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COMBINED EFFECT OF OCCUPATIONAL DUST EXPOSURES AND CIGARETTE SMOKING ON PULMONARY FUNCTION OF ADULTS OF TRIPURA- A NORTH EASTERN STATE OF INDIA.

Biological Science

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ABSTRACT

Background: Occupational related lung diseases are most likely due to the deposition in the lung and are influenced by the type of dusts, exposure duration, concentration and the size of the dust in the breathing zone. In India, many labourers work in construction work with high involvement of stone crushing inspite of the associated health hazards. The health implications of continuous exposure to stone dust have not been studied among workers in Tripura. In the present study we assessed the pulmonary health of dust exposed construction workers of Tripura, India. **Materials and Methods:** A cross-sectional study method was used to include subjects (n =240). An informed consent form according to ICMR guideline was prepared. A complete spirogram was performed using a dry volume sensing spirometer. Forced vital capacity (FVCL), forced expiratory volume in 1 second (FEV1L), FEV1/FVC ratio, forced expiratory flow (FEF 25 – 75 %) and peak expiratory flow rate (PEFRL/Min) were recorded. T- test, ANOVA and Correlation analysis were performed using SPSS 16.0. **Results:** Higher mean values of lung function parameters in control group in comparison to exposed worker group were observed. Lung function measures showed non significant negative correlation with smoking status of subjects. Duration of dust exposure showed significant negative correlation with FVC L, FEV1 and FEF 25-75 % and non significant negative correlation with FEV1/FVC% and PEFRL/min. **Conclusion:** It might be exposure to dust containing silica in stone crushing workers leads to deterioration of pulmonary function and it is correlated with the duration of the exposure.

KEYWORDS

Dust exposure; lung function; smoking, spirometry; FVC.

INTRODUCTION:

Occupational health hazard is a major area of scientific scrutiny around the globe. Over the years, various preventive and protective measures have been suggested for different groups of workers to protect them against occupation related health hazards. Many of these measures are in practice in most of the developed countries, but in developing countries like India this area is much neglected, resulting into occupation related health risks in various groups of workers. [1] One of major form of occupational health hazard is pulmonary insufficiency in workers associated with exposure to occupational dust. [2] Several acute and chronic pulmonary diseases are caused by inhaling hazardous chemical agents at the workplace which include silica, cement, toxic particles, metal fumes etc. [3-6] This can lead to complications, such as pulmonary infections, pulmonary tuberculosis, pneumothorax, cardiac failure and hemoptysis. [7]

Construction has emerged as one of the major industrial activities in India during recent times. Many labourers associated with construction work are exposed to dust which can be a significant risk factor for workers' respiratory functions. The occupational related lung diseases are most likely due to the deposition in the lung and are influenced by the type of dusts, the period of exposure, the concentration and the size of the airborne dust in the breathing zone. [8] Studies shown that dust generated from quarries contain 71% silica which has been classified by the International Agency for Research on Cancer as a Carcinogenic agent for humans. [9,10]

Reduced lung function parameters, such as forced expiratory volume $_{(L)}$ / forced vital capacity $_{(L)}$ (FEV_1/ FVC) , peak expiratory flow rate ($PEFR_{L/min}$) due to continuous exposure to silica dust , along with airway obstruction have been reported in several construction task groups, working with materials such as concrete, ceramic and brick. [11-14]. Besides, cigarette smoking is a key lifestyle factor that affects pulmonary health. Especially heavy smoking combined with occupational contact with dust had been recently associated with various severe respiratory diseases, including lung cancer, silicosis, emphysema and tuberculosis infection. [11-14]

Manual stone crushing is one the activities associated with construction work especially in Tripura. Since no specific professional training is required and there is high level of unemployment, a large section of unskilled labourers are engaged in manual stone crushing in Tripura. To the best of our knowledge, the health implications of continuous exposure to stone dust have not been studied among such workers in Tripura.

With this background, we evaluated pulmonary function status and burden of exposure to stone dust among manual stone crushers working in construction industries in Tripura- a North Eastern state of India.

MATERIALS AND METHODS:

Study design and participants:

An institutional based cross sectional study was conducted in two phases (before COVID Pandemic; between January 2019 and June 2020 and after COVID Pandemic between February 2022 and September 2022) among construction workers and local peoples of Agartala, capital of Tripura.

