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Original Article

Serum Protein D Surfactant Level Based on Length of Exposure in Workers at the Supit Urang Waste Disposal Site, Malang

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Abstract

Background : Waste collectors are at risk of developing lung disease due to exposure to bioaerosols from organic and inorganic materials. The function of surfactant protein D (SP-D) is as innate immunity that protects the lungs. Exposure to bioaerosols in landfills causes inflammatory reactions which can increase the permeability of the blood-lung barrier. As a result, SP-D will leak into the plasma. This study aims to analyze serum SP-D levels in relation to length of exposure in waste collectors.
Methods : This analytical, cross-sectional study was done in a Supit Urang waste disposal site, Malang, Indonesia. Samples for serum SP-D analysis were taken from peripheral blood samples and analyzed with ELISA technique.
Results : There were 68 subjects, consisting of 24 subjects with exposure duration of 5 years, 14 subjects of 5–10 years, and 30 subjects with exposure of 10 years. The number of smokers and non-smokers were 36 and 32 subjects respectively. Significant differences in SP-D serum levels were found between different exposure durations, particularly with exposure of more than 5years. A significant positive correlation was obtained between serum SP-D levels and exposure duration (r = 0.585; p = 0.000). Meanwhile, there was no significant difference in serum Sp-D levels based on smoking status (p=0.112).
Conclusion : Length of exposure significantly affected SP-D serum levels in waste workers, especially with exposure of more than 5 years.

Keywords : Plasma Protein D Surfactant, waste workers, long exposure, high risk.

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INTRODUCTION

Environmental pollution due to waste management is a global problem. This problem includes environmental contamination, causing social problems and affecting economic conditions.[1–3] Waste workers have a heavy workload and exposure to various bioaerosols, both non-organic and organic. Therefore, waste workers are included in a vulnerable group that has higher risk for health problems and work accidents compared to other jobs. Waste workers also have a risk for work-related lung disease, especially due to exposure to bioaerosols from handling organic materials which include the process of collection, separation, and processing of waste. Infection or injury to the lungs will stimulate the production of surfactant protein-D (SP-D) which is a group of collectins.[1–5]

Globally, waste production is estimated to increase to 3.40 billion tons by 2050. Waste production will continue to increase in both developed and developing countries. As a consequence, there is an increased risk of occupational diseases in low-income developing countries because waste management is still not well controlled. Based on previous researches, significant concentrations of pollutants were found in several final waste disposal sites in developing countries including Asia, Africa and Latin America.[5–8]

Waste workers may have a risk of having those waste particles to enter the respiratory tract. Particles measuring 1 μm or smaller can enter the alveolar surface and will interact with surfactant proteins and alveolar macrophages. The main role of surfactants is as an innate immune response. Surfactant protein-D (SP-D) is a group of collectins (collagen-lectins) with a subgroup of the type C lectin superfamily. SP-D is produced and secreted in type 2 pneumocyte cells in the alveolar. Epithelial duct cells are also responsible for the production of this surfactant. Mucosal cells and grandular/ductal epithelial cells in the gastrointestinal cells also produce small amounts of SP-D in response to inflammation caused by bacteria, viruses, fungi, or other harmful or irritating substances. On the basis of this description, it is important to understand its clinical role. [9,10]

Some waste workers also have a smoking habit. Nicotine, acroline, and substances contained in cigarettes reduce alveolar SP-D levels and increase alveolar epithelial damage, characterized by increased serum SP-D and decreased SP-D in bronchoalveolar lavage.[11] Study that compared smokers and ex-smokers reported that serum SP-D was higher in smokers compared to non-smokers and ex-smokers. Subjects without lung function problems had lower baseline SP-D than the group with decreased lung function. Thus, SP-D was significantly associated with decreased lung function during follow-up but only in the smoker group. In a study which examined smokers and COPD group, serum SP-D was examined in healthy smokers and the COPD group, serum SP-D was similar between the two groups.[11–13]

Loss of air blood barrier integrity due to toxic exposure causes intravascular leakage of lung proteins. Thus, the increase of concentration gradient of SP-D allows SP-D synthesized in the respiratory tract to leak into the bloodstream. In some circumstances, including acute cigarette smoke exposure, SP-D can be decreased in bronchial lavage (BAL) while serum SP-D will be increased. Smoking status is a strong predictor of this translocation. Several other conditions that can cause SP-D extravasation are found in COPD, asthma, and cystic fibrosis. Several studies in rabbits and humans have provided evidence that protein clearance is dependent on molecular size from the airspace in the lung. Different things were conveyed by Herbein and Wright who reported that the amount of SP-D from BAL fluid was lower compared to control lungs, due to increased SP-D uptake in tissue neutrophils, so that clearance causes a decrease in alveolar SP-D levels.[12,14–16]

However, there has been no research on serum SP-D levels based on exposure duration in waste workers based on smoking status. Therefore, based on this background, further research is needed to examine serum SP-D levels based on exposure duration and smoking status in waste workers, which aims to determine the risk of lung disease.

METHODS

The research design was a cross-sectional study. Subjects were workers exposed to garbage in the Supit Urang waste disposal site, Malang, East Java, Indonesia. The inclusion criteria were age of 17–80 years, more than 6 months of work with working hours more than 8 hours a day. The exclusion criteria in this study were workers who had been diagnosed with lung malignancy, extrapulmonary cancer, pneumonia and pulmonary TB with or without treatment based on clinical data and treatment history found during the history taking and physical examination.

