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The Effect of Cement Dust Exposure on Lung Function among Cement Factory Workers

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Previous studies reported equivocal results about effects of cement dust on the lung. The objective of the present study was to assess the impact of cement dust on the respiratory health of exposed workers. A cross-sectional study was conducted on 300 cement exposed production workers from the crusher and packing sections, and 303 controls not exposed to any noxious materials that could affect their chest. All subjects were asked personal, occupational and BMRC questionnaire on respiratory symptoms and smoking habits. Forced spirometry and anthropometry were conducted on each subject. Multiple linear regression as well as other statistical tests were used. The level of significance for the present study was considered 0.05. Chronic cough was significantly more encountered among the cement exposed workers (22.7%), compared to the unexposed workers (13.9%) where p-value was < 0.005. Chronic bronchitis was, also, significantly more encountered among the cement exposed workers compared to the unexposed workers (19.0% and 9.9% respectively) where p-value was <0.001. Multiple linear regression analysis revealed that, after allowing for the age, height, weight and the smoking habit, the mean values of FVC, and FEV1 were significantly lower in the cement exposed workers compared to the unexposed group; and the mean value of FEV1% was higher in the cement exposed workers compared to the unexposed group. The mean values for FEF25%-75%, PEFR, FEF75, FEF50, and FEF25 were significantly lower among the cement exposed workers compared to the unexposed group. These effects in the exposed group were found duration of exposure related. It is suggested that workplace exposure to cement dust may lead to increased occurrence of chronic bronchitis and impairment of lung function. It is recommended that more effort should be implemented to protect respiratory systems of workers in cement factories.

Keywords: Cement dust; Lung function; Respiratory symptoms.

Jordan's first cement company was Jordan Cement Factories, which was founded in Amman in 1951.[1] It commissioned plants in Fuhais and Rashadiyah and soon set up a terminal at the Red Sea port of Aqaba. The recent history of the cement industry in Jordan starts in 1998. Since 1998 Lafarge has gradually increased its stake to a majority holding and the renamed Jordan Cement Company now operates as a subsidiary of Lafarge.[2] Cement is one of the most important construction materials in the world. Cement mill workers are exposed to heavy dust during different manufacturing, production, processing, packing and transporting of the finished products.[3] The production of cement is associated with the emissions of dust and particulate matter, nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), heavy metals, and volatile

organic compounds into the environment. The main mineral components of cement -alite - C3S, belite - C2S, tricalcium aluminate - C3A.

The present cement manufacturing process is composed of grinding limestone with quartz or other sources of silica (silicon dioxide (SiO2)), iron ore and other additives. The mixture is put into a rotating kiln with temperature increased to <"1450°C. The materials fused by chemical reactions to form cement clinker which is mixed with gypsum and other substances and crushed to a fine particulate powder to yield cement.[4-6] Portland cement, is a mixture of calcium oxide (60–67%), silicon dioxide (17–25%), aluminum trioxide (3–8%) and ferric oxide (0–5%).[5] The aerodynamic diameter of cement dust particles is within the respirable extent (<10 microns), so occupational exposure to cement dust leads to numerous health hazards such as acute or chronic respiratory diseases and respiratory function deficits.[6]

Pulmonary functional measurements showed significant elevated lung resistance, trans-pulmonary pressures, and functional residual capacity with decreased dynamic lung compliance and arterial oxygen tension with chronic respiratory acidosis.[7]

An association between higher cement dust levels and a reduction in ventilatory function FEV1and FEV1/FVC among roofing fiber cement workers, so they should be protected through certain employment policies and work standards. In addition, cement dust exposed workers were at high risk of developing chronic obstructive pulmonary diseases (COPD).[8]

"The harmful effect of cement dust upon living organisms consists in irritating, sensitizing and pneumoconiotic properties of its components", as cement dust provoke atrophic and hypertrophic alteration in nasal and pharyngeal mucosa and exfoliative bronchitis in animal studies. Also, the Odds Ratio (OR) of chronic bronchitis was 1.7 in the exposed workers compared to unexposed workers, in addition to the asthma. Deficiency in pulmonary ventilation were linked to the duration of mild cases of cement pneumoconiosis who were exposed for at least 10 years to high concentrations of cement dust.[9]

