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Association between Respirable Dust Exposure and Respiratory Health among Cement Workers

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ABSTRACT

Introduction: Cement industry contributes to the major constituent of airborne dust in the atmosphere. This study aims to determine the level of respirable cement dust exposure associated with workers' respiratory health. A cross-sectional study was carried out among 84 administration workers as the comparative group and 84 manufacturing workers as the exposed group. **Method:** A set of validated questionnaires was used to obtain some pertained background information as well as respiratory symptoms among the respondents. Personal Air Sampling Pump was used for assessing personal exposure towards cement dust in 8 hours. For lung function performance, a Spirometry test was carried out and Fractional Exhaled Nitric Oxide (FENO) test was conducted to assess airway inflammation. **Results:** The median for personal exposure level to respirable dust of manufacturing workers was 2.68 (5.90) mg/m^3 with range 0.351 to 10.60 mg/m^3. The lung function abnormality among the manufacturing workers was FVC% (PR=3.82, 95% CI=1.52-9.58) and FEV_1% (PR=5.16, 95% CI=1.65-16.10). Cough was reported to occur the most likely among the manufacturing workers (PR=2.40, 95% CI=1.12-5.15). After adjusting the smoking status, the prevalence of phlegm and cough were 35.7% and 29.8% respectively. 16.7% of manufacturing workers recorded a high level of FENO. The increasing exposure to respirable dust significantly reduces the FVC% of manufacturing workers (r=-0.36, p=0.05). **Conclusion:** The personal exposure to respirable cement dust increases the risk of lung impairment by highly developing respiratory health symptoms, reducing lung function level and increasing the higher level of airway inflammation among highly exposed workers.

Keywords: Cement industry, Fractional Exhaled Nitric Oxide (FENO), Lung function, Personal exposure level (respirable dust), Respiratory symptoms

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INTRODUCTION

Cement and concrete are important economic pillars that contribute about 4% of the Malaysia's gross domestic product (29). Cement is a fine and greyish green powder with an aerodynamic diameter ranging from 0.05 to 10 µm (13). Portland cement is the most commonly used cement and it is mainly used for building material for land-based and offshore installations (17). Cement industry is reported to achieve strong growth demand and is expected to increase due to the government expenditure on infrastructure projects. Cement industry possesses a variety of occupational hazards which can lead to major constituent of airborne dust in the air. The dust generated from this industry may cause health problems to workers through either dermal contact or inhalation (2) also leads to greater risk for chronic respiratory symptoms and decrease in ventilator capacity (3). This includes lung impairment, coughing, aggravation of asthma, chronic bronchitis, and mucus secretion (3, 15, 27). These effects occur due to the inflammation of the respiratory tract that makes people more prone to having infections of the respiratory tract (2). Patients with asthma have high levels of Nitric Oxide in their exhaled breath and high levels of inducible nitric oxide synthase ($iNOS_2$) enzyme expression in the epithelial cells of their airways, suggesting a role for NO in asthma pathogenesis (6).

There is a limited number of studies in Malaysia focusing on the exposure to cement dust and airway inflammation using Fractional Exhaled Nitric Oxide (FENO) compared to the prevalence of respiratory disease (34). A variety of pollutants may exist in portland cement which can contribute to atmospheric pollution, such as gaseous pollutant and most importantly, particulates. Cement dust comprises of various types of particulate matter that are more hazardous to health (24). A comparison was done between the two groups of workers, which were administration and manufacturing workers in the cement industry. The objective was to determine

the relationship between the exposure level of cement dust and respiratory health implications among cement workers.

MATERIALS AND METHODS

Study design and study location

A cross-sectional study was carried out among 84 male administration workers as the comparative group and 84 male manufacturing of cement industrial workers as the exposed group. The selected cement industry was located in Negeri Sembilan, which is one of the leading and biggest cement industry in Malaysia located near to Banjaran Titiwangsa that is used as the source of raw materials of cement production.