This research was conducted at the Supit Urang waste disposal site, Microbiology and Biomedical Laboratory, Central General Hospital of Saiful Anwar East Java on August December 2023. The ethics committee has approved the study and procedures of Medical Faculty of Brawijaya University Malang. Subjects who took part within the study had signed informed consent. The subjects underwent anamnesis, physical analysis and examination, and serum SP-D levels using quantitative sandwich ELISA.

As much as 3 ml blood specimens from workers exposed to inhalation at the Supit Urang waste disposal site met the inclusion criteria. The enzyme-linked immunosorbent assay (ELISA) Kit (Elabscience) measured SP-D serum levels.

Processing and data analysis using SPSS software version 26. Serum SP-D levels and other variables in workers were analyzed using the Shapiro-Wilk test to assess the normality of the data distribution. To assess the correlation between variables, the Spearman test was used and to assess the effect, the independent T-test and ANOVA test were used if the data were normally distributed or the Mann-Whitney test or the Kruskal-Wallis test if the data were not normally distributed, with 95% confidence degree, α=0.05. Value means if p<0,05.

Data normality test using Shapiro Wilk to assess serum SP-D based on age groups showed an abnormal data distribution. Therefore, we continued the comparison test using the Kruskal Wallis test. Then from the results of the Kruskal Wallis Test, a p value of 0.000 (p <0.05) was obtained, so it can be concluded that there is a significant difference in SP-D based on age group. Therefore, we continue with pairwise comparisons testing with the Dunn Test to test the comparison of SP-D between age groups wich can be seen in Figure 1.

RESULTS

There was 68 subjects who met the inclusion criteria. Characteristics data and supporting clinical data are described in Tables 1. The range age of subjects were between 17 and 78 years old with the mean age of 44,7±17,31 years. The number of male subjects were twice the female. Education level of the subjects were varied, with the highest proportion of them were uneducated. Almost all subjects had normal BMI values. The subjects' work type consisted of 32 scavenger, 17 waste sorter, 8 waste processor, and 2 garbage truck drivers. The majority of study subjects had exposure time of more than 10 years (30%). Comparison of smoking status was balanced between smokers (52.9%) and non-smokers (47.1%). Of the total 36 smokers, 26 subjects were included in the mild Brinkman index group, and 10 subjects were included in the moderate group. Fifty-six subjects did not have comorbidities from anamnesis. While the remaining had various comorbidities such as hypertension, diabetes mellitus, asthma, and chronic pulmonary obstructive disease.

Almost all subjects did not have respiratory complaints (80.9%), while those who had complaints consisted of 7 subjects with shortness of breath and 6 subjects with frequent coughing. Waste workers were grouped using complete personal protective equipment when using masks, gloves, and boots based on recommendations from the CDC (Center for Disease Control and Prevention). However, only 13 subjects (19%) used complete PPE, and 31 (45.6%) subjects used masks. All subjects underwent CO exhalation examination and it was found that the majority of subjects were in the non-smoker category (73.5%). In the CO exhalation data, the average was 5.12 ppm, with the non-smoker group having an average of 2.3 ppm. Meanwhile, the SP-D level value had an average of 109.64ng/mL.

The pairwise comparisons test using Dunn Test for the comparison of SP-D in the 17–25 age group, it was significantly different from the SPD in the 36-45 age group, 46–55 age group, 56-65 age group, and the age group >65 years. The comparison of SPD in the 26–35 age group was significantly different from the SP-D in the 56–65 age group, and the age group >65 years.

Based on the test results shown in Figure 1, it is

TABLE 1
Subject's Characteristics

Demography Characteristic	n	%
Age (year)		
Mean±SD	44.7±17.31	
Min–max	17–78	
17–25	11	16.2
26–35	16	23.5
36–45	7	10.3
46–55	11	16.2
56–65	12	17.6
>65	11	16.2
Gender		
Male	46	67.6
Female	22	32.4

TABLE 1. Continued.

Demography Characteristic	n	%
Education		
Uneducated	21	30.9
Elementary School	13	19.1
Junior High School	5	7.4
Senior High School	21	30.9
Bachelor	8	11.8
BMI Classification		
Underweight	12	17.6
Normal	25	36.8
Overweight	15	22.1
Obesity grade I	12	17.6
Obesity grade II	4	5.9
Work type		
Scavenger	41	60.3
Waste sorter	17	25.0
Waste processor	8	11.8
Garbage truck drivers	2	2.9
Exposure Time (year)		
< 5	24	35.3
5–10	14	20.6
>10	30	44.1
Smoking Status		
Smoker	36	52.9
Non-Smoker	32	47.1
Indeks Brinkman (Smoker)		
Mild	26	72.2
Moderate	10	27.8
Severe	0	0
Comorbid		
Hypertension	4	**5.9**
Diabetes Mellitus	2	2.9
Asthma	3	4.4
Chronic Obstruction Pulmonary Disease	3	4.4
Respiratory Symptom		
No Symptom	55	80.9
Symptom		

TABLE 1. Continued.

Demography Characteristic	n	%
Shortness of breath	7	10.3
Cough	6	8.8
Personal Protective Equipment		
Mask	31	45.6
Gloves	34	50.0
Boots	28	41.2
Complete Personal Protective Equipment		
Complete	13	19.1
Not Complete	55	80.9
CO Exhalation		
Non-smoker	50	73.5
Borderline	7	10.3
Smoker low addicted	6	8.8
Smoker moderately addicted	4	5.9
Smoker heavily addicted	1	1.5
		Mean±SD
Sistolik Blood Pressure (mmHg)		133.0 ± 20.1
Diastolic Blood Pressure (mmHg)		86.3 ± 12.7
Body Weight (kg)		59.6 ± 13.5
Body Height (cm)		161.7 ± 7.7
Body Mass Index (kg/m^2)		22.7 ± 4.6
CO Exhalation (ppm)		
Non-smoker		2.3 ± 1.59
Borderline		8.1 ± 0.7
Smoker low addicted		11.5 ± 1.05
Smoker moderately addicted		19.0 ± 3.16
Smoker heavily addicted		31.0 ± 0
SP-D (ng/mL)		109.6 ± 66.6

concluded that the age group of 36 years to over 65 years has a high average SP-D and is not significantly different. Thus, the age group of 36 years to over 65 years is classified as an age group at high risk of being exposed to waste with a high average of SP-D.

