. Companies should provide occupational Health and Safety (K3) facilities such as masks and provide periodical counseling for workers every 3 months.

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