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RESPIRATORY MORBIDITY AND VENTILATORY FUNCTION IMPAIRMENT AMONG CEMENT FACTORY EMPLOYEES

Giridharan S*, Shankar S
Department of Community Medicine, Trichy SRM Medical College Hospital and Research Centre, Tiruchirapalli, India (Affiliated to The Tamilnadu Dr. M.G.R. Medical University, Chennai, India)

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Corresponding author: Dr. S. Giridharan
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Abstract

Background: Cement is one of the most important building materials of the world. More than 250 000 people work in concrete manufacturing. Cement factory workers are exposed to dust during various manufacturing and production process, such as quarrying and handling of raw materials.

Methods: This cross sectional study aims to determine the prevalence of respiratory morbidity and ventilatory function impairment among the cement factory employees and the use of personal protective equipment (PPE).

Results: The mean age was 33.8±11.4 and most of them belonged to 21-30 age groups. The major respiratory symptoms were shortness of breath (18%), coughing out phlegm (22%), coughing that wakes up in the morning (14%) and wheezing (6%). Though study had its focus on respiratory morbidity, a significant proportion of the workers had other chronic non communicable diseases including diabetes (37%), blood pressure (10%) and cardio-vascular diseases/symptoms (26.6%).

Conclusion: Though everyone was aware about the PPEs some lacked the use of it due to discomfort leading to lung function impairment. The percentage predicted lung volumes and the respiratory symptoms helped to create awareness about the use of PPEs and using proper ventilation systems, to protect the workers from developing chronic respiratory diseases in future.

Keywords: Cement factory workers, respiration, morbidity

Introduction

Chronic exposure to Portland cement dust has been reported to lead to a greater prevalence of acute and chronic respiratory symptoms and a reduction of ventilatory capacity. The seriousness of pulmonary function impairment and respiratory disease has not been consistently associated with the degree of exposure [1].

The main cause for these problems is the exposure to dust, while other causes include high ambient temperature and radiant heat. Frequent exposure to dust may lead to ventilator function impairment and sometimes may lead to cancer which ultimately results in death[2]. Several studies have suggested associations between cement dust exposure, chronic impairment of lung function and respiratory symptoms [2-5,6-8]. The lung function of the cement workers also decreased with the duration of employment [6].

In most of the situations, exposed workers are not using personal protective equipment of any kind during the work-shift and have stated that regular use of appropriate personal protective equipment, if available at the worksite, could protect cement workers from adverse respiratory health effects [1].

In spite of the fact that pneumoconiosis was the oldest and best known of the occupational respiratory disease, lung disease from silica exposure were reported over hundreds of years. Some studies have shown a possible relationship between cement dust exposure and the risk of COPD, but other studies have not found any increase in the prevalence of COPD among cement workers compared to controls [6]. Exposure to cement dust at the workplace is known to cause chronic respiratory ailments in the form of cough, dyspnea etc. on the exposed workers [5].

Adverse respiratory health, as identified through respiratory symptoms and ventilatory function, has not been consistently reported for Portland cement dust exposure. The long-term exposure to cement dust does not lead to greater morbidity of severe respiratory diseases [9]. These data were confirmed in another study, who reported that the prevalence of respiratory symptoms was not related to increased exposure to cement dust [10].

It was concluded that adverse respiratory health effects (increased frequency of respiratory symptoms and decreased ventilatory function) observed among cement workers could not be explained by age, BMI and smoking, and hence there were probably attributable to exposure to cement dust. By keeping all the above in mine, this study has the objectives to assess the prevalence of respiratory problems in the employees, to assess the ventilator lung function of the employees and to study the awareness about use of personal protective equipments (PPEs) in cement factory.

Methods

It is a cross sectional observational study which was carried out in a tertiary care teaching hospital at Tiruchirapalli, South India and about twenty (20) workers who had current exposure to dust were examined weekly during their annual checkup and a total of 150 workers were included. This study was conducted for a period of two months between June and August 2016. All employees who are not having previous respiratory illnesses were included and employees with previous respiratory problems before employment in cement factory were excluded. The study was reviewed and approved by Institutional Ethical Committee (IEC) [Ref: CMCH&RC/IEC-No:03 dated 15.04.2015].