Based on Table 2, it shows that there are 27 samples aged between 17 and 35 years who are classified as having a low risk of being exposed to waste, and 41 samples aged between 36 and >65 years who are classified as having a high risk of being exposed to waste. This has been explained in detail in Figure 1. This is related to the younger age group (17–35 years) who tend to have a low risk of being exposed to waste, while the older age group (36–>65 years) tend to have a high risk of being exposed to waste.

For the influence between gender and the risk of exposure to waste, a p-value of 0.048 (p<0.05) was obtained, so it can be concluded that male gender has a significantly lower influence on the risk of exposure to waste.

In the variable based on the last education group, in the group classified as low risk, more people had a high

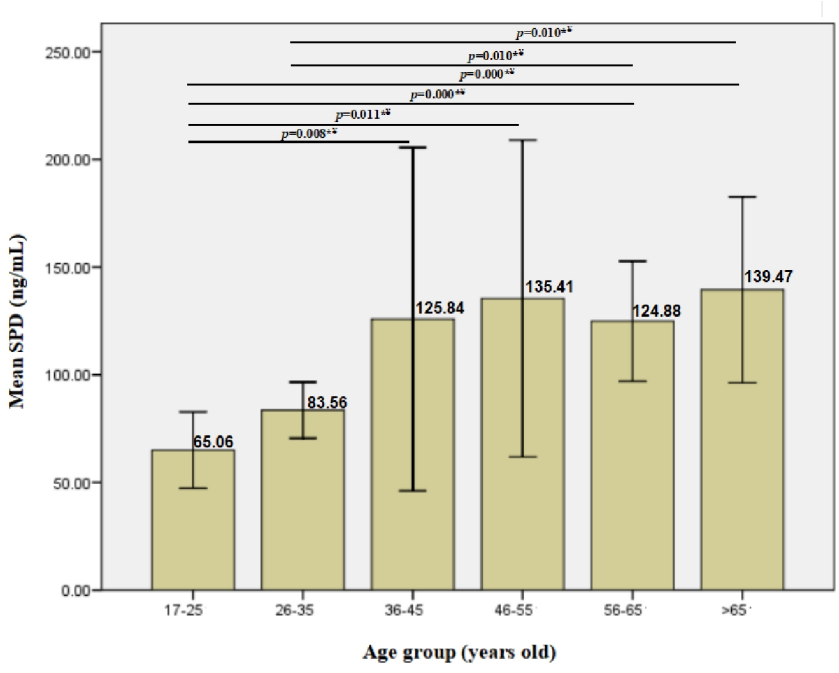

Figure 1. Comparison graph of plasma serum SP-D levels between age group.
Description: *Significant ($p < 0.05$); ¥ Dunn test comparison

TABLE 2
Demography Characteristics That Influence Waste Exposure Based on Serum SP-D

Variable	Waste Exposure Group				*p*
	Low Risk		High Risk		
	n	%	n	%	
Age (years)					0.000*¶
17–25	11	40.7%	0	0.0%	
26–35	16	59.3%	0	0.0%	
36–45	0	0.0%	7	17.1%	
46–55	0	0.0%	11	26.8%	
56–65	0	0.0%	12	29.3%	
>65	0	0.0%	11	26.8%	
Gender					0.048*¶
Male	22	81.5%	24	58.5%	
Female	5	18.5%	17	41.5%	
Education					0.000*¶
Uneducated	2	7.4%	19	46.3%	
Elementary School	2	7.4%	11	26.8%	
Junior High School	1	3.7%	4	9.8%	
Senior High School	15	55.6%	6	14.6%	
Bachelor	7	25.9%	1	2.4%	

TABLE 2. Continued.

Variable	Waste Exposure Group				*p*
	Low Risk		High Risk		
	n	%	n	%	
BMI Classification					0.021*¶
Underweight	2	7.4%	10	24.4%	
Normal	10	37.0%	15	36.6%	
Overweight	4	14.8%	11	26.8%	
Obesity grade I	7	25.9%	5	12.2%	
Obesity grade II	4	14.8%	0	0.0%	
Work Type					0.000*¶
Scavenger	5	18.5%	36	87.8%	
Waste sorter	17	63.0%	0	0.0%	
Waste processor	3	11.1%	5	12.2%	
Garbage truck drivers	2	7.4%	0	0.0%	
Comorbid					
Hypertension	1	3.7%	3	7.3%	0.536
Diabetes Mellitus	0	0.0%	2	4.9%	0.244
Asthma	0	0.0%	3	7.3%	0.151
Chronic Obstruction Pulmonary Disease	0	0.0%	3	7.3%	0.151
Respiratory Symptom					
Shortness of breath	1	3.7%	6	14.6%	0.147
Cough	1	3.7%	5	12.2%	0.227
Personal Protective Equipment					
Mask	18	66.7%	13	31.7%	0.005*¶
Gloves	16	59.3%	18	43.9%	0.215
Boots	10	37.0%	18	43.9%	0.031*¶
Complete Personal Protective Equipment					0.247
Complete	20	74.1%	35	85.4%	
Not Complete	7	25.9%	6	14.6%	

Description: *Significant ($p < 0.05$); ¶ Chi square

school education (55.6%), while in the group classified as high risk, more people did not attend school (46.3%). For the influence between the last education and the risk of being exposed to waste, a *p* value of 0.000 was obtained, so it can be concluded that education has a significant influence on the risk of being exposed to waste. This is correlated with the use of personal protective equipment.