A simple random sampling method was used to include subjects for the study. Total number of subjects (all male) included were 240 with equal distribution of both occupational dust exposed (n = 120) and not exposed control (n = 120) group. An informed consent form according to Indian Council of Medical Research (ICMR) guideline was prepared and explained to each subject regarding the content of the form and importance of the study in their own language. Only willing volunteers were included in the study. Subjects with presence of self reported acute or chronic respiratory disease, clinically significant anemia or presence of any kind of bone deformity of the chest and spine were excluded. Socioeconomic status of the subjects was evaluated through a pre validated questionnaire prepared for the purpose following WHO recommendation. Age (yrs), height (cm) and weight (kg) of subjects were recorded following the standard recommendation of the World Health Organization (WHO). Body mass index was calculated.

A complete spirogram was performed using a dry volume sensing spirometer fitted with software (Helios 702, RMS, India). Standardized procedures conforming to all the recommendation of American Thoracic Society (ATS) on spirometry performance were followed (Standardization of Spirometry, 1994 Update. American Thoracic Society., 1995). The spirometer was checked regularly for any kind of defect. Volume check was done every morning before starting of the experiment according to ATS recommendation. All the maneuvers were explained and demonstrated to the subjects before performance. All the subjects were allowed to have practice before actual reading. The subjects were instructed to take a deep breath until the lung were full and then blow out through the mouth as forcibly and as fast and as long as possible till the maximum capacity, sealing the lips tightly around a clean mouth piece. The recording is done at the same time of the day for all subjects in a private and quiet room. The

recording was taken both in sitting and standing position with nose clip on. Each subject was allowed to repeat the maneuver for a maximum of ten times to obtain acceptable data [15]. Spirometric parameters recorded for analysis are forced vital capacity (FVC_L), forced expiratory volume in 1 second ($FEV1_L$), FEV_1/FVC ratio, forced expiratory flow ($FEF_{25-75\%}$) and peak expiratory flow rate ($PEFR_{L/Min}$).

Blood pressure (BP) was measured in sitting position in the right arm with an appropriate sized cuff. Throughout the study same sphygmomanometer (Brand/model- Doctor Japan: Life Line) was used.

Statistical analysis:
Data were analyzed by using SPSS 16.0. Unpaired student T- test was used for comparative analysis of parameters between two groups. ANOVA was performed to analyse the data of more than two groups. Correlation analysis was performed to assess the correlation between dependent variables (lung function parameters) with independent variables. $P<0.05$ is the level of significance.

RESULTS

Results showed significantly higher mean values ($p<0.05$) of all the anthropometric parameters (except age) in control subjects compared to dust exposed worker group. The lung function parameters like FEV_1/FVC % and $FEF_{25-75\ \%}$ were significantly higher ($p<0.05$) in control group in comparison to dust exposed group. Other lung function parameters like FVC, FEV1, PEFR and mean values of both SBP (mmHg) and DBP (mmHg) showed non-significant difference ($p>0.05$) between dusts exposed worker group and non exposed control group. **[Table 1]**

Based on the smoking history, subjects were classified into non smoker, moderate, heavy and previous smoker. Lung function measures showed non-significant mean difference across the group ($p>0.05$) in overall subjects, in dust exposed worker group and non exposed control group respectively. **[Table 2]**

Age specific studies of lung function parameters showed non-significant mean difference across the age group for overall subjects (except FEV_1/FVC %; $P<0.05$). Similar results were observed in dust exposed worker group. **[Table 3]** In non exposed control group, the results showed significant linear decrease of mean values of FEV_1/FVC%, FEF_{25-75}% and $PEFR_{L/min}$ ($p<0.05$) and non significant linear decrease of mean values of FVC_L and FEV_1 with the increase of subjects age. [**Table 3]**

Subjects (n = 120) were classified into three different groups based on duration of occupational exposure such as exposed for 1-5 years, 5-10 years and above 10 years. Analysis of lung function parameters of subjects with different level of occupational exposure showed significant decrease of mean values of lung function parameters with the increase of duration of occupational exposure (except FEV_1 / FVC (%), $PEFR_{L/min}$;). **[Table 3]**

