FREQUENCY OF SILICOSIS AND ITS RELATIONSHIP WITH DUST AND PULMONARY FUNCTIONS TESTS IN STONE CRUSHING INDUSTRIES WORKERS IN PESHAWAR

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ABSTRACT

Background: Silicosis is an occupational lung disease caused by prolonged inhalation of respirable crystalline silica and pulmonary reaction to it. Its true prevalence is underestimated as during its initial phase the patient is symptom free. It is the commonest occupational lung disease all over the world but it is more frequent in developing countries, including Pakistan, where safe work practice among the workers is poor. Silicosis is a disease with typical radiographic pattern. According to the intensity of exposures and onset of initiation of clinical symptoms silicosis is classified into three groups of simple, advanced and complicated forms. The present study evaluated silicosis and pulmonary functions tests among stone crushing workers.

Objectives: To examine the frequency of silicosis and its association with silica dust in stone crushing industries workers and their pulmonary functions tests.

Material and Method: This cross-sectional analytical study was carried out in one year time in 204 male workers of stone crushing industries in the suburbs of Peshawar. Participants were selected through convenient sampling. Workers who had worked at the site for two years or more, were included in the study while those workers who had worked for less than two years, who did not give consent and those who were not cooperative or were absent on the day of the study, were excluded from the study. They were first interviewed on the pre-tested questionnaire and then Pulmonary Functions Tests (PFT) were performed by spirometer. Chest x-rays were done for those subjects who were having abnormal PFTs. Data was analyzed through SPSS software version 16.0.

Results: Out of the total of 204 participants 13 were suffering from simple silicosis, 4 from advanced silicosis and one was having complicated silicosis. It was observed that a very strong association exists between length of job duration ($p < 0.0001$) and smoking ($p < 0.001$) in the causation of silicosis. PFTs results of 142 (69.6 %) were normal. Abnormal results were found in 62 (30.4 %) participants. Spirometry results of 54 (26.5 %) participants showed a restrictive pattern and 8 (3.9 %) obstructive. A strong relationship was observed between the duration and intensity of exposure and PFTs results (p-value < 0.001). Those who were working for 8 hours or more per day and those who were working for 10 or more than 10 years were having more deranged PFTs. Similarly, PFTs were more deranged in those participants who smoked heavily (p-value ≤ 0.016).

Conclusion: Silicosis being a major public health problem and mainly remains a submerged portion of the iceberg is caused by prolonged exposure to crystalline silica. The working community of this occupation is poor class, illiterate and less aware and sensitive about their health, which makes the situation worse.

Keywords: Silica, Stone crusher workers, Silicosis, Duration of exposure, Pulmonary function tests, chest radiography, Chronic simple silicosis, Accelerated silicosis, Complicated silicosis, Acute silicosis.

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INTRODUCTION

Occupational exposure to dust particularly silica dust is a well-known phenomenon and a common public health problem especially in developing countries which is usually ignored. Stone crushing units are small-scale industries spread in the cities in a poorly organized sector and provide basic material for infrastructure like building constructions and roads. The operations involved by these units emit process and fugitive dust [1]. Mainly rural, migrant and unskilled or low skilled workers are employed in this sector, often with seasonal employment. Exploitation of the labor by the management and their low socioeconomic situation give rise to deficiency of programs to address workers safety and health in this segment [2]. Silica is the main

component of many maters like rock, mineral ores and sand. Silicon dioxide (SiO2) is the generic name of sand which means the chemical compound that is present naturally in different states like amorphous, crystalline and glassy forms [3].

Silicosis and chronic bronchitis are the main diseases which are caused by exposure to crystalline silica. Silica crystals are also known human carcinogens and are a risk factor for systemic autoimmune diseases as well[4]. As silicosis progresses, airflow obstruction increases and is presented with a cough, chest pain and shortness of breath. There is increased risk of TB and other mycobacterial diseases in patients with silicosis because macrophage function is weakened by silica[5]. In developing countries, due to lack of awareness of the problem and effective preventive measures, workers with these diseases can go undiagnosed and untreated[6].