Though, Evidence of respiratory effect upon exposure to cement dust still uncertain, there was a direct association between respiratory malfunction and exposure to cement dust among the cement factory workers, as stated by a previous study done by Kakooei H et al. 2012; which revealed that chronic respiratory symptoms like cough, sputum, wheezing and dyspnea were more common among exposed workers compared to the unexposed workers, also there was a significant reduction in pulmonary function indices like FEV1, FVC, and FEF25-75%.[10]

The occurrence of respiratory symptoms and other respiratory airway obstruction was associated with Portland cement dust exposure since long time, in addition to laryngeal, lung cancer and dermatitis, a significant difference in pulmonary function tests were determined in a comparative study done in Malaysia (Selangor) which showed a significant reduction in FEV1% and FEF25-75% with higher prevalence of respiratory symptoms and diseases.[11]

Reduction of ventilatory lung functions were related to chronic exposure to Portland cement dust in many previous studies, and lead to chronic respiratory symptoms. However, the significance of respiratory illnesses and lung function deterioration has not been regularly related directly with the degree of exposure. Prolonged cough, phlegm, wheeze, bronchitis, sinusitis, shortness of breath and bronchial asthma were found to be significantly higher among the exposed workers compared to the unexposed, in addition to the significantly lower pulmonary function indices VC, FVC, FEV1, FEV1/VC, FEV1/FVC and PEF compared with unexposed workers. These adverse respiratory health effects noticed among cement workers could not be explained by other confounding and explanatory variables like age, BMI and smoking, which highly suggested being due to cement dust exposure.[12]

Respiratory tract disorders are the most important group of occupational diseases associated with a major risk in cement industry, Neghab M, and Choobineh A, 2007 compare male workers with current exposure to cement dust with workers without present or past history of exposure to dust (referent group). Additionally, personal dust monitoring for airborne inhalable and respirable dust was carried out at different worksites. Their results showed that symptoms like cough, phlegm, wheezing and shortness of breath were significantly higher among exposed

workers. Similarly, significant reductions in the lung function indices were detected among the exposed workers.[13]

On the other hand, a systematic review study discusses the confirmation of a relationship between cement dust exposure and respiratory effects among cement workers using (MEDLINE and Embase). Cross-sectional studies show reduced lung function levels at or above 4.5 mg/m^3 of total dust and 2.2 mg/m^3 of respiratory dust. Cohort studies accounted a high yearly decrease in FEV1/FVC for exposed workers. A dose-response relationship between exposure and decline in lung function has only been shown in 1 cohort. Lack of study power, adjustment for possible covariates and confounders are limitations of the included studies. Finally, their study stated that no definite conclusions indicating a causal relationship.[4]

Association between exposure to Portland cement dust and respiratory effects needs to be more scrutinized to control for the healthy worker effect and lacking of complete exposure information to reduce the selection bias in a cross-sectional study in long-term exposed Norwegian cement plant workers. The mean pulmonary function indices and the prevalence of respiratory symptoms were comparable for both exposed workers and controls. Additionally, dose-response relationship was not established. These findings were not consistent with the assumption that exposure to cement dust has a harmful impact on lung function or respiratory health.[5] Chronic respiratory symptoms as chronic cough, chronic phlegm, wheezing, chest pain and dyspnea, are developed due to occupational exposures to airborne cement dust.[14] The respiratory impairment and prevalence of respiratory symptoms amongst suffering workers have been described as a "Cement factory lung disease".[3,15]

In Jordan even though the cement industry is extensively increasing, the study of respiratory symptoms and pulmonary function deterioration is so limited and safe protective measures application in factories are neglected.[16]

Aim of the work

The main aim was to study the impact of exposure to cement dust on the prevalence of respiratory symptoms and impairment of lung function among exposed workers. It was also intended to study relation between duration of exposure to cement dust and these variables.