Study sample

A total of 168 cement industry workers were selected by using simple random sampling regarding the exposure while working. The exposed group comprised of those who worked at the manufacturing area, with high and direct exposure to respirable cement dust. Meanwhile, the comparative group was from the administration workers who worked in the office with less exposure to respirable cement dust. The name list of the workers had been obtained from the human resource department. The selection of these two groups was based on the inclusion criteria as Malaysian male worker with age range 18 to 55 years old and has been working in this industry for more than or equal to 6 months without any medical history or under any treatment regarding respiratory diseases. However, 58 respondents for each group were randomly selected to measure personal exposure (respirable dust). According to guideline on monitoring of the airborne contaminant for chemicals hazardous to health sampling among homogeneous risk groups of workers who works under the same closing area with similar exposure for the same working duration will have similar exposure risk (5). It is suggested that for every homogenous group exposure more than 50 workers, the required of samples are 18 respondent. Therefore, the total number of respondent in both group are at least 36 people.

Instruments and procedures

A set of validated questionnaires which was adapted from the American Thoracic Society had been pre-tested on the others industrial workers with 10% of the sample size before it was used to obtain background information as well as respiratory symptoms among the respondents (30). For the personal exposure level of respirable cement dust, a Gilian GilAir-3 Air Sampling Pump was used and placed at the breathing zone area for assessing personal exposure in 8 hours towards cement dust. For lung function performance, a Chestgraph Spirometer HI-105 was used to measure the air that was expired and inspired as the function of time. Meanwhile, to assess airway inflammation, a NIOX MINO was used to determine the exhaled nitric oxide in worker's breath. Fractional exhaled Nitric Oxide (FeNO) is recommended in the diagnosis of eosinophilic airway inflammation and monitoring airway inflammation in patients with asthma (6). The test was conducted early morning before the respondent consume any food and proceeding to their heavy physical activities (38). The data obtained was compared to the American Thoracic Society Standard for FENO in adults (6).

Data analysis

Statistical analysis was performed by using SPSS version 22 software to determine the association and difference in personal exposure concentration with health symptoms and performance. The tests used in this analysis were descriptive analysis, Chi-Square test, Independent T-test. Mann Whitney U-test, Spearman Rho test and Logistic Regression.

RESULTS

Respondents' background

All respondents chosen in this study were given a consent form first to verify their willingness and voluntary. There was a 100% response rate from the workers who volunteered and selected for participated in this study. They had been categorized into two groups which were those directly exposed group whom were manufacturing workers (50.0%) and indirectly exposed group whom were administration workers (50.0%). Most of the workers were Malay which consists about 91.1% followed by Indian and Chinese with 7.7% and 1.2% respectively of the population selected. The mean income for administration workers was RM4272.00 ± 3941.38 while the mean income for the manufacturing workers was RM3265.45 ± 2079.89. The highest education level received was Master Degree with 0.6%, while most of the workers only required SPM level with 55.4% as their highest level of education.

Contributing Factors

The mean age of the workers in manufacturing department were 36.64 ± 9.52 years old while the workers in administration department were 39.24 ± 10.24 years old. The weight and height of manufacturing department were 78.96 ± 16.22 kg and 168.98 ± 5.34 cm respectively while for the comparative group are 76.71 ± 13.53 kg and 168.49 ± 6.54 cm respectively. The Independent t-test to compare between manufacturing and administration cement workers shows that there was no significant difference of age, weight and height for both groups with p-value more than 0.05.

Smoking habit and working duration could be among the factors that contribute to the increasing of time of exposure and respiratory health effects. The percentage of smokers among manufacturing workers was 53.6% while the total number of smokers among administration workers was 41.7%. There was no significant difference obtained in the number of cigarettes smoked per day

between these two groups (χ^2=2.38, p=0.12). 67% of the manufacturing smokers and 69% of the administration smokers smoked within 10-20 pieces in a day which is classified as moderate smokers.