In overall subjects correlation analysis showed that age had a non significant negative correlation with FVC_L and significant negative correlation with FEV_1, FEV_1/FVC%, FEF_{25-75}% and $PEFR_{L/min}$. Height of the subjects showed significant positive correlation with FVC_L, FEV_1, $FEF_{25-75\%}$ and $PEFR_{L/min}$ and non significant positive correlation with FEV_1/FVC%. None of the lung function parameters showed significant correlation with weight and BMI of subject. Smoking status of subject showed non-significant negative correlation with all the lung function parameters. Duration of occupational dust exposure showed significant negative correlation with FVC_L, FEV_1 and FEF_{25-75} % and non significant negative correlation with FEV_1/FVC% and $PEFR_{L/min}$ of subjects. [**Table 4]**

Correlation analysis of dust exposed worker group showed that all the lung function parameters negatively correlated with age of subjects ($p>0.05$). Height and weight of the subjects showed non-significant positive correlation with FVC_L, FEV_1, FEV_1/FVC% and FEF_{25-75}% and negative correlation with $PEFR_{L/min}$ of subjects. FVC_L, and FEV_1 of subjects showed positive correlation with BMI and whereas FEV_1/FVC%, EFE $_{25-75}$% and $PEFR_{L/min}$ showed non significant negative correlation with BMI of subjects. All the lung function parameter showed non significant negative correlation with smoking status of subjects. Similarly duration of dust exposure showed significant negative correlation with FVC_L, FEV_1 and FEF_{25-75} % and non significant negative correlation with FEV_1/FVC% and $PEFR_{L/min}$ of subjects.

In control group except FVC_L, all other lung function parameters showed significant negative correlation with age. FEV_1 showed significant positive correlation with height of subjects. Height showed non significant positive correlation with FVC_L, FEV_1/FVC%, FEF_{25-75}% and PEFR of subjects. Weight of subjects showed non significant positive correlation with FVC_L and FEV_1 and negative correlation with FEV_1/FVC%, FEF_{25-75}% and PEFR of subjects. Both BMI and smoking status of subjects showed non significant negative correlation with almost all the lung function parameters. BMI of subjects showed non-significant positive correlation with FVC_L. [**Table 4]**

DISCUSSION:

This study demonstrated the combined effect of cigarette smoking and occupational exposures on respiratory function. The anthropometric parameters, lung function indices and cardiovascular parameter were compared between workers exposed to occupational dust from stone crushing and control subjects not exposed to occupational dusts. The spirometric indices such as mean of FEV_1/FVC% and FEF_{25-75}% in dust exposed workers were significantly lower than those of the unexposed control group. Similarly, Aminian et al. reported a significant reduction in mean percentage of the lung function parameters, including FEV_1/FVC%, FVC_L and PEF, FEF_{25-75}% and FEV_1 in workers exposed to cement. [16] However, in our subjects, though we observed reduction in other lung function parameters (FVC_L, FEV_1 and PEFR) in dust exposed workers compared with unexposed control group, but the reduction is not statistically significant. This is consistent with the finding of Rafeemanesh et al. who did not found significant differences in lung function between exposed group and control group. [17] The reduction of lung function parameters among workers may associated with the exposure of occupational dust and duration of dust exposure. [18]

A non significant mean difference in lung function parameters was observed among different group of smoker of control subjects. The highest mean values of lung function measures were observed in non smoker group compared to moderate, heavy and previous smoker group. There is almost linear declining trends of lung function measures was observed among non-smoker, moderate, heavy and previous smoker respectively. Our finding is supported by several previous findings where authors reported that occupational dust exposed smoker workers had a significantly increased risk of abnormal spirometric findings compared to non smoker workers. Compared to non smokers, the smoker workers and those exposed to occupational pulmonary health hazards had a 3.48 times and 3.45 more likelihood of abnormal spirometric findings. The lower values of spirometric measures in smoker and occupational dust exposed workers might be attributed to smoking and dust exposure might have a synergic impact on lung function. [19]

Among dust exposed workers there is a non significant decline of mean lung function values was observed with the increase of subject's age. Whereas in control group significant decrease of mean values of FEV_1/FVC%, FEF_{25-75}% and PEFR was observed with the increase of subjects age. Our finding is supported by the study findings of Ruivo et al. [20] In the present study the effect of duration of exposure on lung function among worker showed significant mean difference across the duration of exposure (except FEV_1 / FVC (%), PEFR). Study done by Meo et al. also reported a significant reduction in FVC_L, FEV_1 and MVV in cement mil workers exposed for 5-10 years. [21]