The prevalence of respiratory problems and changes in the parameters of lung function were studied among the above selected workers. All the participants of the study signed an informed consent before commencement of the study. A modified respiratory medical evaluation questionnaire, suggested by American Thoracic Society [11] was given to the employees and was made to answer it. Then they were impregnated to perform the Pulmonary function tests (PFTs), including Forced Vital Capacity (FVC), Forced Expiratory Volume in the First second (FEV1), Peak Expiratory Flow (PEF), Forced Expiratory Flow between 25% and 75% of the FVC (FEF25-75%), which was measured on-site with a portable calibrated vitalograph spirometer. PFTs were performed with the assistance of a trained, skilled technician under supervision. Before the tests, subjects were made to take rest in sitting position for 5 minutes. Then, they were asked to stand in front of spirometer and a nose clip was put on. Three acceptable maneuvers with an interval of 5 minutes were performed. The best values (percentage predicted lung function) were selected for analysis.

The data were entered in Microsoft excel spreadsheet and analyzed using IBM SPPS Statistics and the results were obtained in the form of tables and percentages.

Results

The results are discussed into four phases including socio-demographic details of the employees, prevalence of respiratory problems, percentage predicted lung function and awareness of the use of PPEs.

Socio-demographic details of the employees

A total of 150 cement factory workers were interviewed, of which all of them were males and belonged to lower middle class. Most of them worked as Attender (34.6%), Fitter (32.4%) and the rest as Electrician (7%), Plumber (3%), Driver (3%), Holder (6%), shifting in weigh bridge (4%) and Maintenance (10%). About 97% of the employees worked full time for 6 months. The other socio-demographic details were vividly described.

The mean age of the study population were 33.8 ±11.4 years ranging from 20 to 54 years. Majority of the study population belonged to 21-30 years (45.3%) of age followed by 31-40 years (36.7%) (Table 1). The mean height, weight and BMI were 168.32±6.38, 71.21±11.53 and 25.11±3.73 respectively. Workers above the age of 40 years, had greater mean of weight and BMI when compared to other age groups since most of the workers belonged to the age group of 21-30 years and the mean of duration of employment was found to be 7.65±1.87.

Table 1: Age based physical characteristics of study population (n=150)

Age (in years)	Frequency (%)	Weight (mean ± S.D) (kg)	Height (mean ± S.D) (cms)	BMI (mean ± S.D) (kg)
21-30	68 (45.3)	69.13±12.08	168.72±6.30	24.29±4.11
31-40	55 (36.7)	72.00±11.16	168.35±6.33	25.36±3.39
>40	27 (18)	74.81±10.03	167.26±6.79	26.69±2.81
Total	150 (100)	71.21±11.53	168.32±6.38	25.11±3.73

The literacy status of the subjects included in the study were analyzed thereby 96% of the study population were literate and 59.3% were diploma holders. The other details were analyzed and tabulated in table 2.

Table 2: Literacy Level among the employees (n=150)

Education status	Frequency	Percentage
Illiterate	6	4
Primary school	10	6.7
High school and higher Secondary	45	30
Diploma Holders	89	59.3
Total	**150**	**100**

About 46 (30.6%) employees are current smokers and their mean of packs per day is about 1.65±1.084. The mean of years smoked is 5.8±7.3 (Figure 1).