SUBJECTS AND METHODS

This is a cross section study, where all available field workers in Rashadiyah cement factory (Tafilah Governorate, Jordan) were included in the study (total number was 300 workers). A total of 303 workers not exposed to noxious materials that could affect their chest were selected randomly from among men in a research project conducted by the main author. Both cement exposed workers and unexposed workers were asked a personal and occupational questionnaire, in addition to the medical research council questionnaire on respiratory symptoms.[17]

Forced spirometry was conducted on each subject in the study. Lung function indices derived from time-volume curve and flow-volume curve were recorded for each worker. They included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory volume in one second as percent of FVC (FEV1%), peak expiratory flow rate (PEFR), forced expiratory flow between 25% to 75% of FVC (FEF25-75), forced expiratory flow at 75% of FVC (FEF75), forced expiratory flow at 50% of FVC (FEF50%), and forced expiratory flow at 25% of FVC (FEF25). Lung function measurements were conducted according to standard techniques and maneuvers.[18]

Anthropometric measurements were conducted according to standard techniques and maneuvers.[19]

Data were analyzed using SPSS/pc (IBM version 22), where simple and multi-factorial statistical tests were employed. Results were considered significant if the p value was less than 0.05.[20]

Ethical consideration

The research protocol was approved by the Research Ethics Committee of the Faculty of Medicine; Mutah University. Moreover, informed Verbal and written consent were obtained from all participants after explaining the aim of the study. Privacy and confidentiality of the information was assured.

RESULTS

The mean age of exposed group was 34.02 years (± 8.56 years), while mean age of unexposed groups was 33.6 years (± 8.57 years). These differences were not statistically significant where t-test was 1.41, and p value was 0.235. The mean duration of exposure of the workers to cement dust ranged from 2 to 12 years with mean of 7.81 years. The proportions of smokers and ex-smokers were significantly higher among unexposed workers (54.5% and 65.2% respectively), compared to cement exposed workers (45.5% and 34.8% respectively); where X^2 was 12.69, and p-value 0.002 (table 1).

The present study revealed that chronic cough was significantly more encountered among cement exposed workers (22.7%), compared to unexposed workers (13.9%) where p-value was 0.005. Chronic bronchitis as diagnosed by reference to the British Medical Research Council (BMRC)[17] Questionnaire on respiratory symptoms was also, significantly more frequent among cement exposed workers compared to unexposed workers (19.0% and 9.9% respectively) where p-value was 0.001 (table 1).

Tables 2 and 3 display the correlation/ regression relationships between exposure to cement dust and lung function indices. The effects of age, smoking, weight and height were allowed for. The mean values of FVC and FEV1 in cement exposed workers were significantly lower than those for unexposed workers (B: - 0.678, and -0.619 respectively); on the other hand, the mean value of FEV1% for the unexposed workers was significantly lower than the latter one (B: 5.281). Table 2 and 3 revealed, also, that the mean values of the indices of caliber of large airways (PEFR and FEF75), medium sized airways (FEF25-75, and FEF50) as well as small airways (FEF25) in the cement exposed workers compared to the unexposed ones (B: -1.024, -0.982, -0.661, -0.748, and -0.395 respectively).

Tables 4 and 5 demonstrate the correlation/ regression relationships between duration of exposure to cement dust in years and lung function indices after allowing for the effects of age, smoking, weight and height. Increased duration of exposure to cement dust was significantly associated with decreased FVC and FEV1 (B: - 0.085, and -0.078 respectively); on the other hand, it was significantly associated with increased FEV1% (B: 0.640). Table 2 and 3 revealed also, that increased duration of exposure to cement dust was significantly associated with decease in the indices of caliber of large airways (PEFR and FEF75),

Table 1. Distribution of cement exposed workers and controls according to prevalence of respiratory symptoms