The results from Mann Whitney U test showed that the mean of working duration for administration workers were longer as compared to the manufacturing workers. The range of working duration for the administration workers were between 1-23 years with the median of 9.50 years while the manufacturing workers was 1-20 years with median 7.50 years. However, there was no significant difference of working duration between the two studied groups (z=-0.368, p= 0.713).

Personal exposure level (respirable dust)

58 samples were taken to represent each of the workers that worked in the administration or manufacturing department. The monitoring for personal exposure level was done during their working hours. Mann Whitney U test was conducted and the results in Table I show that there was a significant difference in personal exposure level of respirable dust between the two groups (z = -2.527, p = 0.012). The percentage of personal exposure level for respirable dust in the manufacturing workers was exceeded the permissible exposure limits of Factories and Machinery (Mineral Dust) Regulations 1989 (12) compared to the administration workers. Malaysian government have set the permissible exposure limits for respirable dust is 5 mg/m3 in time weighted average of 8 hours working per day. The median of respirable dust exposure among the manufacturing workers is 2.68 (5.90) mg/m^3 while the median of respirable dust among the administration workers are 1.88 (2.27) mg/m^3. About 34.5% of respirable dust sample was determined to exceed for the manufacturing workers compared to the administration workers with 6.9% of respirable dust sample exceeded. The concentration obtained from the manufacturing workers was between 0.351 to 10.60 mg/m^3 while for the administration workers was 0.029 to 5.63 mg/m^3.

Table I: Comparison of Personal exposure level (respirable dust) between manufacturing and administration workers

Variables	Manufacturing (N=29)	Administration (N=29)	z-value	p-value
Median (IQR)	2.68 (5.90)	1.88 (2.27)	- 2.527	0.012*
Range (mg/m^3)	0.351-10.60	0.029-5.63		
N exceeded (%)	10 (34.5)	2 (6.9)		
N not exceeded (%)	19 (65.5)	27 (93.1)		

Mann Whitney U test
*Significant p < 0.05

Prevalence of respiratory health symptoms

Respiratory symptoms of respondents were categorized into cough, phlegm, wheezing and chest tightness. The results in Table II show that, the manufacturing workers have been most reported of getting phlegm, followed by cough, wheezing and chest tightness with 35.7%, 29.8%, 19.0% and 15.5% respectively. As for the administration workers, they reported phlegm, cough, chest tightness and wheezing with 27.4%, 15.5% 11.9% and 10.7% respectively. The manufacturing workers were found to be positively associated with high experience of cough (PR=2.314, 95% CI = 1.089-4.918). After adjusting for smoking status, the manufacturing workers were found to be positively associated with cough (PR=2.400, 95% CI = 1.119-5.147).

Table II: Prevalence of respiratory health symptoms for manufacturing and administration workers

Variables	Manufacturing (N=84)	Administration (N= 84)	PR 95% CI	*PR 95% CI
	Number (%)	Number (%)		
Cough				
Yes	25 (29.8)	13 (15.5)	**2.314* (1.089-4.918)**	**2.400 (1.119-5.147)**
No	59 (70.2)	71 (84.5)		
Phlegm				
Yes	30 (35.7)	23 (27.4)	1.473 (0.765-2.837)	1.490 (0.765-2.903)
No	54 (64.3)	61 (72.6)		
Wheezing				
Yes	16 (19.0)	9 (10.7)	1.961 (0.813-4.728)	2.149 (0.873-5.293)
No	68 (80.9)	75 (89.3)		
Chest tightness				
Yes	13 (15.5)	10 (11.9)	1.355 (0.558-3.287)	1.259 (0.509-3.113)
No	71 (84.5)	74 (88.1)		

Logistic Regression
*Significant PR > 1, 95% CI
*Adjusted PR for smoking status

Comparison of lung function test

Lung function test was conducted on all respondents. The results in Table III show a significant difference of FVC% and FEV_1% between manufacturing workers and administration workers with p < 0.05. However from the statistical results obtained, FEV_1/FVC% do not show any significant difference between the two study groups