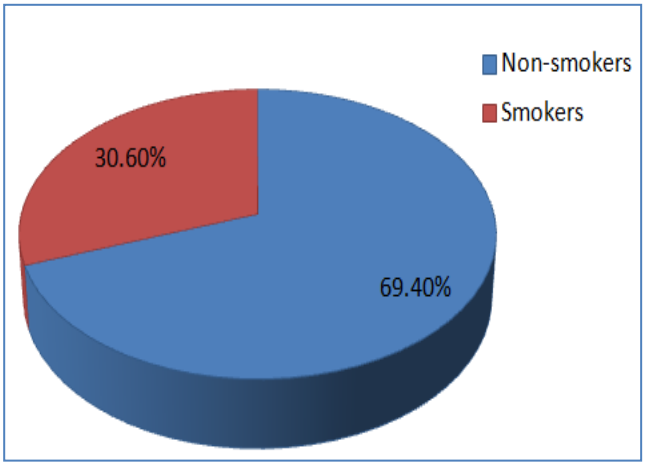

Figure 1: Habit of smoking present among the employees

Prevalence of respiratory problems

The chronic respiratory symptom noticed was shortness of breath (18%), Coughing that produces phlegm (22%), cough that wakes early in the morning (14%) and wheezing (6%). The respiratory morbidity among the subjects included in this study were analyzed and impregnated in table 3.

Table 3: Respiratory morbidity present among the employees

Respiratory morbidity	Frequency (n=150)
Shortness of breath	27 (18)
Shortness of breath when walking fast on level ground or walking up incline	22 (14.6)
Shortness of breath when walking with people at an ordinary pace on level ground	15 (10)
Stopping for breath when walking at your own pace on level ground	7 (4.6)
Shortness of breath when washing/ dressing	7 (4.6)
Shortness of breath that interferes with job	16 (10.7)
Coughing that produces Phlegm	33 (22)
Coughing that wakes early in the morning	21 (14)
Coughing that occurs mostly when lying down	12 (8)
Wheezing	9 (6)
Wheezing that interferes with job	6 (4)
Chest pain when breathed deeply	5 (3.3)

[Figures in parenthesis denoted percentages]

Non-communicable related problems

Other non-communicable diseases noticed among the study group include Diabetes (37%), asthma (3%), and other CVS problems (26.6%) such as Angina (16.6%) and Hypertension (10%). Medication was taken by some for lung problems (10.67%) and elevated blood pressure (5.3%). Among the workers, 21 (31.5%) had frequent pain or tightness in the chest among which 11 (7.3%) of them had it during physical activity and also interfered with job while none of them had any other CVS symptoms such as heart skipping a beat and heartburn.

Table 4: CVS symptoms present among the employees

CVS symptoms	Frequency (n=150)
Frequent pain or tightness in chest	21 (31.5%)
Pain or tightness in chest during physical activity	11 (7.3%)

Ventilator lung function

Table 5 describes the mean and standard deviation of the lung functions among the 150 employees. It has been compared with duration of employment, smoking history and age category of the employees in the consequent subheadings.

Table 5: Percentage predicted lung function among the employees

Parameter	% Predicted lung function (mean ± S.D) n=150
VC	90.24±15.70
FVC	88.47±15.4
FEV_1	85.13±16.8
FEV_1/ VC	94.57±10.62
FEV_1/ FVC	97.4±10.74
$FEF_{25-75\%}$	73.71±24.62
PEF	63.99±20.07

[Vital capacity (VC); Forced vital capacity (FVC), Forced Expiratory Volume in the First second (FEV_1), Forced Expiratory Flow between 25% and 75% of the FVC ($FEF_{25-75\%}$) and Peak Expiratory Flow (PEF)]

Lung function vs duration of employment

Based on the duration of employment which ranged from 2 to 20 years, the study population was classified into 2 groups based on median which was found out to be 7.5 years and their lung function are analyzed and compared.

1. Group 1 - below 7.5 years (75) and
2. Group 2 - above 7.5 years (75)

As years of working increased some parameters of lung function (VC, FVC, FEV_1) decreased and their difference except FEV_1 was significant, while there was no statistical difference for other lung function parameters such as FEV_1, FEV_1/VC, FEV_1/FVC, PEF, $FEF_{25-75\%}$ had no significant value.