Variables	Non-Exposed		Exposed		
	Number	%	Number	%	X^2 (p-value)
Smoking Habit					12.69 (0.002)
Smoker	170	54.5%	142	45.5%	
Ex-Smoker	30	65.2%	16	34.8%	
Non-Smoker	103	42.0%	142	58.0%	
Chronic Cough					
Yes	42	13.9%	68	22.7%	7.84 (0.005)
No	261	86.1%	232	77.3%	
Chronic Phlegm					
Yes	60	19.8%	78	26.0%	3.281 (0.070)
No	243	80.2%	222	74.0%	
Chronic Bronchitis					
Yes	30	9.9%	57	19.0%	0.11 (0.001)
No	273	90.1%	243	81.0%	
Bronchial Asthma					
Yes	17	5.6%	29	9.7%	3.56 (0.059)
No	286	94.4%	270	90.3%	

Table 2. Correlation regression relationship between exposure to cement dust and FVC, FEV1, FEV1% and PEFR after allowing for age, smoking habit, weight and height

Lung Function Indices	FVC		FEV_1		FEV_1%		PEFR	
	β	t- test (p)	β	t- test (p)	β	t-test (p)	β	t- test (p)
Constant	-0.223	-0.377(0.706)	.395	0.68(0.49)	1.951	0.072(0.943)	-0.261	-0.126(0.900)
Age(Years)	-0.022	-8.152(0.000)	-0.023	-8.67(0.000)	-0.788	-6.284(0.000)	-0.001	-0.146(0.844)
Smoking(Yes, No)	-0.051	-1.113(0.266)	-0.047	-1.05(0.29)	-2.805	-1.347(0.179)	-0.538	-3.377(0.001)
Weight(Kgs)	0.003	1.593(0.112)	-0.002	-0.95(0.34)	-0.110	-1.293(0.196)	0.004	0.682(0.496)
Height(Cms)	0.029	8.278(0.000)	.027	7.67(0.000)	0.873	5.366(0.000)	0.053	4.288(0.000)
Exposure(Yes, No)	-0.678	-14.84(0.000)	-0.619	-13.79(0.000)	5.281	2.525(0.012)	-1.024	-6.408(0.000)

Table 3. Correlation regression relationship between exposure to cement dust and FEF25-75, FEF75, FEF50 and FEF25 after allowing for age, smoking habit, weight and height

Lung Function Indices	FEF_{25-75} β	FEF_{75} t- test (p)	FEF_{50} β	FEF_{25} t- test (p)	β	t- test (p)	β	t- test (p)
Constant	2.423	1.707(0.088)	0.679	0.3200.749	3.306	1.975(0.049)	1.775	1.890(0.059)
Age(Years)	-0.034	-5.113(0.000)	-0.008	-0.8000.424	-0.031	-4.035(0.000)	-0.026	-6.035(0.000)
Smoking(Yes, No)	-0.133	-1.222(0.222)	-0.430	-2.6360.009	-0.164	-1.276(0.202)	-0.034	-0.476(0.634)
Weight(Kgs)	-0.008	-1.867(0.62)	0.000	-0.0720.943	-0.007	-1.289(0.198)	-0.008	-2.839(0.005(
Height(Cms)	0.029	3.450(0.001)	0.047	3.7090.000	0.027	2.667(0.008)	0.017	3.016(0.003)
Exposure(Yes, No)	-0.661	-6.035(0.000)	-0.982	-6.0020.000	-0.748	-5.787(0.000)	-0.395	-5.457(0.000)

Table 4. Correlation regression relationship between duration of exposure to cement dust and FVC, FEV1, FEV1% and PEFR after allowing for age, smoking habit, weight and height

Lung Function Indices	FVC β	FEV_1 t- test (p)	FEV_1% β	PEFR t- test (p)	β	t-test (p)	β	t- test (p)
Constant	-0.147	-0.246(0.806)	0.462	0.789(0.430)	2.049	0.075(0.940)	-0.037	-0.018(0.986)
Age(Years)	-0.023	-8.874(0.000)	-0.024	-8.878(0.000)	-0.783	-6.240(0.000)	-0.002	-0.215(0.798)
Smoking(Yes, No)	-0.052	-1.133(0.258)	-0.048	-1.069 (0.286)	-2.816	-1.351(0.177)	-0.542	-3.410(0.001)
Weight(Kgs)	0.003	1.759 (0.079)	-0.001	-0.790(0.430)	-0.112	-1.313(0.199)	0.005	0.772(0.440)
Height(Cms)	0.029	8.095 (0.000)	0.026	7.67(0.000)	0.873	5.349(0.000)	0.052	4.176(0.000)
Duration Exposure (Years)	-0.085	-14.699(0.000)	-0.078	-13.79(0.000)	0.640	2.415(0.016)	-0.133	-6.557(0.000)

