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The Relationship of Dust Exposure with Respiratory Disorders Symptoms Among Textile Industry Workers

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ABSTRACT

Preliminary study of the total dust exposure in the textile industry of Semarang city is 233 μg/Nm^3, which exceeds the quality standard. The high concentration of dust is influenced by increased productivity, so that it has the potential as a source of pollutants that can affect the respiratory system of workers. The purpose of this study was to determine the relationship between dust exposure and respiratory disorders symptoms in workers. The method used is a cross-sectional study with a sample size of 161 people and 6 points of dust measurement locations. The Modified Medical Research Council (MMRC) standardized questionnaire was used to collect data. The data were analyzed using the SPSS 24 with Chi square and Binary logistic regression tests to determine the relationship. The results showed that the average dust concentration exceeded the quality standard, namely 4 location points for $PM_{2.5}$, 1 location point for PM_{10}, and 2 location points for total dust. The average exposure to respirable dust is 3.93 μg/m^3, which exceeds the quality standard. A total of 57% of workers experienced symptoms of respiratory disorders with the results of bivariate statistical analysis of 5 significant variables, namely $PM_{2.5}$ ($p = 0.021$), PM_{10} ($p = 0.002$), total dust ($p = 0.000$), respirable dust ($p = 0.002$), and working period ($p = 0.037$). Meanwhile, the results of the binary logistic regression test had 2 significant variables, namely total dust ($p = 0.000$) and respirable dust ($p = 0.006$). The conclusion of this study is that total dust and respirable dust that exceed the quality standard have a higher risk of causing respiratory disorders symptoms with a probability of 71.6% and dust may be minimized by adding a pneumablo to each machine.

Keywords:dust exposure, respiratory symtoms, textile industry.

INTRODUCTION

Air is one of the natural resources that are essential for living things, especially humans. Nowadays, clean air is found very rarely; this is related to the development of industrial development and household activities (Wardhana, 2004). The development of industry in Indonesia is currently growing rapidly. This can be seen from the increase in productivity by 4.27% in the third quarter of 2021 (Ministry of Industry and Transmigration of the Republic of Indonesia, 2021). The positive impact of industrial development is in the form of opening up employment opportunities and increasing the socio-economic level of the community, but the resulting negative impact is an increase in the number of air pollutants emitted by the production process. One of the pollutants that workers can be exposed to is dust.

Dust is a solid chemical substance, generated by natural or mechanical forces such as processing, crushing, softening, rapid packing, and blasting both organic and inorganic (Suma'mur, 2014). The impact caused by dust depends on the type of dust exposed and where the dust sticks or enters the respiratory tract depending on the size of the dust particles (Aprilia & Rahayu, 2014).

Activities in the textile industry generally include spinning, dyeing, and finishing activities that tend to produce pollutants such as cotton dust particles (Basti, 2014). This is because cotton has very fine and light fibers so that the particles can

easily fly in the air. Pollutant particles can be in the form of total suspended particulate (TSP) with a particle diameter of up to 100 μm, particles with a diameter of less than 10 μm (PM_{10}), and particles with a diameter of less than 2.5 μm ($PM_{2.5}$). Meanwhile, polluting gases can be in the form of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), oxidant/surface ozone (O_3), and others (Yulinawati, 2015).

According to the International Labor Organization (ILO), respiratory tract diseases are 21% of the causes of death caused by work with other contributions of 34% being cancer, 25% accidents, 15% cardiovascular disease, and 5% caused by other factors (International Labour Office, 2013). According to WHO, three million deaths occur each year as a result of particulate exposure. Particulate exposure increases the risk of a variety of chronic and acute respiratory and cardiovascular conditions in children and adults (World Health Organization, 2012).

The results of a preliminary study conducted on 27th May 2022 in one of the yarn spinning units in the Ring Spinning process show the average total dust concentration (TSP) for 1 hour produced was 233 ug/Nm^3 with a maximum value of 1.478 μg/Nm^3 and a minimum value of 0.005 μg/Nm^3; this exceeds the threshold value set by Government Regulation no. 22 of 2021 concerning Implementation of Environmental Protection and Management which standard a threshold value for total dust (TSP) which is 230 μg/Nm^3 (Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management, 2021). Meanwhile, according to interviews with 12 morning shift workers, 8 out of 12 (67%) workers felt symptoms such as coughing, chest tightness, and sneezing during their work activities. Symptoms of cough felt by workers are a reaction to non-specific protective mechanisms against dust entering the respiratory tract (International Labour Office, 2013).