Table 6: Lung function vs duration of employment

Lung function	Group 1 (mean ± S.D) n=75	Group 2 (mean ± S.D) n=75	t-value	p-value
VC	93.45±17.271	87.03±13.332	-2.548	0.012
FVC	91.61±16.931	85.32±13.071	-2.548	0.012
FEV_1	87.37±15.153	82.89±15.144	-1.641	0.103
FEV_1/VC	93.86±11.774	95.29±9.369	0.828	0.409
FEV_1/FVC	96.33±12.012	98.47±9.261	1.218	0.225
$FEF_{25-75\%}$	73.61±26.346	73.81±22.950	0.050	0.961
PEF	63.07±21.828	64.91±18.259	0.560	0.571

[Abbreviations as mentioned in the footnote of table 5; p value- calculated using independent sample 't' test]

Lung function vs smoking

The mean value of the lung function parameters was less among the smokers compared with that of the non-smokers except for FEV_1/VC and FEV_1/FVC. These differences in the lung volumes between both the groups were found to be statistically significant except for FEV_1/VC, FEV_1/FVC and PEF.

Table 7: Lung function among the employees vs smoking

Lung function	Smokers (mean ± S.D) n=46	Non-smokers (mean ± S.D) n=104	t-value	p-value
VC	75.01±9.131	96.97±13.088	-10.311	0.000
FVC	73.54±8.956	95.07±12.831	-10.311	0.000
FEV_1	71.57±11.492	91.13±15.249	-7.775	0.000
FEV_1/VC	95.40±9.521	94.21±11.107	0.628	0.531
FEV_1/FVC	98.39±10.410	96.96±10.906	0.751	0.454
$FEF_{25-75\%}$	63.11±22.495	78.40±24.158	-3.650	0.000
PEF	62.33±20.256	64.72±20.056	-0.672	0.502

[Abbreviations as mentioned in the footnote of table 5; p value- calculated using independent sample 't' test]

Lung function vs age

The categorized age is classified into 3 groups and their lung function is analyzed. As age increases, the mean value of their lung function parameters decreased and significant difference is noticed for FEV_1/ VC and FEV_1/ FVC. In this parameter, the study subjects were grouped into three categories as described below

1. Group 1 : 21-30 years
2. Group 2 : 31-40 years and
3. Group 3 : >40 years

Table 8: Lung function among the employees vs age

Lung function	Group 1 (mean ± S.D) n=68	Group 2 (mean ± S.D) n=55	Group 3 (mean ± S.D) n=27	t-value	p-value*
VC	93.84±19.11	89.76±15.75	89.19±14.15	0.885	0.415
FVC	92.00±18.73	88.00±15.44	87.44±13.88	0.885	0.415
FEV_1	85.96±20.36	87.65±15.22	82.76±16.19	1.332	0.267
FEV_1/VC	92.05±13.54	97.85±7.268	92.93±11.10	4.379	0.014**
FEV_1/FVC	94.52±14.37	100.35±7.63	96.16±10.83	3.613	0.029***
$FEF_{25-75\%}$	72.11±26.12	79.58±21.01	69.60±26.10	2.622	0.076
PEF	62.41±27.07	64.76±17.34	63.99±19.17	1.23	0.884

*- p value was calculated using ANNOVA test; ** - Post Hoc Analysis indicates significant in FEV1/VC against group2 (31-40 yrs) & group3 (>40yrs) and *** - Post Hoc Analysis indicates significant in FEV1/FVC against group2(31-40 yrs) & group3(>40yrs)

Safety precautions

All the employees had awareness about the safety precautions and equipments since it was major factory which followed proper guidelines. Safety training classes were available to them weekly but some (4.7%) failed to attend them due to lack of interest. None of them wore a respirator. Some of them (2.6%) did not use protective clothing and equipment due to uneasiness.