Correlation analysis of exposed worker group showed that all the lung function parameters negatively correlated with subject's age ($p>0.05$). This result is supported by the study conducted by Dehghan, Mohammadi, Sadeghi and Attarachi. [22] Height and weight showed non significant positive correlation with FVC_L, FEV_1, FEV_1/FVC% and FEF_{25-75}% and negative correlation with PEFR. FVC_L, and FEV_1 showed positive correlation with BMI and whereas FEV_1/FVC%, EFE $_{25-75}$% and PEFR showed non significant negative correlation with BMI. All the spirometric measures showed non significant positive correlation with smoking status of exposed group. Similarly duration of dust exposure showed significant negative correlation with FVC_L, FEV_1 and FEF_{25-75}% and non significant negative correlation with FEV_1/FVC% and PEFR of subjects. Study done by Kumar et al also reported significant reduction in lung function values with duration of exposure. [23] Our findings corroborate the findings of studies

conducted by Neghab et al. and Jaen et al. [24] Honda et al. found a general tendency for some parameters of pulmonary function to become smaller as estimated cumulative exposure increased.[25] Exposure to occupational pulmonary health hazards and cigarette smoking was related to spirometric abnormalities, a findings supported by the study conducted by Jaakkola et al. [26]

The cross sectional design of this study is a major limitation. With cross sectional studies, temporal and casual relationship cannot be clearly ascertained. Therefore, longitudinal and industry-based studies with large sample size and determination of occupational exposure are necessary to find out the casual association between occupational exposure and spirometric abnormalities.

CONCLUSION

This study showed a significant correlation among occupational exposures to pulmonary health hazards, decreased spirometric parameters. Exposure to dust containing silica in stone crushing workers leads to deterioration of pulmonary function and it is correlated with the duration of the exposure. Protection of the workers may be provided by wet working, proper ventilation, screening of workers before hiring, providing them with suitable masks and safety glasses. Workers should have information about health risks, suitable working conditions, personal hygiene and preventive measures. They should undergo frequent medical examination.

Table 1: Comparison of anthropometric, pulmonary function and cardiovascular parameters between dusts exposed worker group and control groups.

Parameters	Mean + SD		p
	Exposed group (n = 120)	Control group (n = 120)	
Anthropometric parameters			
Age (yrs)	29.97±12.37	31.46±9.38	0.59ns
Height (cm)	159.98±6.6	166.17±6.92	0.001*
Weight (kg)	52.97±7.18	62.30±11.02	0.001*
BMI	20.51±2.26	22.56± 3.74	0.013*
Pulmonary function parameters			
FVC L	2.00±1.08	2.22±1.13	0.114ns
FEV1 L	1.60±0.99	1.93±1.06	0.272ns
FEV1/FVC%	80.00±18.38	85.23±17.09	0.001*
FEF 25-75%	2.23±1.13	2.54±1.57	0.001*
PEFR L/min	3.09±1.59	3.78±2.36	0.188ns
Cardiovascular parameters			
SBP (mmHg)	126.6±13.21	122.50±13.88	0.24ns
DBP (mmHg)	78.10±6.27	80.33±11.38	0.35ns

BMI , body mass index; FVC , forced vital capacity; FEV1, forced expiratory volume in one second ; FEV1/FVC % , ratio of FEV1/FVC; FEF, forced expiratory flow ; PEFR, peak expiratory flow rate; SBP , systolic blood pressure, DBP, diastolic blood pressure, SD, standard deviation; p = level of significance; ns = non significant; * = p<0.05

Table 2: Comparison of pulmonary function parameters between different groups of subjects with smoking status.