Several studies have explained the association of dust exposure and lungs problems in the workers exposed to different types of dust in their occupations. Silicosis is, therefore, the most prevalent lung disease among pneumoconiosis in the communities. Being respiratory ailment, silicosis impairs the lungs functions. However, when there is much damage to the lung tissue the pulmonary functions are deteriorating as occurs in the advanced stages of the disease. The best indicator in the pulmonary function tests is the Forced Expiratory Flow (FEF) rate[7]. Workers who are exposed to silica dust for more than ten years, mostly develop respiratory problems. Other contributing factors like the density of dust, increasing age, tobacco smoking and length of exposure to dust containing silica have a direct effect on the severity of the problems[8].

With respect to the global and regional scenario, silicosis remains a very real threat to some people on a daily basis and still, the mortality from this disease is in thousands around the world every year. More than 500,000 cases of silicosis were recorded in China between 1991 and 1995. The prevalence of the problem was found to be 55 % in India, in one group of young quarrying workers of sedimentary rocks. In the northeast of Brazil, the prevalence of silicosis in the workers was found to be 26 % in the exposed group. According to the National Institute of Occupational Safety and Health (NIOSH), more than 1,700,000 labors in the US are daily exposed to crystalline silica dust[5]. With the increase in the number of years of exposure, the risk of developing the disease among the workers increased. Silicosis was found to be 12 % in workers who worked for 30 years or more[9].

Chaudhury et al state that in India almost 3 million workers were found exposed to silica in industries like stone cutting, agate, silica milling, mines and other such industries. They comment that as this sector is unorganized and comorbidities such as tuberculosis and malnutrition also play a role, so mortality is high due to silicosis[10]. While in a study in Nowshera district of Pakistan, Ishtiaq M et al found that 49.50 % of the coal workers had coal workers pneumoconiosis and silicosis and 52.50 % had findings in their pulmonary functions tests[11].

Signs, symptoms and pulmonary functions were found to be more significant in the exposed workers of stone crushing industries as compared to the controls. Forced Vital Capacity (FVC) and Forced Expiratory Time (FET) are at a low level while Forced Expiratory Volume in one second (FEV_1) / FVC ratio and Mid Expiratory Flow rate (MEF) were at a high level[12]. A positive relationship was found between the manual stone quarrying and occurrence of respiratory disease symptoms. Regarding knowledge of the exposure, about 83% of workers know that their work exposes them to health hazards but cannot quit owing to poverty or lack of other jobs opportunities and social welfare etc" [13].

An extensive work has been done globally but little literature was found regarding this topic in Khyber Pakhtoonkhwa and particularly in Peshawar. Secondly, more than ten thousand workers are employed in 150 to 200 traditional stone crushing units in Peshawar who work under much hazardous environment and thus pose a great risk to their health. The stone crushing workers of Peshawar district are one of the neglected groups and thus this study was carried out to measure silica exposure and its effect on human lungs, like silicosis, among these workers and also evaluated the associated factors.

MATERIAL AND METHODS

This community-based cross-sectional analytical study was conducted in stone crushing workers of stone crushing units in the suburbs of Peshawar. The study population was male workers of the stone crushing machines. The age range was 17 to 56 years. A total of 204 workers were selected by convenient sampling from PAF road, Kohat road, Warsak road and Peer Bala. The data collection was started in November 2016 and completed in October 2017. So it took almost one year time. Those workers who had worked at the site for two years or more, were included in the study. Those workers who had worked for less than two years, who were absent on the day of the study, who did not give consent and those who were not cooperative, were excluded from the study.

Questionnaire was used as the data collection tool and demographic and occupational details of the participants were recorded on it. The first part of the questionnaire was related to socio-demographic characteristics and second part had a medical history of the participants with a focus on respiratory problems. All the participants were informed about the procedure and then a written consent was taken from them. Weight (in Kg) and height (in cm) of the participants were measured. Pulmonary functions were measured by a por-

table spirometer (Spirolab II). The important readings of PFTs like Forced Vital Capacity, Forced Expiratory Volume in the first second and ratio between FEV1 / FVC % were recorded. X-ray chest of the participants with abnormal PFTs were done.