On the basis of this background, respiratory disorders due to occupational diseases are still a health problem in Indonesia, especially textile industry workers. This is because workers in the textile industry are always exposed to cotton dust and have not received occupational health services as expected. Particulate dust is the main pollutant that causes public health problems. Therefore, researchers are interested in conducting the research related to the relationship between exposure to cotton dust and symptoms of respiratory disorders in textile industry workers in Semarang City.

MATERIAL AND METHODS

This research was conducted in the textile industry of the spinning unit *v*, the city of Semarang, Indonesia. The population in this study was 269 people. The number of samples in the study using the slovin formula, obtained as many as 161 people with inclusion criteria willing to be research subjects, shift workers, willing to be examined for respirable dust levels, willing to be interviewed and participate in research by filling in the information on concerns. The sampling method in this study used a random sample technique.

Data were collected through measurements, questionnaires, interviews, and laboratory results. The measurements including the concentration of $PM_{2.5}$, PM_{10}, and Total Dust were made using the Hazz Dust EPAM-5000. Measurement of the concentration of respirable dust was conducted using a Personal Dust Sampler with the results of the concentration of dust on filter paper weighed at the Environmental Engineering Laboratory, Diponegoro University, Semarang, Indonesia. The variables used in this study were 8 independent variables, namely $PM_{2,5}$, PM_{10}, total dust or TSP, respirable dust, working period, length of exposure, use of personal protective equipment, and smoking habits as well as 1 dependent variable, namely respiratory disorders symptoms.

The quality standard used for $PM_{2.5}$ and PM_{10} dust is from the National Ambient Air Quality Standard (NAAQS) which was set in May 2022 with concentrations of 35 μg/m^3 and 150 μg/m^3, respectively (International Labour Office, 2013).Total dust uses the standard of the Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management with a concentration of 230 μg/Nm^3 (Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management, 2021). The quality standard for respirable dust uses the Regulation of the Minister of Health Manpower and Transmigration of the Republic of Indonesia Number 13 of 2011 concerning Threshold Values for Physical Factors and Chemical Factors in the Work Area with the quality standard for particulates not classified as respirable is 3

mg/m^3 (Ministry of Industry and Transmigration of the Republic of Indonesia, 2011).

The method used is quantitative by using observational analysis method with a cross-sectional approach. Data analysis was carried out using the Statistical Package for the Social Sciences 24. There were three stages of analysis, namely univariate, bivariate, and multivariate. Univariate analysis was conducted to describe the frequency distribution and the frequency of the variables studied. Bivariate analysis aimed to determine the relationship between one independent variable and one dependent variable used the Chi-Square test with a 95% confidence level ($\alpha = 0.05$). Multivariate analysis was carried out to determine the dominant variable that has the most influence on the dependent variable using binary logistic regression by selecting variables that have a p value < 0.25.

The research proposal was approved by the Health Ethics Commission of the Faculty of Public Health, Diponegoro University with the registration number: 376/EA/KEPK-FKM/2022. Informed consent from each respondent was obtained before interviewingand data were identified.

RESEARCH AND DISCUSSION

On the basis of the results of the univariate analysis in Table 1, most respondents were exposed to respirable dust > 3 mg/m^3 with a total of 116 (72%), while exposure to respirable dust was 3 mg/m^3 in 45 (28%). There are 118 (73.3%) workers who have worked in this industry for more than 5 years and those who have worked for less than 5 years 43 (26.7%). The use of personal protective equipment by 80 (49.7%) workers did not comply with the use of personal protective equipment while 81 (50.3%) other workers complied with the use of personal protective equipment. In terms of the smoking habits, 71 (44.1%) workers are smokers and 90 (55.9%) are non-smokers. Most of the respondents experienced symptoms of respiratory disorders with a total of 91 (56.5%) workers and 70 (43.4%) other workers did not experience symptoms of respiratory disorders.

According to Figure 1, the results show that 54 people (33.5%) had complaints of coughing, 53 people (32.9%) had complaints of phlegm, 34 people had complaints of shortness of breath (21.1%), 51 people had complaints of wheezing (31.7%), and complaints of chest pain 48 people (29.8%).