Based on BMI classification, in the low-risk group, there were more normal patients (37.0%), while in the high-risk group, there were also more normal patients (36.6%), where out of 68 samples, the largest number of patients were normal (36.8%). For the influence between BMI classification and the risk of waste exposure, a *p* value of 0.021 was obtained ($p<0.05$), it can be concluded that BMI classification has a significant influence on the risk of waste exposure (low or high risk).

In the type of work variable, in the low-risk group, more people work as waste sorters (63.0%), while in the high-risk group, more people work as scavengers (87.8%). For the influence between the type of work and the risk of exposure to waste, a *p* value of 0.000 was obtained, so it can be concluded that the type of work has

TABLE 3
Demography Characteristics in Relation with Exposure Time

Variable	Exposure Time (years)						*p*
	< 5		5–10		>10		
	n	%	n	%	n	%	
Age (years)							0.000*¶
17–25	10	41.7%	1	7.1%	0	0.0%	
26–35	11	45.8%	4	28.7%	1	3.3%	
36–45	1	8.3%	3	21.4%	2	6.7%	
46–55	1	4.2%	1	7.1%	9	30.0%	
56–65	0	0.0%	3	21.4%	9	30.0%	
>65	0	0.0%	2	14.3%	9	30.0%	
Gender							0.007*¶
Male	22	91.7%	7	50.0%	17	56.7%	
Female	2	8.3%	7	50.0%	13	43.3%	
Education							0.003*¶
Uneducated	3	12.5%	4	28.6%	14	46.7%	
Elementary School	1	4.2%	3	21.4%	9	30.0%	
Junior High School	2	8.3%	1	7.1%	2	6.7%	
Senior High School	11	45.8%	5	35.7%	5	16.7%	
Bachelor	7	29.2%	1	7.1%	0	0.0%	
BMI Classification							0.000*¶
Underweight	2	8.3%	1	7.1%	9	30.0%	
Normal	7	29.2%	11	78.6%	7	23.3%	
Overweight	4	16.7%	0	0.0%	11	36.7%	
Obesity grade I	7	29.2%	2	14.3%	3	10.0%	
Obesity grade II	4	16.7%	0	0.0%	0	0.0%	
Work Type							0.000*¶
Scavenger	7	29.2%	8	57.1%	26	86.7%	
Waste sorter	13	54.2%	3	21.4%	1	3.3%	
Waste processor	2	8.3%	3	21.4%	3	10.0%	
Garbage truck drivers	2	8.3%	0	0.0%	0	0.0%	
Comorbid							
Hypertension	1	4.2%	0	0.0%	3	10.0%	0.383
Diabetes Mellitus	0	0.0%	0	0.0%	2	6.7%	0.271
Asthma	0	0.0%	1	7.1%	2	6.7%	0.424
Chronic Obstruction Pulmonary Disease	1	4.2%	0	0.0%	2	6.7%	0.603
Respiratory Symptom							
Shortness of breath	2	8.3%	0	0.0%	5	16.7%	0.220

TABLE 3. Continued.

Variable	Exposure Time (years)						*p*
	< 5		5–10		>10		
	n	%	n	%	n	%	
Cough	2	8.3%	0	0.0%	4	13.3%	0.346
Personal Protective Equipment							
Mask	18	75.0%	4	28.6%	9	30.0%	0.002*¶
Gloves	18	75.0%	5	35.7%	11	36.7%	0.010*¶
Boots	10	41.7%	5	35.7%	13	43.3%	0.038*¶
Complete Personal Protective Equipment							0.539
Complete	18	75.0%	11	78.6%	26	86.7%	
Not Complete	6	25.0%	3	21.4%	4	13.3%	

Description: *Significant ($p < 0.05$); ¶ Chi square

TABLE 4
Plasma Serum SP-D Level based on Exposure Time

Exposure Time (years)	Mean±SD SP-D (ng/mL)	*p*
Age (years)		0.000*¥
< 5	70.3 ± 18.44	
5–10	98.4 ± 26.76	
>10	146.4 ± 83.15	