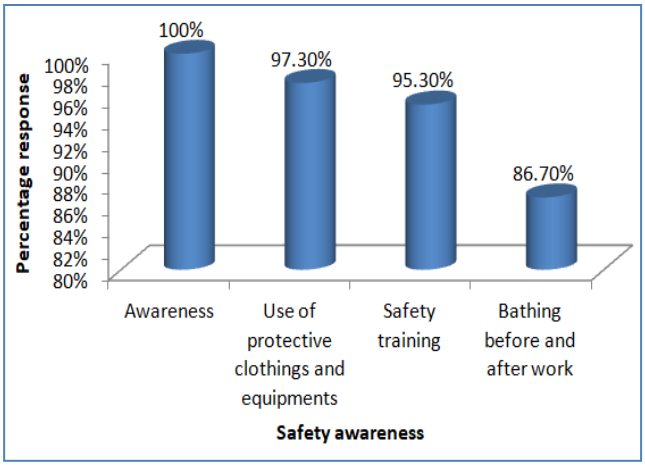

Figure 2: Safety precautions followed by the employers

About 135 (91%) wore mask and 64 (42.6%) wore goggles. All of them wore shoes which were compulsory in the factory during their work time.

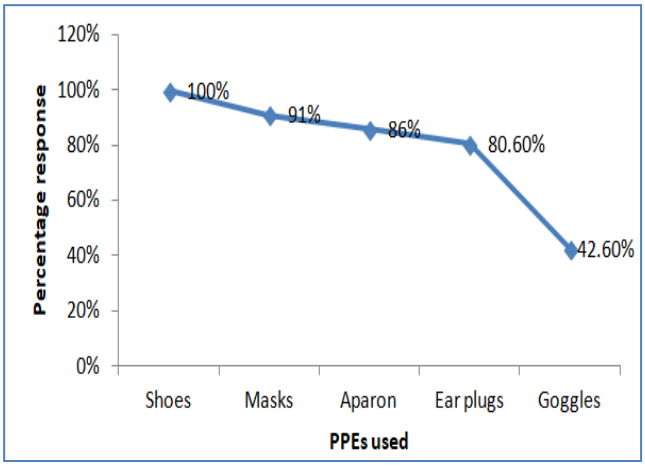

Figure 3: Percentage usage of PPEs

All of them worked in dusty conditions and most of them in humid (94%) and hot (90%) conditions during their

work time. Others who weren't exposed to these conditions mostly worked in Maintenance.

Table 9: Environmental conditions of the employees

Environmental conditions	Frequency (n=150)
Dusty	150 (100%)
Humid	141(94%)
Hot	135(90%)

Discussion

Occupational and environmental exposure to cement dust and their effects on human health is a leading respiratory health problem. Exposure to cement dust can cause various acute and chronic respiratory diseases including respiratory function impairment. In this study, all the employees were males and majority (45.3%) of the study population belonged to 21-30 years of age. Most of the workers were working as Attender and Fitter. About 96% were educated and 97% worked full time.

Prevalence of respiratory problems

The prevalence of the chronic respiratory symptoms was 54% with shortness of breath (18%), Coughing that produces phlegm (22%), coughing that wakes early in the morning (14%) and wheezing (6%). The result is similar to study conducted by Sundararaj [12] in cement factory in South India.

Kakooei et al. found no statistically significant association between cement dust exposure and respiratory symptoms in a smaller size sample [3]. Fell et al. studied 119 cement workers and 50 controls in Norway and also did not find an association between health outcomes (increased respiratory symptoms and decreased pulmonary function) and cement dust [9]. These different results could be explained by the difference of various races, exposure to dusts, duration of employment, genetic variations, accuracy of completing the questionnaire and use of personal protective equipments.

Other non communicable diseases were also present which include Diabetes (37%), asthma (3%), high blood pressure (10%) and other CVS problems (36.5%). Medication was taken also taken for lung problems (10.67%) and blood pressure (5.3%).