There was a significant difference of abnormalities found among the manufacturing and administration workers. From the logistic regression test as in Table IV obtained, the abnormalities of manufacturing workers were significantly higher as compared to the administration workers with FVC% (PR=3.903, 95% CI=1.565-9.735)

Table III: Comparison of lung function test between manufacturing and administration workers

Variables	Manufacturing (N=84)	Administration (N=84)	z value	p value
	Median (IQR)	Median (IQR)		
FVC%	85.60 (17.97)	90.95 (15.14)	- 2.359	**0.018***
FEV_1%	87.02 (19.08)	93.73 (15.51)	- 3.015	**0.003***
FEV_1/ FVC%	103.18 (7.44)	103.25 (5.59)	- 0.692	0.489

Mann Whitney U test
*Significant p < 0.05

Table IV: Lung function abnormalities for manufacturing and administration workers

Variables	Manufacturing (N=84)	Administration (N=84)	PR 95%CI	*PR 95% CI
	Number (%)	Number (%)		
FVC%				
Abnormal	22 (26.2)	7 (8.3)	**3.903*** (1.565-9.735)	**3. 821** (1.524-9.583)
Normal	62 (73.8)	77 (91.7)		
FEV_1%				
Abnormal	18 (21.4)	4 (4.8)	**5.455*** (1.760-16.909)	**5.161** (1.654-16.102)
Normal	66 (78.6)	80 (95.2)		
FEV_1/FVC%				
Abnormal	-	-	-	-
Normal	84 (100)	84 (100)		

Logistic Regression
*Significant PR > 1, 95% CI
*Adjusted PR for smoking status

and FEV_1% (PR=5.455, 95% CI=1.760-16.909). After adjusting for smoking status, the PR for abnormalities of lung function among manufacturing workers compared to that of the administration workers was still significantly higher with FVC% (PR=3.821, 95% CI=1.524-9.583) and FEV_1% (PR=5.161, 95% CI=1.654-16.102).

Fractional Exhaled Nitric Oxide (FENO)

The result in Table V shows that there are significant difference of Fractional Exhaled Nitric Oxide (FENO) between manufacturing workers and administration workers ($\chi 2=6.303$, $p<0.05$). FENO level was reported to be significantly higher among manufacturing workers with four (16.7%) workers recorded high level of FENO, seven (29.2%) workers recorded intermediate level of FENO and 13 (54.2%) workers recorded normal level of FENO. The administration workers recorded four (16.7%) for intermediate level of FENO and 20 (83.3%) for normal level of FENO.

Table V: Comparison of FENO level between manufacturing and administration workers

Variables	Manufacturing (N=24)	Administration (N=24)	χ^2	p-value
	Number (%)	Number (%)		
FENO Concentration (Level)				
>50 ppb (High)	4 (16.7)	0 (0)	6.303	**0.043***
25-50 ppb (Mediate)	7 (29.2)	4 (16.7)		
<25 ppb (Low)	13 (54.2)	20 (83.3)		

Chi Square test
*Significant p < 0.05

Correlation between age, respirable dust, and working duration with lung function levels

Age of the workers had a significantly positive and weak relationship with FEV_1 and FEV_1/FVC% among all respondent of cement industrial workers (r= 0.222, p=0.004) for FEV_1 and (r=0.169, p=0.029) for FEV_1/FVC%. There was a significantly positive and weak relationship between working duration and FEV_1/FVC% (r=0.156, p=0.044) on all respondent of cement industrial workers. However the exposure to PM2.5 had a significantly negative and fair relationship with FVC% of manufacturing workers (r=-0.360, p=0.05). The results were reported as in Table VI.