Description: *Significant ($p < 0.05$); ¥ Kruskal-Wallis

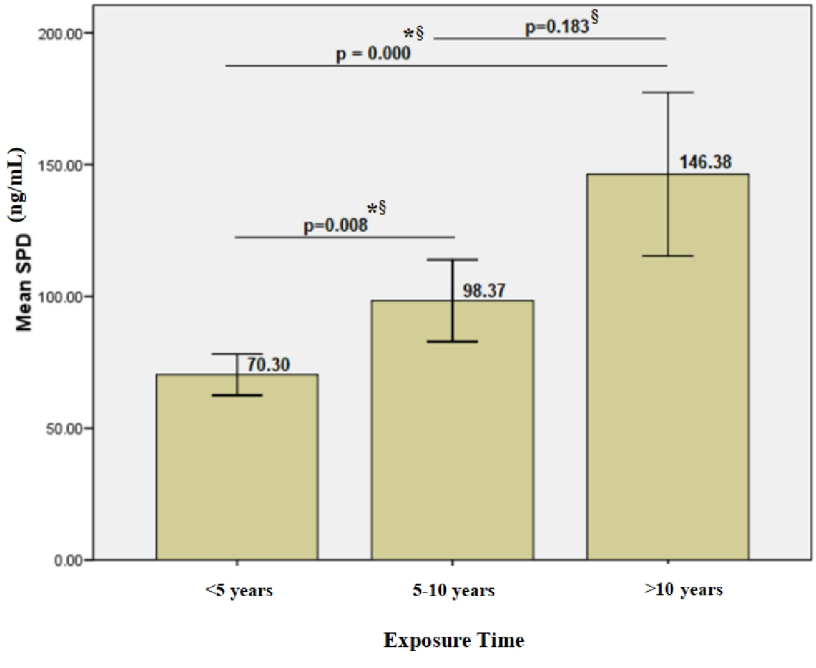

Figure 2. Comparison graph of serum SP-D levels between exposure time; *Significant ($p < 0.05$); § Dunn.

TABLE 5
Correlation of Serum SP-D Levels with Exposure Duration

Exposure Time (years)	SP-D Serum	
	r	*p*
All Subject	0.585	0.000*¶
Smoker	0.492	0.002*¶
Non-Smoker	0.648	0.000*¶

Description: *Significant ($p < 0.05$); ¶ Spearman test

TABLE 6
Serum SP-D Levels base on Smoking Status

Smoking Status	Mean ± SD SP-D (ng/mL)	*p*
		0.112α
Non-Smoker	120.7 ± 74.79	
Smoker	99.9 ± 57.63	
Indeks Brinkman		0.543α
Mild	96.0 ± 56.55	
Moderate	109.6 ± 62.32	
CO Exhalation		0.617¥
Non-smoker	100.1 ± 64.28	
Borderline	121.9 ± 77.56	
Smoker low addicted	87.0 ± 20.30	
Smoker moderately addicted	75.9 ± 18.58	
Smoker heavily addicted	111.0 ± 0	

Description: *Significant ($p< 0.05$); α Mann-Whitney Test; ¥ Kruskal-Wallis

a significant influence on the risk of exposure to waste (low or high risk).

Based on comorbidities, for comorbidities of hypertension, diabetes mellitus, asthma, and COPD each have *p*-values of 0.536, 0.244, 0.151, and 0.151, respectively, so it can be concluded that comorbidities do not have an influence on the high or low risk of exposure to waste.

In the group of subjects with complaints of shortness of breath, the group classified as low risk was 3.7%, while in the group classified as high risk there were 14.6%. Meanwhile, in the group of subjects with complaints of cough, the group classified as low risk was 3.7%, while in the group classified as high risk there were 12.2% who had complaints of cough. For the influence between complaints of shortness of breath and cough with the risk of exposure to waste (low or high risk), the p=0.147 and p=0.227 so that it can be concluded that complaints of shortness of breath and cough do not have a significant effect on the waste risk of exposure.

In the use of masks, in the low-risk group there were 66.7%, while in the high-risk group there were 31.7% who used masks. For the influence between the use of masks and the risk of exposure to waste (low or high risk) a *p* value of 0.005 was obtained, so it can be concluded that the use of masks has a significant effect on the risk of exposure to waste (low or high risk). The same results were obtained in the group using boots, in the low-risk group there were 37.0%, while in the high-risk group there were 43.9% and p=0.031 was obtained. In contrast to the group using gloves, in the low-risk group there were 59.3%, and in the high-risk group there were 43.9% and p=0.215 was obtained, so it can be concluded that the use of gloves has no effect on the risk of exposure to waste. In the Complete Personal Protective Equipment usage group, a *p*-value of 0.247 was obtained, so it can be concluded that Complete Personal Protective Equipment has no influence on the risk of exposure to waste.

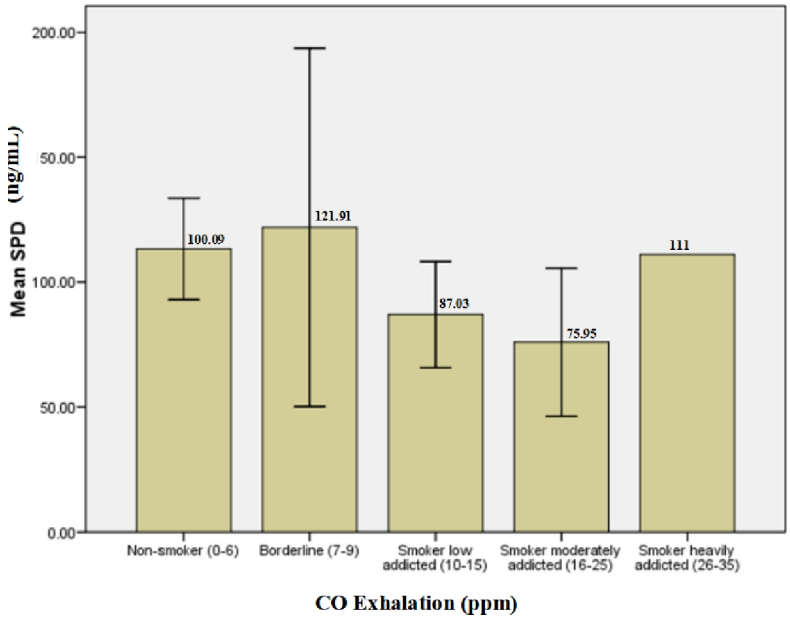

Figure 3. Graph of Serum SP-D Levels based on CO Exhalation (smokelyzer).