The dependent variables like silicosis and Pulmonary Functions Tests (PFTs) and the independent variables like age, gender, weight, height, the silica dust exposure intensity and duration and smoking status were all recorded on the pretested questionnaire. The data collected were analyzed using SPSS for Windows software version 16.0. Descriptive statistics i.e. percentages, mean and standard deviation were used to describe the parameters of the study. P-value of 0.05 or less was considered for statistical significance. Chi-square test and t-test were applied for calculating proportions and percentages.

RESULTS

Out of the total 204 subjects, 18 were having silicosis. 13 had simple silicosis, 4 advanced silicosis and one subject had complicated silicosis. The rest 186 were having no silicosis as shown in the following table.

Pulmonary Functions Tests (PFT) results of 62 (30.4 %) participants showed abnormal readings and 142 (69.4 %) were normal. Out of the abnormal results, the PFTs of 54 participants (26.5 %) showed a restrictive pattern and 8 (3.9 %) obstructive pattern as shown in the following table.

When the Job duration in years and silicosis cross-tabulation was done and analyzed it was found that as the job duration increases the number of cases of silicosis increases. The chi square value is 24.39 and p-value is < 0.0001 which means that there is a very strong association between these two variables because the silica exposure increases with the passage of time.

The association of daily working hours and silicosis was worked out it was found that as the daily working hours of the workers increases, so is increase in the exposure and the number of silicosis cases also increases as shown in the above table. The chi square value of 10.65 and p value < 0.01 signifies a strong association between silicosis and hours of daily exposure.

The association of smoking and silicosis was worked out and it was found that out of 132 non-smokers 4 cases of silicosis are there while in case of smokers 14 out of 72 are having silicosis with 4 cases of advanced silicosis and one of complicated silicosis. The p-value of < 0.001 signifies that a very strong association exists between smoking and silicosis.

The above table shows that cases of silicosis were more in the participants who had deranged PFTs. Silicosis was more prevalent in the subjects who were having restrictive pattern in their PFTs. The association calculated in the cross-tabulation above shows p-value of less than 0.001 and signifies overwhelming association between these two variables.

Symptoms

This table shows that 50 % of the subjects were having the symptom of cough for more than two weeks, 4.9 % were also having blood in sputum. 36.3 % had shortness of breath, 26.5 % had wheeze and 16.7 % had the symptom of loosing of weight.

DISCUSSION

The workers at stone crushing units are exposed to dust and gases comprising mainly of silica along with other carbon-containing elements like iron, and manganese. Silica dust is known to have a bad effect on the lung functions of the exposed workers. It was found in this study that stone crushing industries workers were exposed to higher concentration of silica dust and therefore were having greater (45 %) occurrence of respiratory symptoms which is similar to the study of AN Nwibo in Nigeria[14]. The prevalence of silicosis found in this study was almost 9 % which is similar (8.9 %) to a study by Mashaallah Aghilinejad et al conducted in Hamadan province of Iran[15] (1). The prevalence found by Gibbs GW and Du Toit RS in their study on gold miners of South Africa is 18-19 % which quite higher than our study rate. (Ref: Estimating the quartz exposure of South African gold miners[16] (2). The prevalence found by Rajnarayan R. Tiwari, Raj Narain, Y. K. Sharma, and Sunil Kumar in ex-workers of quartz crushing units in Gugrat India is 17.9% which is also more than our study results[17] (3).

We observed in this study that out of 132 non-smokers 4 cases of silicosis were diagnosed while in case of smokers 14 out of 72 were having silicosis with 4 cases of advanced silicosis and one of complicated silicosis (p-value of < 0.001) that means a very strong association exists between smoking and silicosis. Lap Ah Tse in a study demonstrated that the risk ratio effect of silicosis on the respiratory diseases among smokers was 81–95% of that among the non-smokers, whilst the risk ratio effect of silicosis on the pulmonary tuberculosis in smokers was oppositely 21% higher than that in the non-smokers[18] (4). Smoking is by far the largest risk for lung cancer and must be considered in any occupational study of lung cancer. Recent reviews of studies of the interaction between smoking and occupational exposure to asbestos suggest that it may be greater than additive but somewhat less than multiplicative. Smokers who were exposed to silica dust have been found to develop clinical silicosis more frequently than non-smokers exposed to the same dose, implying that silicotics who were smokers would have on average lower cumulative exposure to crystalline silica dust than silicotics who were non-smokers[19] (5).