Table VI: Correlation between age, respirable dust, and working duration with the lung function levels

Correlation	Manufacturing (N=84)		All respondents (N=168)	
	r value	p value	r value	p value
Age				
FVC%	0.046	0.676	0.136	0.079
FEV_1%	0.061	0.582	**0.222**	**0.004***
FEV_1/FVC%	0.019	0.866	**0.169**	**0.029***
Working Duration				
FVC%	0.036	0.742	0.042	0.585
FEV_1	0.088	0.427	0.121	0.117
FEV_1/ FVC%	0.055	0.617	**0.156**	**0.044***
Respirable Dust	**(N= 29)**		**(N=58)**	
FVC%	**- 0.360**	**0.05***	0.070	0.604
FEV_1%	- 0.314	0.097	0.030	0.824
FEV_1/ FVC%	0.002	0.990	-0.124	0.354

Spearman Rho
*Significant p < 0.05

Association between smoking status and lung function and respiratory symptoms

Previously, FVC% and FEV_1% showed a significant difference between manufacturing and administration workers. For the symptoms, cough showed significant prevalence among manufacturing workers compared to administration workers. Smoking contributes to the high prevalence of respiratory health problem (31). However, smoking and non-smoking is not significantly associated with FVC%, FEV_1% and cough among manufacturing and administration workers as in Table VII.

Table VII: Effect of smoking on workers lung function and respiratory symptoms

Smoking Status	Variables	Manufacturing (N=84)	Administration (N=84)	χ^2	PR 95% CI
		Number (%)	Number (%)		
Smoking	**FVC%**				
	Abnormal	12 (26.7)	3 (8.6)	4.232	0.258
	Normal	33(73.3)	32 (91.4)		(0.066-1.000)
	FEV_1%				
	Abnormal	9(20.0)	4 (11.4)	1.063	0.516
	Normal	36(80.0)	31(88.6)		(0.145-1.841)
	Cough				
	Yes	12 (26.7)	5(14.3)	1.803	0.458
	No	33(73.3)	30(85.7)		(0.144-1.454)
Non-Smoking	**FVC%**				
	Abnormal	4(10.3)	9 (18.4)	1.135	1.969
	Normal	35(89.7)	40 (81.6)		(0.557-6.956)
	FEV_1%				
	Abnormal	3(7.7)	6(12.2)	0.490	1.674
	Normal	36(92.3)	43(87.8)		(0.391-7.173)
	Cough				
	Yes	12(30.8)	8 (16.3)	2.579	0.439
	No	27(69.2)	41 (83.7)		(0.159-1.215)

Chi Square test
*Significant PR > 1, 95% CI

DISCUSSION

Contributing Factors

According to American Thoracic Society, lung function and airway inflammation are greatly influenced by age, weight, height and smoking status (6). Working duration could also be one of the factors which greatly influences both test results. The age, height and weight for the manufacturing workers and administration workers were not significantly different, thus these factors were successfully controlled. Besides, the smoking status and working duration between those study groups showed no significant difference. It is important to control the smoking status of the respondents as suggested by a number of previous studies. This is due to the fact that smoking might aggravate the adverse effect of cement dust on the workers' lung function. (3,16).

Personal exposure level (respirable dust)

According to Factories and Machinery (Mineral Dust) Regulations 1989 (12), the permissible exposure limit for average of 8 hours working period for respirable dust is 5 mg/m^3. Cement dust was prescribed as one of the mineral dust under this regulation. Considering on the cement exposure on the workers, an assessment of contaminant exposure was conducted to determine the workers' personal exposure in full period of single sample. The number of respondents involved in this personal exposure level monitoring were 29 from manufacturing and 29 from administration. This selection of respondents was based on the Guidelines on Monitoring of Airborne Contaminant for Chemicals Hazardous to Health by Department of Occupational Safety and Health (5). Representatives with homogeneous risk from each department were selected to represent the exposure. From the statistical analysis, it was discovered that there was a significant difference in personal exposure level of respirable dust between manufacturing and administration workers (z=-2.527, p = 0.012). The median for exposure level of respirable dust among manufacturing workers were 2.68 (5.90) mg/m^3. However, the number of workers who exceeded Permissible Exposure Limit (PEL) were 10 persons over 29 of the study sample with 34.5% and ranged between 0.351-10.60 mg/m^3. Kakooei *et al*., (2011) informs that in a cement factory in Iran, the mean air concentration of respirable dust of the exposed group was 11.96 mg/m^3 (11), which exceeded the recommended threshold limit value (TLV) based on the American Conference of Governmental Industrial Hygienists (1). Meanwhile, a local study by Noor et al., (2000) in Rawang found that the highest exposure group was exposed in the working environment to cement particles with 8049.86 µg/m^3 of a fine dust, which is almost 54 times higher than the recommended limit set by the country (16).