Based on Table 3, as many as 24 subjects exposed to waste exposure for <5 years were mostly aged 17–35 years, of the 14 samples exposed to waste exposure for 5–10 years were mostly aged 26 years to >65 years, and of the 30 samples exposed to waste exposure for >10 years were mostly aged 46 years to >65 years. For the influence between age and duration of waste exposure, a *p* value of 0.000 was obtained, so it can be concluded that age group has a significant influence on the duration of waste exposure, where there is a tendency that younger patients tend to have more exposure duration <5 years, while older patients tend to have more >10 years.

Cross tabulation between gender and duration of exposure shows that there are 24 samples exposed to waste exposure for <5 years dominated by men, from 14 samples exposed to waste exposure for 5–10 years shows the number of men and women have the same percentage, and from 30 samples exposed to waste exposure for >10 years slightly more men. For the influence between gender and duration of exposure to waste exposure, with p=0.007 was obtained where there is a tendency that women tend to experience more exposure durations of >10 years, while men tend to experience more <5 years.

There is an influence between the last education and the duration of exposure to waste with a p=0.003 where there is a tendency that patients with higher education tend to have more exposure durations of <5 years, compared to patients with lower education with longer exposure durations. Cross tabulation between BMI classification and duration of exposure shows that the *p* value is 0.003, there is a significant influence between BMI classification and duration of exposure, where there is a tendency that patients who have normal BMI and obesity tend to have more duration of exposure <5 years, compared to patients with a lower BMI classification with a longer duration of exposure.

There is a significant influence between occupation and duration of exposure with p=0.000, where there is a tendency that patients who work as waste sorters tend to have more exposure duration <5 years, compared to patients with occupation as waste scavengers who have a longer exposure duration. Cross tabulation between comorbidities and duration of exposure showed a *p* value >0.05, so there was no significant influence between any type of comorbidity and duration of exposure. The same thing was also found between respiratory complaints and duration of exposure, showing a *p* value >0.05, so there was no influence between any respiratory complaints and duration of exposure.

For the influence between the use of masks, gloves, or boots with the duration of exposure to waste, *p* value of >0.05 were obtained, so it can be concluded that there are significant influence between the use of masks, gloves, or boots with the duration of exposure, where there is a tendency that subject who use masks tend to have more exposure durations of <5 years, while patients who do not use one of personal protective equipment tend to have more exposure to waste between 5–10 years and >10 years. Meanwhile, there was no significant relationship between the completeness of personal protective equipment and the duration of exposure, with p=0.539.

Based on Table 4, a comparative test between exposure duration groups was obtained with *p* value of 0.000 and continued with a pairwise comparisons test and a significant increase in the average SP-D levels was obtained in the 5–10 and >10 year groups compared to the less than 5 year exposure group (p=0.08 and p=0.000). However, there was no significant increase in the average SP-D levels in the 5–10 year exposure group compared to the >10 year exposure group (p=0.183) although there was a tendency to increase in the exposure period >10 years. The number of subjects who smoked was 36 people (52.9%), and the average serum SP-D levels in the study subjects were found to increase along with the duration of exposure with a *p* value = 0.000. Because there was a significant difference, it was necessary to continue with the Dunn pairwise comparisons test. There was a significant increase in the average SP-D levels in the 5–10 and >10 year groups compared to the less than 5 year exposure group (p= 0.08 and p=0.000). This will be seen more clearly in Figure 2. Based on the Spearman correlation test between the duration of exposure and SP-D in all groups, a positive correlation coefficient value of 0.585 was obtained with p=0.000.

Based on the correlation test between exposure time and SP-D in all subject, there is a significant positive correlation coefficient value of 0.585 (p=0.000). In this study, we also differentiated the correlation test between smoker and non-smoker groups. A significant positive correlation coefficient value of 0.492 (p =0.002) was obtained in the smoker group. Meanwhile, in the non-smoker group obtained a significantly strong positive correlation coefficient value of 0.648 (p <0.000).

Based on Table 6, the average SP-D in non-smoking patients was 120.74 ng/mL, and the average SPD in smoking patients was 99.78 ng/mL, but there was no significant increase (p=0.112) in SP-D levels in the smoking group, and there was actually a tendency for a decrease in the average serum SP-D levels in smokers. The group of subjects with moderate Brinkman index showed a non-significant increase in serum SP-D levels compared to subjects with mild Brinkman index (p=0.543), although there was a tendency for increased serum SP-D levels. Serum SP-D levels based on the CO exhalation group can be seen in Table 6 as well, and there was no significant difference between groups with the Kruskal Wallis test results obtaining a *p* value of 0.617.

In Figure 3, the borderline group had the highest serum SP-D levels, while the moderately addicted smoker group had the lowest serum SP-D levels.

DISCUSSION

The subject characteristics data in this study, were of age between 17 and 78 years old with an average age distribution of 44.71 ± 17.31 years, the majority were 46 male, the 22 female. This is in accordance with another research previously done in Malang bird market. In demographic analysis, the population age structure is divided into three groups, namely (a) young age group, under 15 years; (b) productive age group, aged 15–64 years; and (c) old age group, aged 65 years and over, where the majority of workers are male and entering productive age. Similar to the study previously, there was a significant difference in age category (p=0.07). This is associated with the length of exposure received by the subjects.[17,18]

In terms of education level, the majority of the subjects were high school graduates and did not attend school. In the BMI category, the majority of subjects were in the normal category. While in terms of work type, the most subjects were 41 scavengers, where the rest were waste sorters, waste processors, and 2 others were waste transport drivers. In line with the researches conducted in 2010 and 2011, most of the subjects had normal BMI due to the heavy workload with high physical activity that made the workers continue to move with high metabolism.[19,20] In the education category, there were also the most subjects with high school education because this type of work does not require a high educational classification. However, in contrast to the two studies where the majority of subjects worked as liquid waste workers,[19,20] this study mostly involved scavengers who worked in solid waste as much as 41% of the total subjects.