Table 1. Univariate analysis

Respondent Characteristics	Frequency (n)	Percentage (%)
Respirable dust		
> 3 mg/m^3	116	72
≤ 3 mg/m^3	45	28
Working period		
> 5 years	118	73.3
≤ 5 years	43	26.7
Length of work		
> 8 hours	27	16.8
≤ 8 hours	134	83.2
Use of PPE		
Don't comply with the use of PPE	80	49.7
Compliance with the use of PPE	81	50.3
Smoking habit		
Smoker	71	44.1
Not a smoker	90	55.9
Respiratory disorders symptoms		
Have respiratory disorders symptoms	91	56.5
No respiratory disorders symptoms	70	43.5

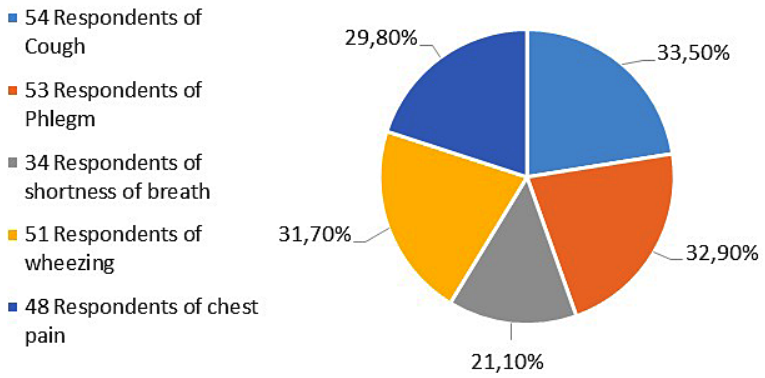

Figure 1. Respiratory disorders symptoms in workers

Respiratory disorders symptoms are influenced by many factors both from within the individual and from outside. Of course, this is also related to the pattern of daily activities and potential co-factors such as age, gender, ethnicity, smoking habits, and allergen factors (Ministry of Industry and Transmigration of the Republic of Indonesia, 2011). In addition, workload and work environment conditions can also affect the symptoms of respiratory disorders suffered to human (Budiono et al., 2016).

The results of the dust exposure concentration in the spinning unit V which are written in Table 2, the average $PM_{2.5}$ dust concentration has 4 points that exceed the quality standard, namely in the drawing section 57 μg/m^3, flyer 47 μg/m^3, ring spinning 50.5 μg/m^3, and winding 60.5 μg/m^3 with the maximum value in the winding section in the second measurement with a $PM_{2.5}$ dust concentration of 82 μg/m^3 and a $PM_{2.5}$ dust concentration, the lowest was in the carding section in the first measurement of 16 μg/m^3. The average PM_{10} dust concentration from 6 measurement locations, 1 point of measurement location exceeded the quality standard with a concentration of 218.5 μg/m^3 in the ring spinning section with the highest PM_{10} dust concentration at 340 μg/m^3 in the second measurement section. Ring spinning and the lowest concentration of 28 μg/m^3 was in the second measurement of the blowing section. The results of the measurement of total dust content in the spinning unit V obtained 2 locations for measuring total dust exceeding the quality standard with concentrations of 4111.4 μg/Nm^3 and 452.23 μg/Nm^3, respectively, in the ring spinning and winding sections. The highest total dust concentration is 4484.82 μg/Nm^3 in the ring spinning II measurement and the lowest concentration is in the blowing II measurement with a concentration of 53.61 μg/Nm^3.

Most of the highest dust concentrations are in the ring spinning and winding parts, this is because the number of machines in this part is greater than the number of machines in other process parts. In addition, the characteristics of ring spinning and winding machines are that they produce more dust because the working process pulls the roving into yarn of the desired size, and provides the right twist and desired strength, which is then carried out by the process of winding the yarn into a larger roll. while removing weak and uneven parts. This causes a lot of fine dust to fly

Table 2. Result of concentration of dust exposure in spinning unit V

Location	Results		Mean	Median	SD	Min	Max
	I	II					
$PM_{2.5}$ (μg/m^3)							
Blowing	29	23	26	39	18,6	16	82
Carding	16	37	26.5				
Drawing	52	62	57				
Flyer	32	62	47				
Ring spinning	39	62	50.5				
Winding	39	82	60.5				
PM_{10} (μg/m^3)							
Blowing	45	28	36.5	5	82,7	28	340
Carding	34	32	33				
Drawing	36	55	45.5				
Flyer	39	75	57				
Ring spinning	97	340	218.5				
Winding	98	117	107.5				
Total dust or TSP (μg/Nm^3)							
Blowing	74.3	53.61	63.95	113,68	1483,95	53,61	4484,82
Carding	91.43	98.97	95.2				
Drawing	98.09	88.66	93.38				
Flyer	128.39	134.02	131.2				
Ring spinning	3737.97	4484.82	4111.4				
Winding	524.87	379.6	452.23				

considering the nature of cotton that is easy to fly. The more machines that are operated, the greater the production capacity and the more intensive the activities in the unit which have an impact on the high concentration of dust generated from the production process (Aryasih et al., 2015).