Table 5. Correlation regression relationship between duration of exposure to cement dust and EF25-75, FEF75, FEF50 and FEF25 after allowing for age, smoking habit, weight and height

Lung Function Indices	FEF_{25-75} β	FEF_{75} t- test (p)	FEF_{50} β	FEF_{25} t- test (p)	β	t- test (p)	β	t- test (p)
Constant	2.575	1.8110.071))	0.916	0.4310.666	3.514	2.097(0.036)	1.835	1.948(0.052)
Age(Years)	-0.034	-5.223(0.000)	-0.009	-0.9030.376	-0.032	-4.143(0.000)	-0.027	-6.128(0.000)
Smoking(Yes, No)	-0.136	-1.252(0.211)	-0.435	-2.6700.008	-0.169	-1.314(0.189)	-0.035	-0.409(0.624)
Weight(Kgs)	-0.008	-1.782(0.075)	0.000	-0.0160.988	-0.006	-1.201(0.230)	-0.008	-2.769(0.006(
Height(Cms)	0.028	3.341(0.001)	0.046	3.5960.000	0.026	2.546(0.011)	0.017	2.943(0.003)
Duration Exposure (Years)	-0.086	-6.192(0.000)	-0.128	-6.1790.000	-0.098	-6.018(0.000)	-0.050	-5.457(0.000)

medium sized airways (FEF25-75, and FEF50) as well as small airways (FEF25), (B: -6.557, -0.128, -0.089, -0.098, and -0.050 respectively).

DISCUSSION

Portland cement, is a mixture of calcium oxide (60–67%), silicon dioxide (17–25%), aluminum trioxide (3–8%) and ferric oxide (0–5%).[5] The aerodynamic diameter of cement dust particles is within the respirable extent (<10 microns), so occupational exposure to cement dust leads to numerous health hazards such as acute or chronic respiratory diseases and respiratory function deficits.[6] The cement dust emissions are not only deteriorating air quality but also destruct the human health. Emissions have local and global environmental impact resulting in global warming, acid rain, ozone depletion, biodiversity loss and decreased crop productivity.[15]

Thus, the present study was conducted to investigate the association between exposure to cement dust and occurrence of respiratory symptoms and impairment of lung function. The current research revealed that, after allowing for the effect of smoking, chronic cough and chronic bronchitis were significantly associated with cement dust exposure ($p < 0.05$). These findings were consistent with previous studies.[10, 12-14] Previous studies reported increased frequency of phlegm production, asthma and lung infections among cement exposed workers.[21,13] This was not in line with findings from the present study. The association between cement dust exposure and impairment of lung function is equivocal.[5, 12, 22]

However, in the present study cement dust exposure was significantly associated with decrease in mean values of FVC and FEV1, PEF, FEF75%, FEF50% and FEF25% ($p <0.05$). These changes were significantly associated with increased duration of exposure. This is in line with other studies. [6, 9. 13. 23,24.]

In immuno-compromised COVID, lung infection is associated with a significant incidence of secondary infections. The finding stated that cement particle exposure or inhalation causes respiratory complications and its accumulation in the lung causes epithelial damage, atypia, squamous metaplasia, acute inflammatory infiltrated cells and chronic inflammatory infiltrated cells were detected. [25, 26] So, service training, smoking cessation programs, improving hygienic practices are important tasks in order to maintain the health and safety of workers.

CONCLUSION AND RECOMMENDATIONS

The present study suggested that environmental exposure to cement dust may lead to higher occurrence of chronic respiratory symptoms and to mixed impairment of ventilatory function. This could be due to existence of quartz in raw material of cement dusts. It is recommended that more effort should be done to protect respiratory systems of workers in cement factories.

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Conflict of interest

No financial interest or other conflict of interest.

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