In contrast to the previous study which divided the subject groups based on the duration of exposure into 4 groups, this study divided the subject groups into 3 groups, consisting of <5 years, 5–10 years, and >10 years with the assumption that the previous 4 groups had significant differences in the <1 year, 2–10 years, and 11–20 years groups. While in the >20 years group it was not significantly significant (p = 0.171).[17]

In this research design, the research subjects were divided into 3 groups based on smoking status according to previous research namely non-smokers, active smokers, and former smokers.[16,17] However, of the 68 subjects in this study, there were no former smokers. So the smoking history category was only divided into 2, smokers and non-smokers. In grouping smoker subjects, in line with previous research in 2021, dividing smoker groups based on objective data and subjective data. Objective data uses grouping based on smokelyzer to measure CO exhalation levels, which divides subject groups into non-smokers, borderlines, low-addicted smokers, moderately addicted smokers, and heavily addicted smokers. While subjective data uses anamnesis of the number of cigarettes per day which is grouped based on the Brinkman index: mild, moderate, and heavy Brinkman index.[21] In this study, data on the smoker group was only on the mild and moderate Brinkman index.

Most of the research subjects had a duration of

exposure >10 years, consist of 30 people (44.1%). The difference in serum SP-D levels in each group was found to be significant and increased with the duration of exposure (p = 0.000). Based on the one sample test of each exposure category, exposure <5 years and 5–10 years were more significant than exposure >10 years. This means that a significant increase was obtained when exposure was >5 years. This should be a special concern for policy makers, namely the local Environmental Service, to be able to start conducting periodic health checks for workers with a service period of more than 5 years. The relationship between duration of exposure and serum SP-D levels showed a significant relationship between duration of exposure and SP-D levels, which had a positive correlation in all groups of research subjects (r = 0.585, p = 0.000), a positive correlation in the smoker group (r = 0.492, p = 0.002), and a positive correlation in the non-smoker group (r = 0.685, p = 0.000).

In line with previous study found an increase in serum SP-D levels in bird market workers according to the duration of exposure. Bioaerosols in landfills can cause inflammatory reactions that can increase the permeability of the blood and lung barriers. So that occupational exposure to bioaerosols can cause increased leakage of surfactant protein D into the bloodstream. Chronic exposure to bioaerosols can cause damage to epithelial secretory cells and reduce the amount and function of lipopolysacharides which can cause subclinical inflammatory reactions, so that lung protein leakage can describe an early sign of bioaerosol exposure from waste workers. A previous study stated that SP-D tended to be higher in groups exposed to waste or garbage compared to groups not exposed (administrative employees). [17,19,20,22]

From 68 research subjects, the numbers of smokers and non-smokers were almost the same, 36 and 32 subjects respectively. The Mann Whitney test obtained a p value of 0.112 (p>0.05), there is no significant difference in serum SP-D levels in SP-D between the smoker and non-smoker groups in terms of subjective data (Brinkman index) and objective data (CO exhaled levels). The same thing was found in previous study,[18] where in the group of workers who smoked in the poultry market the p-value was 0.245. In another study there was also no significant difference in SP-D levels between the group of waste workers with smoking status and type of waste exposure in both the non-smoker group (p=0.2), the smoker group (p=1.0), and the former smoker group (p=0.1). In several studies focusing on smokers, SP-D levels increased in the group of smokers with COPD. In smokers who have not been diagnosed with COPD, in this case smokers do not have complaints with normal function tests, SP-D levels are not different compared to non-smokers. Acrolene contained in cigarettes has the ability to damage the structure of SP-D multimers, so it is estimated to reduce the amount and function of SP-D. Even in a previous study, BAL SP-D levels in the non-smoker group were the highest compared to smokers with or without COPD, associated with good innate immune function. Another possible cause of increased serum SP-D levels in non-smoking status is exposure factors to particle pollutants, antigens, and aerosol agents including debris or organic dust in the waste disposal environment which causes inflammation in the respiratory tract with good innate immunity compared to the smoking group due to the content of substances in cigarettes which can distort the components and function of SP-D.[13,16,17,20,23]

CONCLUSION

Serum SP-D levels in smokers was not higher than non-smokers in waste workers at the Supit Urang landfill. Both Co exhaled levels and Brinkman index were not associated with serum SP-D levels in workers who smoked at the Supit Urang landfill. Meanwhile, exposure duration was positively correlated with serum SP-D levels in waste workers at the Supit Urang landfill, in smokers, non-smokers, and all study subjects. Which means longer the exposure time, the higher the serum SP-D level.