The results of the bivariate analysis in Table 3, it was found that 5 variables had a relationship with respiratory disorders symptoms ($p < 0.05$) including $PM_{2.5}$, PM_{10}, respirable dust, total dust, and working period. The results of the analysis showed that the $PM_{2.5}$ concentration that exceeded the quality standard (>35 μg/m^3) had a 2,009 times risk of causing respiratory disorder symptoms compared to the $PM_{2.5}$ concentration which was below the quality standard (≤ 35 μg/m^3) (p = 0.021; 95 % CI = 1.015 – 3.997; PR 2.009). The concentration of PM_{10} dust that exceeds the quality standard (>150 μg/m^3) is 1.576 times more at risk of causing respiratory disorder symptoms than the concentration of PM_{10} that is below the quality standard (≤ 150 μg/m^3) (p = 0.002; 95% CI = 1.199 – 2.072; PR 1.576). The result of analysis of total dust that exceeds the quality standard (> 230 μg/Nm^3) has a risk of 2.249 times causing respiratory disorder symptoms compared to the total dust content below the quality standard (≤ 230 μg/Nm^3) (p = 0.000; 95% CI = 1.374 – 3.683; PR 2.249). Exposure to respirable dust in workers above the quality standard (> 3 μg/m^3) has a 1.818 times risk of causing respiratory disorder symptoms compared to levels of respirable dust below the quality standard (≤ 3 μg/m^3) (p = 0.002; 95% CI = 1.200 – 2.756; PR 1.818). The workers who have worked for more than 5 years (> 5 years) have a risk level of 1.478 times causing respiratory disorder symptoms compared to the workers whose working period is less than 5 years (≤ 5 years) (p = 0.037; 95% CI = 1.011 – 2.160; PR 1.478).

The relationship of $PM_{2.5}$ dust exposure with respiratory disorders symptoms

A total of 85 (60.3%) of the 141 respondents who experienced respiratory disorders symptoms who were exposed to $PM_{2.5}$ dust exceeded the

Table 3. Bivariate analysis

Variable	Respiratory disorders symptoms		Total	PR	95% CI	*p*
	Yes	No				
$PM_{2.5}$						
> 35 μg/m^3	85 (60.3%)	56 (39.7%)	141 (100%)	2.009	1.015–3.997	0.021*
≤ 35 μg/m^3	6 (30%)	14 (70%)	20 (100%)			
PM_{10}						
> 150 μg/m^3	51 (70.8%)	21 (29.2%)	72 (100%)	1.576	1.199–2.072	0.002*
≤ 150 μg/m^3	40 (44.9%)	49 (55.1%)	89 (100%)			
Total dust or TSP						
> 230 μg/Nm^3	79 (65.8%)	41 (34.2%)	120 (100%)	2.249	1.374–3.683	0.000*
≤ 230 μg/Nm^3	12 (29.3%)	29 (70.7%)	41 (100%)			
Respirable dust						
> 3 mg/m^3	75 (64.7%)	41 (35.3%)	116 (100%)	1.818	1.200–2.756	0.002*
≤ 3 mg/m^3	16 (35.6%)	29 (64.4%)	45 (100%)			
Period of work						
> 5 years	73 (61.9%)	45 (51.3%)	118 (100%)	1.478	1.011–2.160	0.037*
≤ 5 years	18 (41.9%)	25 (18.7%)	43 (100%)			
Length of work						
> 8 hours	15 (55.6%)	12 (44.4%)	27 (100%)	0.980	0.678–1.416	1.000
≤ 8 hours	76 (56.7%)	58 (64.7%)	134 (100%)			
Use PPE						
No	48 (60%)	32 (40%)	80 (100%)	1.130	0.861–1.483	0.468
Yes	43 (53.1%)	38 (35.2%)	81 (100%)			
Smoking habit						
Smoker	45 (63.4%)	26 (40%)	71 (100%)	1.240	0.948–1.622	0.119
Not a smoker	46 (51,1%)	44 (48,9%)	90 (100%)			

quality standard (>35 μg/m^3) from the National Ambient Air Quality Standard (NAAQS) which was set in May 2022(Unites States Environmental Protection Agency, 2022). These results show a statistically significant relationship between exposure to $PM_{2.5}$ dust in the workspace environment and respiratory disorders symptoms in workers (p = 0.021; 95% CI = 1.015 – 3.997; PR 2.009) which means the workers are exposed to $PM_{2.5}$ exceeding the quality standard has a 2,009 times risk of experiencing respiratory disorder symptoms than workers exposed to $PM_{2,5}$ below the quality standard.