Pulmonary function Parameters	Overall Subjects				p
	Non smoker (n=120)	Moderate smoker (n=80)	Heavy smoker (n=20)	Previous smoker (n=20)	
FVC L	2.12±0.72	1.85±1.06	1.98±0.66	2.06±1.24	0.92ns
FEV1 L	1.98±0.76	1.70±1.02	1.58±0.60	1.83±1.11	0.93 ns
FEV1 /FVC (%)	94.04± 14.99	90.78± 15.0	78.51± 14.30	89.47± 14.64	0.44 ns
FEF25-75%	2.74±1.30	2.38±1.45	1.82±0.99	2.43±1.39	0.83 ns
PEFR L / min	2.77±1.31	3.22±1.97	2.77±1.77	3.56±2.16	0.67 ns
	Exposed group				
	Non smoker (n=40)	Moderate smoker (n=60)	Heavy smoker (n = 12)	Previous smoker (n=8)	
FVC L	1.52±1.22	2.07±0.10	2.01±0.17	1.89±1.06	0.79ns
FEV1 L	1.38±1.01	1.81±0.23	1.84±0.43	1.80±1.05	0.74 ns
FEV1 /FVC (%)	94.98±8.70	87.73±15.59	91.74±12.32	93.55±10.94	0.78 ns
FEF25-75%	2.02±0.93	2.3±1.02	2.37±1.26	2.42±1.32	0.80 ns
PEFR (L / min	2.72±1.16	3.68±2.23	3.33±2.41	3.27±1.89	0.76 ns
	Control group				
	Non smoker (n=80)	Moderate smoker (n=20)	Heavy smoker (n=8)	Previous smoker (n=12)	
FVC L	2.13±1.01	2.37±1.17	1.89±1.13	1.75±1.19	0.72ns
FEV1 L	2.07±1.05	2.09±1.11	1.34±0.89	1.42±0.98	0.55 ns
FEV1 /FVC (%)	96.58± 3.33	86.32± 16.52	69.3± 5.55	82.47± 23.12	0.44 ns
FEF25-75%	3.26±1.32	2.66±1.56	1.35±1.00	2.26±1.95	0.63 ns
PEFR (L/ min)	4.89±1.56	4.04±2.46	1.86±1.08	3.06±2.40	0.50 ns

FVC , forced vital capacity; FEV1, forced expiratory volume in one second ; FEV1/FVC % , ratio of FEV1/FVC; FEF, forced expiratory flow ; PEFR, peak expiratory flow rate; n = number of subjects; ns = non significant

Table 3: Comparison of pulmonary function parameters of different age group of subjects and different level of exposure of worker subjects.

Pulmonary function Parameters	Age groups			p
	<20 yrs (n=28)	20-40yrs (n=168)	40-60yrs (n=44)	
FVC L	2.25±1.16	1.99±1.20	1.74±0.71	0.60ns
FEV1 L	2.10±1.10	1.82±1.07	1.33±0.67	0.21 ns
FEV1 /FVC (%)	93.51±7.90	92.83±10.81	73.53±19.95	0.001*
FEF25-75%	3.09±1.49	2.40±1.32	1.69±1.13	0.06 ns
PEFR (L / min)	4.47±2.60	3.42±1.79	2.58±2.0	0.10 ns
		Exposed group		
	<20 yrs (n=20)	20-40yrs (n=80)	40-60yrs (n=20)	
FVC L	1.69±1.18	1.99±1.04	1.77±0.79	0.85ns
FEV1 L	1.58±1.05	1.86±1.02	1.54±0.76	0.82 ns
FEV1 /FVC (%)	95.48±7.42	94.35±9.14	85.44±16.21	0.12ns
FEF25-75%	2.06±1.12	2.70±1.07	2.29±1.28	0.49 ns
PEFR (L / min)	2.82±1.44	3.43±1.19	3.72±2.48	0.46 ns
		Control group		
	<20 yrs (n=8)	20-40yrs (n=88)	40-60yrs (n=24)	
FVC L	2.64±1.38	2.28±1.18	1.72±0.71	0.42ns
FEV1 L	2.45±1.26	2.05±1.06	1.15±0.59	0.11 ns
FEV1 /FVC (%)	92.25±6.66	90.31±12.95	63.60±18.04	0.001*
FEF25-75%	3.69±1.99	2.72±1.45	1.19±0.77	0.03 *
PEFR L / min	6.03±3.54	3.98±1.94	1.63±0.86	0.008 *
		Duration of exposure		
	1-5 yrs (n=8)	5-10yrs (n=80)	Above 10 yrs (n=32)	
FVC L	2.17±1.05	1.00±0.23	1.08±0.83	0.01*
FEV1 L	2.03±0.95	0.92±0.14	0.94±0.68	0.009 *
FEV1 /FVC %	94.66±7.72	93.48±11.18	91.05±14.48	0.704ns
FEF25-75%	2.62±1.08	1.37±0.65	1.60±0.94	0.03 *
PEFR L / min	3.31±1.38	2.35±1.20	2.85±2.17	0.56ns

FVC , forced vital capacity; FEV1, forced expiratory volume in one second ; FEV1/FVC % , ratio of FEV1/FVC; FEF, forced expiratory flow ; PEFR, peak expiratory flow rate; SD- Standard deviation; p = level of significance; ns = non significant; * = p<0.05

Table 4: Correlation between pulmonary function parameters, anthropometric parameters, smoking status and duration of dust exposure.