REFERENCES

1. Ferronato N, Torretta V. Waste mismanagement in developing countries: A review of global issues. Vol. 16, International Journal of Environmental Research and Public Health. MDPI AG; 2019. p. 1–28.
2. Gupta N, Yadav KK, Kumar V. A review on current status of municipal solid waste management in India. Vol. 37, Journal of Environmental Sciences (China). Chinese Academy of Sciences; 2015. p. 206–17.
3. Vitorino de Souza Melaré A, Montenegro González S, Faceli K, Casadei V. Technologies and decision support systems to aid solid-waste management: a systematic review. Vol. 59, Waste Management. Elsevier Ltd; 2017. p. 567–4.
4. Raulf M, van Kampen V, Neumann HD, Liebers V, Deckert A, Brüning T, *et al*. Airway and blood inflammatory markers in waste collectors. In: Advances in Experimental Medicine and Biology. Springer New York LLC; 2017. p. 1–14.
5. Vinti G, Bauza V, Clasen T, Medlicott K, Tudor T, Zurbrügg C, *et al*. Municipal solid waste management and adverse health outcomes: A systematic review. Vol. 18, International Journal of Environmental Research and Public Health. MDPI; 2021. p. 1–28.
6. Kaza, S., Yao, L., Bhada-Tata, P. and Woerden, F. (2018). WHAT A WASTE 2.0 A Global Snapshot of Solid Waste Management to 2050 OVERVIEW. [online] Available at: https://openknowledge.worldbank.org/server/api/core/bitstreams/92a50475-3878-5984-829e-0a09a6a9badc/content. p.1–38.
7. Vaccari M, Tudor T, Vinti G. Characteristics of leachate from landfills and dumpsites in Asia, Africa and Latin America: an overview. Vol. 95, Waste Management. Elsevier Ltd; 2019. p. 416–31.
8. Vaccari M, Vinti G, Tudor T. An analysis of the risk posed by leachate from dumpsites in developing countries.

Environments - MDPI. 2018 Sep 1;5(9):1–17.
9. Carreto-Binaghi LE, Aliouat EM, Taylor ML. Surfactant proteins, SP-A and SP-D, in respiratory fungal infections: their role in the inflammatory response. Respir Res. 2016 Dec 1;17(1):66.
10. Okamoto T, Fujii M, Furusawa H, Tsuchiya K, Miyazaki Y, Inase N. The usefulness of KL-6 and SP-D for the diagnosis and management of chronic hypersensitivity pneumonitis. Respir Med. 2015 Dec 1;109(12):1576–81.
11. Moazed F, Burnham EL, Vandivier RW, O'Kane CM, Shyamsundar M, Hamid U, *et al*. Cigarette smokers have exaggerated alveolar barrier disruption in response to lipopolysaccharide inhalation. Thorax. 2016 Dec;71(12):1130–6.
12. Khan R, Muhammad Waseem H, Usman Ahmad H, Ajmal Khan R, Parvez Lone K. Plasma surfactant Protein-D levels in healthy subjects and COPD patients patients [Internet]. Article in Journal of the Pakistan Medical Association. 2019. Available from: https://www.researchgate.net/publication/333703641
13. Klont F, Horvatovich P, Ten Hacken NHT, Bischoff R. Cigarette smoking prior to blood sampling acutely affects serum levels of the chronic obstructive pulmonary disease biomarker surfactant protein D. Vol. 58, Clinical Chemistry and Laboratory Medicine. De Gruyter; 2020. p. E138–41.
14. Sorensen GL. Surfactant protein D in respiratory and non-respiratory diseases. Vol. 5, Frontiers in Medicine. Frontiers Media S.A.; 2018.p.1–37
15. Sorensen GL, Dahl M, Tan Q, Bendixen C, Holmskov U, Husby S. Surfactant protein-d-encoding gene variant polymorphisms are linked to respiratory outcome in premature infants. Journal of Pediatrics. 2014 Oct 1;165(4):683–699.
16. Moré JM, Voelker DR, Silveira LJ, Edwards MG, Chan ED, Bowler RP. Smoking reduces surfactant protein D and phospholipids in patients with and without chronic obstructive pulmonary disease. BMC Pulm Med. 2010 Oct 25;10.p. 1–8.
17. Ratih Dwi Ary Merdekawati, Tri Wahju Astuti, Garinda Alma Duta. Increased Serum SP-D Level, Neutrophils and Lymphocytes Sputum in Malang Splendid Bird Market Workers. JURNAL RESPIROLOGI INDONESIA. 2022 Apr;42(2):129–35.
18. Odewabi AO, Ajibola RS, Oritogun KS, Ekor M. Levels of Clara cell secretory protein and surfactant protein A in municipal solid waste management workers in Ibadan, Southwest Nigeria. Toxicol Ind Health. 2023 May 1;39(5):267–80.
19. Tschopp A, Bernard A, Thommen AM, Jeggli S, Dumont X, Oppliger A, *et al*. Exposure to bioaerosols,,respiratory health and lung-specific proteins: A prospective study in garbage and wastewater workers. Occup Environ Med. 2011 Nov;68(11):856–9.
20. Daneshzadeh Tabrizi R, Bernard A, Thommen AM, De Winter F, Oppliger A, Hilfiker S, *et al*. Surfactant protein-D and exposure to bioaerosols in wastewater and garbage workers. Int Arch Occup Environ Health. 2010 Dec;83(8):879–86.
21. Fitri Indah Sari, Tri Wahju Astuti, Rezki Tantular. Exhaled Carbon Monoxide (eCO) and Serum CC16 Levels in Active Smokers. Jurnal Respirologi Indonesia. 2021 Jul;41(3):200–6.
22. Eriksen E, Afanou AK, Straumfors A, Graff P. Bioaerosol-induced in vitro activation of toll-like receptors and inflammatory biomarker expression in waste workers. Int Arch Occup Environ Health. 2023 Sep 1;96(7):985–98.
23. Liao JP, Wang X, Liu F, Cheng Y, Hu ZW, Zhang LN, *et al*. Serum surfactant protein D, lung function decline, and incident chronic obstructive pulmonary disease: A longitudinal study in Beijing. J Thorac Dis. 2021 Jan 1;13(1):92–100.