This research is in line with Derso's research conducted in the city of Gondar, Ethiopia in 2021, where the highest concentration of $PM_{2.5}$ dust of 256 mg/m^3 is in the ginning section or the process of separating cotton fiber from seeds which then turns cotton into yarn (Derso et al., 2021). In addition, a study conducted by Doctor in India in 2006 showed that the concentration of cotton dust with a particle size of 2.5 g was higher in the ginning department which increased the risk of respiratory symptoms with a p value of < 0.005 and a concentration of 2.11 μg/m^3 (Doctor et al., 2006).

Theoretically, the results of the cotton yarn production process can pose a risk of developing respiratory symptoms in workers.This is because PM2.5 has properties that are easily inhaled due to its very small size so that due to its size, $PM_{2.5}$ can reach the alveoli and can cause inflammation in the lungs,, blood vessels, even the liver and other organs (Environmental Protection Agency, 2013). This is supported by Arba's research in 2019 which said that the concentration of $PM_{2.5}$ had a significant value (p < 0.05) on health problems in the form of coughing (70%) and eye irritation (47%) (Arba, 2019). The concentration of $PM_{2.5}$ in the air can affect health if inhaled by humans. The $PM_{2.5}$ that is inhaled will enter the alveoli, causing an inflammatory reaction that results in limited lung expansion (Fordiastiko, 2012). This is in line with Santiasih's research in 2012 where the concentration of $PM_{2.5}$ has a positive correlation with symptoms of respiratory disorders in the workers who work indoors (Santiasih, 2012).

The relationship of PM_{10} dust exposure with respiratory disorders symptoms

The workers exposed to PM_{10} dust in the work environment of 72 respondents, 51 (70.8%) experienced symptoms of respiratory disorder problems who were exposed to PM_{10} dust exceeding the quality standard (>150 μg/m^3) from the National Ambient Air Quality Standard (NAAQS) set in May 2022 (Unites States Environmental Protection Agency, 2022). These results show a statistically significant relationship between the exposure to PM_{10} dust in the workplace and workers' respiratory disorder symptoms (p = 0.002; 95% CI = 1.199 – 2.072; PR 1.576). This means that workers exposed to PM_{10} dust exceed the standard. A qualified worker is 1,576 times more likely to experience respiratory disorders symptoms than workers exposed to PM_{10} dust below quality standards.

This research follows Derso's study conducted in the city of Gondar, Ethiopia, in 2021, where the highest concentration of PM_{10} dust of 820 mg/m^3 is in the ginning section or the process of separating the cotton fiber from seeds which then turns cotton into yarn (Derso et al., 2021). This is similar to Ahmad's research in Pakistan in 2020, where the PM_{10} concentration exceeded the standard for three consecutive months with each concentration of 309.5 μg/m^3, 302 μg/m^3, and 311 μg/m^3 in the shop inspection unit, while the concentration was 226 μg/m^3, 234.2 μg/m^3, and 227.3 μg/m^3 in the fabric cutting unit (Hamid et al., 2020).

Theoretically, PM_{10} is a respirable particulate and an excellent indicator of well-being. This is because PM_{10} is breathed into the respiratory system more effectively than larger particulates. Determining the extent of particle exposure and the health impacts it produces depends heavily on how effectively particulates are inhaled into the respiratory system. The lower respiratory tract and gas exchange zones in the respiratory system are more susceptible to the characteristics ofPM_{10}, which can lead to persistent respiratory tract irritation and a variety of tissue reactions that can lead to respiratory issues (Koren, 2003). In the LubukKilangan District of Indonesia, exposure to high concentrations of PM_{10} increases the risk of respiratory issues in people by 41% (Riski, 2017). According to the research done by Azni in Jakarta in 2015 on ready-to-use sectors, the workers exposed to PM10 concentrations for at least five years had a minimum lifetime risk of respiratory disorders of 3.3 times (Azni et al., 2015)

The relationship of totaldust exposure with respiratory disorder symptoms

A total of 79 (65.8%) of the 120 respondents who experienced respiratory disorder symptoms

were exposed to total dust exceeding the quality standard (>230 μg/Nm^3) from the Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management (*Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management*, 2021) These findings show a statistically significant link between workplace total dust exposure and workers' respiratory disorder symptoms (p = 0.000; 95% CI = 1.374–3.683; PR 2.249). This means that the workers exposed to workplace total dust levels above the quality standard are 2,249 times more likely to experience respiratory disorder symptoms than those exposed to workplace total dust levels below the standard.