Anthropometric Variables	Overall subjects									
	FVC L		FEV1 L		FEV 1/ FVC%		FEF25-75 %		PEFR L/min	
	r	p	r	p	r	p	r	p	r	p
Age (yrs)	-0.199	0.13	-0.300	0.02*	-0.449	0.001**	-0.344	0.007**	-0.270	0.04*

Height (cm)	0.367	0.004**	0.343	0.007**	-0.046	0.729	0.296	0.022*	0.257	0.048*
Weight (kg)	0.251	0.053	0.175	0.182	-0.211	0.106	-0.021	0.872	-0.027	0.838
BMI	0.100	0.447	0.020	0.878	-0.235	0.070	-0.184	0.160	-0.177	0.176
Smoking Status	-0.036	0.785	-0.052	0.693	-0.102	0.437	-0.069	0.603	-0.060	0.648
Exposure duration	-0.473	0.008**	-0.517	0.003**	-0.159	0.401	-0.431	0.017*	-0.149	0.433
	Exposed group									
Age (yrs)	-0.210	0.26	-0.251	0.18	-0.300	0.10	-0.212	0.261	-0.017	0.930
Height (cm)	0.224	0.233	0.235	0.211	0.300	0.107	0.213	0.259	-0.037	0.848
Weight (kg)	0.164	0.388	0.143	0.452	0.072	0.705	0.012	0.948	-0.128	0.501
BMI	0.080	0.673	0.046	0.811	-0.134	0.480	-0.125	0.512	-0.156	0.410
Smoking Status	-0.176	0.351	-0.167	0.378	-0.190	0.314	-0.084	0.659	-0.194	0.30
Exposure duration	-0.473	0.008**	-0.517	0.003**	-0.159	0.401	-0.431	0.017*	-0.149	0.433
	Control group									
Age (yrs)	-0.236	0.210	-0.402	0.028*	-0.632	0.001**	-0.524	0.003**	-0.559	0.001**
Height (cm)	0.389	0.033	0.378	0.039*	-0.009	0.962	0.315	0.090	0.350	0.058
Weight (kg)	0.196	0.298	0.116	0.543	-0.155	0.413	-0.129	0.496	-0.117	0.540
BMI	0.013	0.946	-0.069	0.716	-0.165	0.380	-0.284	0.129	-0.287	0.124
Smoking Status	-0.159	0.401	-0.195	0.301	-0.143	0.449	-0.140	0.461	-0.175	0.356

FVC , forced vital capacity; FEV1, forced expiratory volume in one second ; FEV1/FVC % , ratio of FEV1/FVC; FEF, forced expiratory flow ; PEFR, peak expiratory flow rate; *correlation is significant at the 0.05 level ; **correlation is significant at the 0.01 level