This shows that the manufacturing workers were highly exposed to the cement particles than the administration workers. Additionally, the manufacturing workers were directly exposed to the higher concentration of cement dust while working compared to the administration workers who work in a closed office equipped with proper ventilation system. The median for exposure level of respirable dust among the administration workers was 1.88 (2.27) mg/m^3. However, the administration workers had eventually exceeded 6.9% of the permissible exposure limit with the range between 0.029-5.63 mg/

m^3. This happened due fact that the office building was located near to the cement manufacturing process where this respirable particle had been blown through windows and automatic doors, then trapped inside the building. The administration workers were also be exposed to cement dust during break hour as they have to walk through the cement process to go to the cafeteria and also prayer room. Besides, administration workers spend sometimes in a plant, and this is not avoiding them from the dusty atmosphere. For instance, the officers who handle production, mechanics, quality control, and inventory. These officers are required to enter the production area for inspection or during emergency.

Prevalence of respiratory health symptoms

The respiratory health symptoms were assessed by using a validated questionnaire adapted from American Thoracic Society for adults. The questions asked included socio-demographic, socioeconomic, respiratory health history, dietary, exposure history, also smoking status. Respiratory health history comprises of the workers history on cough, phlegm, wheezing and chest tightness.

The results obtained shows that the workers in both groups mostly experienced phlegm followed by cough. The number of phlegm occurrence was 30 (35.7%) among the manufacturing workers and 23 (27.4%) among the administration workers while the number of cough occurrence was 25 (29.8%) among the manufacturing workers and 13 (15.5%) among the administration workers. However, only cough shows significantly positive association with exposure on the manufacturing workers (PR=2.314, 95% CI=1.089-4.918) and after adjusted for smoking status, the results show an increasing number of PR (PR=2.400, 95% CI=1.119-5.147).

Thus, the manufacturing workers were of 2.4 times higher risk to develop cough as compared to the administration workers after adjusted smoking status. A previous study by Noor *et al*., (2000) also found that cough was significantly higher among the exposed group than the control group (16). About 25% of the workers who were directly exposed to cement dust were reported for having cough compared to the 5.7% from the control group. A similar result was also obtained by Zeleke *et al*., (2010), where chronic cough was significantly higher in prevalence than control (27). The increased in the prevalence of cough caused by high dust exposure, which was caused by the re-suspension of dust particles during the shoveling of dust. This activity may produce a continuous supply of dust to the breathing zone area, thus affecting the workers by depositing in the upper part of the airway. Many findings have supported that cement dust exposure and adverse respiratory health effects such as chronic cough reported higher prevalence among exposed cement dust workers compared to control (3, 9, 28).

Comparison of lung function test

There were significantly lower FVC% and FEV1% for manufacturing workers compared to the administration workers with $p<0.05$. A previous study by Al Neaimi *et al*., (2001) demonstrated that the ventilatory functions (FVC%, FEV_1%) were significantly lower in the cement mill workers compared with administration group (3). A similar study was also found by Poornajaf *et al*., (2010) where the results indicated that the exposed workers had significantly lower ventilator indices of FVC, FEV_1, and FEV_1/FVC than the control group with 35.7% of the exposed workers had abnormality in lung function compared to 5.7% of those unexposed (20). Meanwhile, this study found that about 26.2% of FVC% and 18% of FEV_1% develop abnormalities of lung function among manufacturing compared to 8.3% of FVC% and 4% of FEV_1% from administration workers.