According to Sufya's research from the spinning unit II PT Dan LirisSukoharjo in 2010, all three of the sampling points for dust concentration surpassed the NAV value, with concentrations of 0.318 mg/m^3, 1.777 mg/m^3, and 0.208 mg/m^3, respectively (Akunsari, 2010). Mulyati also performed a study at PT. Grandtex Bandung in 2015, the results of the total dust concentration exceeding the quality level were found to be 0.325 mg/m^3 in the spinning unit and 1.070 mg/m^3 in the weaving department (Mulyati et al., 2015) According to a 2021 study conducted in Nigeria by Nagoda, workers in the spinning department had the highest rate of respiratory illnesses, with a prevalence of coughing of 27.3% and a significant value of 0.05 (Nagoda et al., 2012). Wami in 2018 showed that in Ethiopia the workers exposed to cotton dust had a higher prevalence of respiratory complaints than those who were not (p = 0.001). Twenty workers (15.3%) were not exposed to cotton dust, and 129 (478%) did report respiratory difficulties (Wami et al., 2018).

Theoretically, the dust contained in the work environment has the potential to pose a risk of health problems in the nose and throat which can lead to colds and other infections (Anes et al., 2015). According to the 2012 Nagoda study, the workers who were exposed to dust had a 4.63 times higher chance of developing coughing fits, a 5.1 times higher risk of developing phlegm, and a 4.55 times higher risk of developing chest tightness (Nagoda et al., 2012). In 2018, a related study was also conducted by Wami in Ethiopia, where workers in the ginning and spinning sections had a 5.1 and 4.96 times higher risk of experiencing respiratory symptoms than workers in administrative units and other sectors (AOR = 5.1, 95% CI: 2.13, 12.16, and AOR = 4.96, 95% CI: 2.18, 11.29) as well as workers in the weaving and blowing divisions had a 5.9 and 5.14 times higher risk of experiencing respiratory symptoms compared to the workers in administrative units and other sectors (AOR = 5.9, 95% CI: 2.46, 14.27, and AOR = 5.14, 95% CI: 1.4, 18.94) (Wami et al., 2018).

The relationship of respirabledust exposure with respiratory disorders symptoms

The workers who were exposed to respirable dust 116 respondents, 75 (64.7%) had respiratory disorders symptoms as a result of respiratory disorders symptoms caused by respirable dust exceeding the quality standard (>3 mg/m^3) from the Regulation of the Minister of Health and Transmigration of the Republic of Indonesia Number 13 of 2011 concerning Threshold Values Limits of Physical Factors and Chemical Factors in the Work Area (Ministry of Industry and Transmigration of the Republic of Indonesia, 2011). According to these findings, there is a statistically significant link between workplace exposure to PM_{10} dust and workers' symptoms of respiratory disorders (p = 0.002; 95% CI = 1.200–2.756; PR 1.818). This means that the workers exposed to respirable dust that is above the quality standard are 1.818 times more likely to experience respiratory disorder symptoms than those exposed to respirable dust that is below the standard.

This study is consistent with Oo (2021) study in Thamie, Myanmar, where 105 workers (50.7%) frequently reported inhaling textile dust with a concentration greater than 3 mg/m^3, with an average respirable dust concentration of 3.3 mg/m^3 and a range between 2.4 mg/m^3 and 4.1 mg/m^3. P value 0.001 indicated significant results between occupational respiratory disease and exposure to respirable dust (Oo et al., 2021).

In theory, breathing patterns are very influential in the process of entering dust into the respiratory tract. Inhaled dust can enter the body by inhalation. The factors that can affect the inhalation of pollutants into the lungs are physical components, chemical components, and the patient himself. Size and shape will affect the process of accumulation in the lungs. The chemical components that influence this process include the tendency to react with surrounding tissues which can cause extensive fibrosis in the lungs and can be antigenic that

enter the lungs (Ojima, 2016). The accumulation of dust has the potential to cause lung function and respiratory disorders, which are influenced by the type of particles, duration of exposure, particle content, and particle size (Soeript, 2008). Similar observations were reported in Oo'sresearch in 2017 in Thamie, Myanmar where the exposure to inhaled dust has a risk value of 4.12 times experiencing respiratory problems (Oo et al., 2021).