REFERENCES

1. Park K. In: Park's textbook of preventive and social medicine. Occupational health. 18th ed. M/s Banarsidas Bhanot, Jabalpur, India; 2007: 608-610.
2. Bujak-Pietrek S, Szadkowska-Stańczyk I. Dust exposure assessment among construction workers in Poland, 2001-2005. Med Pr 2009; 60(4):247-257.
3. Flanagan ME, Seixas N, Majar M, Camp J, Morgan M. Silica dust exposures during selected construction activities. AIHA J (Fairfax, Va) 2003; 64(3):319-328.
4. McLean D, Glass B, 't Mannetje A, Douwes J. Exposure to respirable crystalline silica in the construction industry-do we have a problem? N Z Med J 2017; 130(1466):78-82.
5. Blanc PD, Toren K. Occupation in chronic obstructive pulmonary disease and chronic bronchitis: an update [State of the Art Series. Occupational lung disease in high-and low income countries, Edited by M. Chan-Yeung. Number 2 in the series]. The International Journal of Tuberculosis and Lung Disease 2007; 11(3):251-257.
6. Meo SA, Al-Drees AM, Al Masri AA, Al Rouq F, Azeem MA. Effect of duration of exposure to cement dust on respiratory function of non-smoking cement mill workers. Int J Environ Res Public Health 2013; 10(1):390-398.
7. Guha N, Straif K, Benbrahim-Tallaa L. The IARC Monographs on the carcinogenicity of crystalline silica. Med Lav 2011; 102(4):310–320.
8. Mengesha YA, Bekele A. Relative chronic effects of different occupational dusts on respiratory indices and health of workers in three Ethiopian factories. Am J Ind Med 1998 ; 34(4): 373-380.
9. Deborah S. Breathtaking: Premature Mortality due to Particulate air pollution in 239 America Cities. New York. Natural Resources Defence Council. 1996; 1415.
10. National Industrial Sand Association. Respiratory Health Effects of Crystalline Silica. 1997. Available from: www.riccisand.com/health 6.
11. Mariammal T, Amutha AJ, Sornaraj R. Work related respiratory symptoms and pulmonary function tests observed among construction and sanitary workers of Thoothukudi. Int J Pharm Tech Res 2012; 4(3):1266-1273.
12. Scarselli A, Binazzi A, Marinaccio A. Occupational exposure to crystalline silica: estimating the number of workers potentially at high risk in Italy. Am J Ind Med 2008; 51(12):941-949.
13. Iftikhar B, Khan MH, Hussain H, Iqbal M, Jadoon GS. Relationship between silica dust exposure and Chronic Obstructive Pulmonary Disease in workers of dust generating industries of district Peshawar. Gomal J Med Sci 2009; 7(1):4650.
14. Johncy SS, Ajay KT, Dhanyakumar G, Raj NP, Samuel TV. Dust exposure and lung function impairment in construction workers. J Physiol Biomed Sci 2011; 24:9-13.
15. Pellegrino R, Viegi G, Brusasco V, Crapo R.O, Burgos F, Casaburi R et al. Interpretative strategies for lung function tests. *Euro. Respir. J* 2005; 26: 948 - 968.
16. Aminian O, Aslani M, Sadeghnilat Haghighi K. Cross shift study of acute respiratory effects in cement production workers. Acta Med Iran 2014 ;52(2):146-152.
17. Rafeemanesh E, Alizadeh A, Saleh LAfshari., Zakeri H. A study on respiratory problems and pulmonary function indexes among cement industry workers in Marshad, Iran. Med Pr 2015;66(4):471-477.
18. Oleru UG. Pulmonary function and symptoms of Nigerian workers exposed to cement dust. Environmental Research J 1984; 33(2): 379-385.
19. Mirsaeed A, Faezeh D, Mehndi A et al. Combined effect of cigarette smoking and occupational exposure on lung function: A Cross- sectional Study of Rubber industry workers. Workplace Health and Safety 2013;61(5):213-220.
20. Susana R, Paulo V, Cristiana M, Cristina B. Effects of aging on lung function. A comparison of lung function in healthy studies and the elderly. Rev Port Pneumol 2009;15(4):629-653.
21. Ayoub MS, AI Drees AM, AI Masri AA, AI Rouq F. Effect of Duration of Exposure to Cement Dust on Respiratory Function of Non-Smoking Cement Mill Workers. Int.J. Environ. Res. Public Health 2013;10(1): 390-398.
22. Dehghan F, Mohammadi S, Sadeghi Z, Attarchi M. Respiratory complaints and spirometric parameters in tile and ceramic factory workers. Tanaffos 2009; 8: 19-25.
23. Dey D, Kumar S, Chakraborty S. Comparative study of lung function among control group and workers of different pollutant industries. IOSR Journal of Dental and medical sciences 2018; 17(2):01-05.
24. Naghab M, Rahimi E, Emad A, Rajaeei Fard A. An epidemiological study of talk related respiratory morbidity among employees of a rubber industry in Shiraz-Iran. International Archives of Occupational and Environmental Health 2007; 80(6): 539-546.
25. Honda Y, Beall C, Delzell E, Oestenstad K, Brill I, Mattews R. Mortality among workers at a talk mining and milling facility. Annals of Occupational Hygiene 2002; 46(7): 575-585.
26. Jaakkola MS, Sripaiboonkij P, Jaakkola JJ. Effects of occupational exposures and smoking on lung function in tile factory workers. International Archives of Occupational and Environmental Health 2011; 84(2): 151-158.