Percentage predicted lung volumes

Al-Neaimi et al. [1] demonstrated that the ventilatory function (FVC, FEV_1, and PEF) were significantly lower in the cement mill workers compared with unexposed subjects. Meo et al. [13] conducted a study on lung function and Surface Electromyography of intercostal muscles in cement mill workers. The study population were closely matched in terms of anthropometric variables and found significant reduction in lung function parameters, FVC, FEV_1, PEF in cement millworkers compared with controls, however, they did not report any association between lung function and duration of exposure to cement dust. Similarly, Mwaiselage et al. [4] investigated ventilatory function in cement factory workers and reported that exposed workers had significantly lower FVC, FEV_1, and PEF than controls. Nordby et al. [14] reported that Forced Expiratory Volume in the first second (FEV_1) reduced with an exposure-response relationship in the highest compared with the lowest exposure level of cement dust. Concurrently, Zelke et al. [15] found that FVC and FEV_1 were significantly reduced among the cement production workers but not among the controls. The reduction in lung function was probably associated with high cement dust exposure.

There was significant change in the VC and FVC values when compared to the workers who worked for a long duration (>7.5yrs) with short duration (<7.5yrs) while the lung function were reduced in the longer duration employed workers when compared to the short term duration workers.

In parallel to our findings, Merenu et al. [16] investigated the effect of cement dust exposure on 56 cement factory workers with a mean of 10 years exposure to cement dust on lung function. They found that the vital capacity and forced expiratory volume in one second were significantly lower in cement factory workers than in control subjects. Their results suggest that chronic cement dust exposure impairs lung function. Similarly, El Badari and Saeed [17] reported a significant reduction in FVC,FEV_1 and PEFR in cement dust exposed workers compared to control. The lung function indices were found to be reduced with increasing duration of exposure to cement dust.

Olerue reported that the lung function parameters FVC and FEV_1 were decreased with duration of employment in cement industry, but this level was not statistically significant [6]. Our results, however reveals a significant reduction in FVC and FEV1 with increased duration of occupational exposure to cement dust. A possible reason for this difference is the selection criteria. Olerue[6] selected 76 cement mill workers from a cement plant that had started production of cement only 6 years ago and grouped the cement mill workers with very little duration of exposure, into 2 groups, namely 6 to 36 months and 37 to 72 months. This duration of occupational exposure was small and it could be the reason for the non-significant difference in the lung function parameters FVC and FEV1.

Alakija et al. [18] showed that cement mill workers had a consistent decline in FVC, FEV1 and PEF with prolonged years of service in the cement industry. They also reported that workers who had less than five years of occupational exposure to the cement dust had a significantly higher FVC, FEV1 and PEF than the workers who had more than 15 years of exposure. The results of the present study are in agreement with the outcomes [18].

In this study, lung Function among the employees was compared with smoking and there is a reduction in the lung volumes in the smokers when compared to the non-smokers. There is a significant change in VC, FVC, $FEF_{25-75\%}$. As age increases there is a significant decrease in the parameters lung function such as FEV_1/VC and FEV_1/FVC.

Awareness of the use of PPE

In this study, responses from the questionnaires and interview of the workers indicate that protective measures were provided and that they were used. Thus, the observed impaired lung function may be due to the ineffectiveness of the protective gears. However, non compliance of the workers in the use of protective gears cannot be ruled out in spite of contrary questionnaire and interview responses. Thus, lung function tests may be useful in assessing the effectiveness of preventive measures such as the wearing of dust masks or compliance by workers to preventive measures. Unlike previous reports which indicate the non provision of protective gears in cement factories [1] in the developing world, the findings of the present study indicate they were provided.

Conclusion

The prevalence of chronic respiratory morbidity among workers in the cement sector in South India was significantly higher compared to the general population of the country but lower in comparison to similar workers in other developing countries from Africa and the Middle East. The morbidities could be associated to the occupational exposure among workers in the manufacturing sections, who were directly exposed to the cement dust. The duration of the job in the factory, the type of work section and the number of work hours were the important risk factors. In addition socioeconomic inequalities in terms of education, income, occupation, rural-urban divide affected the differentials in morbidity among the workers.

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