The relationship of working period with respiratory disorder symptoms

A total of 73 (61.9%) of the 118 respondents who experienced respiratory disorders symptoms had a working period of more than five years (>5 years). These results show a statistically significant relationship between years of service and respiratory disorder symptoms in workers (p = 0.037; 95% CI = 1.011 – 2.160; PR 1.478) which means that the workers who have a working period of > 5 years have a 1.478 times risk of experiencing respiratory disorder symptoms rate than the workers with ≤ 5 years of service.

In Primasanti's 2022 research at PT. BTS's yarn spinning department, it was discovered that the workers with the highest respiratory complaints were 47 people (82.4%) felt in the workers who had a working period of 5 years (Primasanti et al., 2022) This is consistent with Wami's 2017 research in Ethiopia, which found a link between textile industry workers who have worked for more than five years and have a 2.38 times greater risk of experiencing symptoms of respiratory disorders than the workers who have worked for 2 to 5 years (Wami et al., 2018) Tageldin's research published in Machinery in 2017 found a link between working period involving exposure to cotton dust and respiratory problems. Cotton dust has a greater impact on the symptoms of respiratory disorders the longer itsexposure (Tageldin et al., 2017).

In theory, the longer a person works in a dusty work environment, the more likely that person will develop lung disease (Suma'mur, 2014). Working in a dusty environment for an extended period of time will exacerbate the effects of inhaled dust, which can manifest as coughing, shortness of breath, and sneezing that irritates the respiratory tract (Retnowati, 2009). Similar to the research conducted in India by Saha in 2014 and Mansouri in 2016, the study's findings indicated that the longer the duration of exposure to cotton dust, the worse the symptoms of respiratory disorders. This is understandable because more experienced workers who have been exposed to cotton dust during their tenure in the cotton industry are more likely to develop respiratory symptoms (Saha et al., 2014; Mansouri et al., 2016).

The relationship of length of work with respiratory disorders symptoms

A total of 15 (55.6%) of the 27 respondents who experienced respiratory disorders symptoms had an exposure duration of more than 8 hours (> 8 hours). These results statistically show that there is no significant relationship between duration of exposure and respiratory disorders symptoms in workers (p = 1,000; 95% CI = 0.678 – 1.416; PR 0.980) which means that the workers who have an exposure duration of > 8 hours have a 0.980 times risk of experiencing symptoms of respiratory disorders than the workers who have a duration of exposure ≤ 8 hours.

This study is consistent with Irjayanti's 2013 research, which concluded that there was no relationship between the length of exposure and respiratory problems with p-value = 0.718 hours of work, but it did not indicate that the exposure received by the person was also large, even though the working hours were the same between one worker and another. On the other hand, the exposure dose that enters the worker's body varies. This is also related to the work environment and the completeness with which personal protective equipment is used (Irjiyanti et al., 2012).

The majority of respondents worked a minimum of 8 hours per day in accordance with the minister of manpower's regulation, which requires workers to work long hours. In theory, the longer workers are at work, the greater their risk of being exposed to dust particles. Working in a high dust concentration environment has a negative impact on the length of exposure. The hazards posed by the workplace can affect health, particularly the respiratory tract, with prolonged exposure (Arba, 2019).According to Suma'mur in 2014, if a person is exposed to dust with a concentration greater than the NAV for an extended period of time, respiratory disorders are likely to develop (Suma'mur, 2014). Silpasuwan, in his 2018 research, said that the workers who worked > 8 hours/day had a risk of 2.88 times more likely to have respiratory tract disorders than the workers who worked fewer hours (OR = 2.88; 95CI = 1.18 – 7.12) (Silpasuwan et al., 2016). The occurrence of respiratory

tract disorders in workers is influenced not only by the level of concentration received per day during working hours (Hu et al., 2017).

The relationship of using personal protective equipment with respiratory disorder symptoms

As far as the workers who use personal protective equipment are concerned,out of 80 respondents, 48 (60%) have symptoms of respiratory disorders and do not use personal protective equipment. These findings show that there is no statistically significant relationship between the use of personal protective equipment and symptoms of respiratory disorders in workers (p = 0.468; 95% CI = 0.861 – 1.483; PR 1.130), implying that the workers who do not use personal protective equipment are 1,130 times more likely to experience respiratory disorder symptoms than workers who do.