The reduction of lung function occurs mostly among manufacturing workers compared to administration workers, as the statistical analysis was found that manufacturing workers were positively associated with the increasing of abnormalities of FVC% (PR=3.903, 95% CI=1.565-9.735) and FEV_1% (PR=5.455, 95% CI=1.760-16.909). Besides, after adjusting for smoking status, the PR for abnormalities of lung function was significantly increased and positively associated with the manufacturing workers exposure with FVC% (PR=3.821, 95% CI=1.524-9.583) and FEV_1% (PR=5.161, 95% CI=1.654-16.102).

The abnormalities of the lung were indicated by FVC% and FEV_1%. The restrictive disorder occurred when FVC% and FEV_1% was reduced to <80% while the FEV_1/FVC% ratio was normal at >70%. The obstructive disorder occurred when FEV_1% was reduced to less than 80% and FVC% was usually reduced to less than 80% but not lesser than FEV_1% while the FEV_1/FVC% ration was reduced to <70%. From the PR, the manufacturing workers were 3.8 times more likely to get a restrictive disease (FVC %) and 5.1 times more likely to get chronic obstructive disease (FEV_1%). Some studies revealed that the exposure of cement dust particles led to obstructive lung changes (15,16,26). Manufacturing workers have a higher tendency to experience a decreased lung function level because of their directly exposure with the dust particle while working as compared to the administration workers who were indirectly exposed. The reduction of lung function level could possibly be associated with the exposure regarding their work activities (3,7,11,14).

Fractional Exhaled Nitric Oxide (FENO)

The procedure of Fractional Exhaled Nitric Oxide (FENO) test was conducted by using NIOX MINO devices with the interpretation by American Thoracic Society (6) whom recommended that if the concentration of FENO is less than 25ppb in adults, this shows that the person

is a normal and less likely of having inflammation and responsiveness to corticosteroids. However if the person has more than 50ppb of FENO concentration, this indicates that they are likely having inflammation and responsive to corticosteroids. Besides, the concentration of FENO between 25 to 50ppb means that the person is considered to have intermediate inflammation and responsive to corticosteroids.

FENO was recorded higher among manufacturing workers compared to administration workers. 16.7% of the respondents among manufacturing workers were recorded to have high level of FENO which was above 50ppb whereas none of the administration workers had more than 50ppb. Meanwhile, 29.2% of the manufacturing workers had intermediate level of FENO compared with 16.7% on administration workers.

According to Meo *et al*., (2013), the level of FENO significantly increased with the increase of dust exposure among cement mill workers compared to control (14). They found that the mean concentration of FENO among the exposed group was 31.71 ± 2.96 ppb while the control group was 25.39 ± 2.46 ppb. Besides that, the exposure to gas and dust for at least 1 year would induce an early sign of upper and lower airway inflammation by increasing the alveolar concentration of Nitric Oxide (23,25). All the studies above coincide with this finding which discovered that the manufacturing workers who were directly exposed to dust may induce an airway inflammation (7,23,25).

Correlation between age, respirable dust, and working duration with the lung function levels

Working duration is usually in line with the increment of age. Age and working duration had significantly positive but weak relationships of FEV_1/FVC% among all respondents of cement industrial workers (r=0.169, p=0.029) and (r=0.156, p=0.044) respectively. This can be interpreted as the increasing of age and working duration has a weak relationship with the increase of lung function levels (36,37). Various studies revealed the difference in observation of age dependent to the changes of human lung function (35,39). Male coal miners who were highly exposed to dust had no difference of FEV_1 and FVC levels in workers of the age 34-40 years (19). Lung function levels were not consistently decrease over-age either among the smokers and non-smokers, whereas 40% shows a significant slope either positive or negative (22).