This study is consistent with Ramadhansyah's research from 2020, which found no correlation between the variable of compliance in the use of personal protective equipment and symptoms of respiratory disorders (p = 0.667) (Ramadhansyah, 2021). This is consistent with Ipmawati's 2018 research, which found that while the use of personal protective equipment had no effect on symptoms of respiratory disorders, it did have an effect on the incidence of respiratory symptoms because it increased the risk of receiving direct exposure to pollutants (Ipmawati, 2018).

In theory, noncompliance with the use of personal protective equipment can cause problems if workers do not use it, especially when doing work that allows direct contact with dust (Sandra, 2013).

The relationship of smoking habit with respiratory disorder symptoms

The workers with a smoking habit account for 45 (63.4%) of the 71 respondents who are experiencing symptoms of respiratory disorders due to their smoking habit. These findings show that there is no statistically significant relationship between smoking habits and symptoms of respiratory disorders in workers (p = 0.119; 95% CI = 0.948 – 1.622; PR 1.240), implying that the workers who smoke have a 0.948 times greater risk of experiencing symptoms of respiratory disorders than nonsmokers.

This finding is in line with the 2017 Anyfantis study in Greece, where smoking prevalence was high (48.4%) among cotton industry workers (p = 0.521) (Anyfantis., 2017). These results suggest that smoking may increase the effect of cotton dust exposure on respiratory symptoms (Mastrangelo et al., 2003). Silpasuwan conducted research in Bangkok, Thailand, in 2015 and found no link between smoking habits and respiratory disorders, as evidenced by statistical results of p = 1.00 (Silpasuwan et al., 2016).

In theory, smoking habits can reduce and disrupt the respiratory system, and continuous inhalation of dust poses a health risk to workers, particularly those who are at risk of dust exposure (Gholami et al., 2020). Smoking activities can cause changes in the structure and function of the airways and tissues. Enlargement of mucous cells (hypertrophy) and increased mucus glands (hyperplasia) that occurs in the large airways, in addition to mild inflammation to narrowing due to the addition of cells and accumulation of mucus in the small airways (Puspita, 2015).

The results of the multivariate analysis in Table 4 show that two variables have an influence on the symptoms of respiratory disorders in shift workers in the spinning unit V, namely total dust (p = 0.000) and respirable dust (p = 0.006). Statistically, the independent variable with the smallest p value is total dust with p = 0.000 and the largest OR value is total dust with a value of 4.175 so that total dust is the most dominant variable affecting respiratory symptoms.

With a p = 0.05, the results of the logistic regression analysis revealed that total dust and respirable dust had a significant relationship with respiratory disorders symptoms in spinning unit workers. The findings revealed that the variables influencing the symptoms of respiratory disorders are not singular, implying that one variable is interrelated with other variables in causing respiratory disorder symptoms in workers.

Table 4. Multivariate analysis

Variabel	B	Adjusted OR	95% CI for OR		*p*
			Lower limit	Upper limit	
Total dust	1.429	4.175	1.892	9.211	0.000
Respirable dust	1.063	2.896	1.364	6.149	0.006
Constant	-1.564	0.209			0.000

The probability of a person experiencing respiratory disorders symptoms in workers can be calculated using the following formula:

$$P = \frac{1}{1 + e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}} =$$

$$= \frac{1}{1 + 2.718^{-2.561+1.493+1.058+0.854+0.770}} = (1)$$

$$= \frac{1}{1.1991} = 0.833$$

The probability of developing respiratory disorder symptoms in respondents (spinning unit workers) who are exposed to dust is 71.6% if the respondent is exposed to total dust in his work environment that exceeds the quality standard (> 230 μg/Nm^3) and the respirable dust concentration that exceeds the quality standard (> 3 mg/m^3). According to the findings of a multivariate analysis, the measurement of dust concentrations of $PM_{2.5}$, PM_{10}, working period, and smoking habit was not associated with respiratory disorder symptoms in shift workers of a spinning unit V. This demonstrates that total dust exposure in the workplace, as well as respirable dust by workers, can cause symptoms of respiratory disorders in spinning unit shift workers.

CONCLUSIONS

The average results of $PM_{2.5}$, PM_{10}, total dust, and respirable dust measurements exceed the standard quality. The research analysis results show that the variables affecting respiratory disorders are not singular, with total dust being the most dominant variable affecting respiratory disorders and the probability of workers being affected by respiratory disorders being 71.6%. Dust emission can be minimized by adding a pneumablo to each machine.

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