Age plays important role in lung function test, as maximum lung growth appears in after the 20s or 30s, hence, will slowly decline the lung function forced vital capacity (FVC) and forced expiratory volume-one second (FEV_1) (10). However, lung will remain stable around 5-10 years or more and start declining in later adulthood (19). A study from Meo *et al*., (2013) state that the exposure for more than 10 years to cement dust prominently decreased the pulmonary function (14). The decreasing lung function levels were caused by the decreasing of elastic recoil and stiffening of lung tissue that were associated with aging. Pruthi and Multani., (2012) found that as the age increase, this will decline the FVC and FEV_1 in 5 aging stage of adults between 25 to 75 years old (21). Age can be confounding factors that may affect lungs especially in children. However, the data regarding FENO in adults were inconsistent (8,18).

The exposure to respirable dust was found to have a significantly negative and fair relationship with FVC% of manufacturing workers (r=-0.360, p=0.05). This means that with the increasing concentration of respirable dust will cause the reduction of lung function level. Therefore, this indicates that the higher magnitude of respirable cement dust exposure may increase the risk of lung impairment. This coincides with the study on personal exposure measurements who exceed the exposure limits among workers showed lower lung function parameter with 49% compared to control workers (20). Continuous exposure with higher concentration of respirable dust will likely decrease the FVC%. There are 34.5% of the respondent among manufacturing workers had exceeded the permissible exposure limit for respirable dust concentration thus this were significantly correlated with the decreasing of lung function level even after adjusting for smoking status. The deposition of the unwanted particle such as $PM_{2.5}$ in the bronchial tree restricts their lung to fully exhale by reducing their FVC thus declining the lung function status (17). The exposure to air pollutant in occupational setting and environment decline the lung function levels by predictors of FEV_1 (19). The usage of personal respiratory protection while working in a highly dusty working place reduced dynamic lung volume where the effect of the exposure might be worse due to the high respirable dust exposure of 0.351-10.60 mg/m^3. The decrease of association between the reduction of FVC and cement exposure was caused by the different usage of personal respiratory protection (17).

Association between smoking status and lung function and respiratory symptoms

FVC%, FEV_1%, and cough were not significantly associated with smoking and non-smoking status among manufacturing and administration workers. The risk of getting FVC% and FEV_1% were not different after adjusting for smoking status. This shows that smoking status did not increase the risk of respiratory health problem among cement workers. The reducing of pulmonary function was not significantly affected by the smoking habits (32). Various studies suggested that smoking might increase the prevalence of lung function level among cement workers, however, the finding was showed contradictory whereas the chronic exposure to cement dust ($PM_{2.5}$) was indeed affected to lung function (15,16,33).

CONCLUSION

The study found that personal exposure to respirable cement dust increased the risk of lung impairment by highly developing respiratory health symptoms, reducing lung function level also increasing the high level of FENO among highly exposed workers. The number of the manufacturing workers who had a cough was 25 (29.8%) thus, 2.4 times higher risk to develop cough compared to the administration workers. While the percentage of these workers who got phlegm, wheezing and chest tightness were higher compared to the administration workers of 35.7%, 19.0% and 15.5% respectively. The tendency for the manufacturing workers to get restrictive disease (FVC %) and chronic obstructive disease (FEV_1%) were 3.8 and 5.1 times more likely as compared to the administration workers. The FENO level which indicates an airway inflammation was significantly higher among manufacturing workers with 16.7% was found having high level concentration of FENO and 29.2% was found have mediate level concentration of FENO.

The impairment of lungs usually depends on direct or indirect exposure of cement dust particles. However, some of the factors also need to consider physical activities, types of diet, medicine and supplement also the level of awareness and knowledge. Those factors may or may not influence the respiratory health level and lung function impairment.

Cement particles contain variety of pollutants, eventually the direct impact on respiratory disease causes by specific-related pollutant was not assessed in this study. Particles contain in cements dust might be an absolute testament of the respiratory problem among workers.

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