In our study, 29.5 % participants had abnormal

Table No 1: Number of Silicosis cases

	Frequency	Percent	Cumulative Percent
No Silicosis	186	91.2	91.2
Simple Silicosis	13	6.4	97.5
Advanced Silicosis	4	2.0	99.5
Complicated Silicosis	1	0.5	100
Total	204	100	

Table No 2: Pulmonary Functions Tests (PFT) Results

	Frequency	Percent	Cumulative Percent
Normal	142	69.6	69.6
Restrictive	54	26.5	96.1
Obstructive	8	3.9	100
Total	204	100	

Table 3: Job duration in years and Silicosis Cross-tabulation

Job duration in years	Silicosis				Total	Chi sq. value	Degree of freedom	p-value
	No Silicosis	Simple Silicosis	Advanced Silicosis	Complicated Silicosis				
Less than 5 Years	67	0	1	0	68	24.39	6	< 0.0001
5-10 Years	81	4	0	1	86			
More than 10 Years	38	9	3	0	50			
Total	186	13	4	1	204			

Table 4: Silicosis and Daily Working Hours Cross-tabulation.

Silicosis	Daily Working Hours			Total	Chi sq. value	Degree of freedom	p-value
	4 Hours	6 Hours	8 Hours or more				
No Silicosis	26	105	55	186	10.65	6	< 0.01
Simple Silicosis	3	6	4	13			
Advanced Silicosis	0	1	3	4			
Complicated Silicosis	1	0	0	1			
Total	30	112	62	204			

Table 5: Silicosis and Smoking Cross-tabulation

Silicosis	Smoking		Total	Chi sq. value	Degree of freedom	p-value
	Non-smoker	**Smoker**				
No Silicosis	128	58	186	15.83	3	< 0.001
Simple Silicosis	3	10	13			
Advanced Silicosis	1	3	4			
Complicated Silicosis	0	1	1			
Total	132	72	204			

Table 6: PFTs Results and Silicosis Cross-tabulation

PFTs Results	Silicosis				Total	Chi sq. value	Degree of freedom	p-value
	No Silicosis	Simple Silicosis	Advanced Silicosis	Complicated Silicosis				
Normal	136	4	2	0	142	36.15	6	< 0.001
Restrictive	44	8	2	0	54			
Obstructive	6	1	0	1	8			
Total	186	13	4	1	204			

Table 7: Symptoms of the workers.

	Cough for > 15 days	Hemoptysis	SOB	Wheeze	Losing Weight
Yes	102 (50 %)	10 (4.9 %)	74 (36.3%)	54 (26.5 %)	34 (16.7 %)
No	102 (50 %)	194 (95.1 %)	130 (63.7 %)	150 (73.5 %)	170 (83.3 %)

PFT results. The PFTs results of 41 participants (23.3 %) showed a restrictive pattern and 11 participants (6.2 %) obstructive pattern. This is comparable with the study of Dr. Priyanka Mirdha, who observed highly significant ($p < 0.01$) decrease in pulmonary function parameters (FVC, FEV1, FEV1/FVC, PEFR) [20]. During six years follow up studies it was found that respiratory parameters declined regularly but slowly and gradually. In adult workers as the age advances pulmonary functions falls and volume and airflow in spirometry decreases[21]. Hertzberg VS et al observed that as the silica exposure increases in smokers the percent-predicted FVC and FEV1 and FEV1/FVC are decreased[22].

The association of PFTs and job duration in years in our study was worked out and it was found that PFTs of the workers are compromised as the exposure duration increases. A strong association (p-value < 0.001) was observed between the increase in job duration and PFTs in the stone crushing industries workers due to the increased exposure to silica dust with the passage of time. In similar studies conducted by Sjur Humerfelt, Geir E Eide, Amund Gulsvik [23] and Sachin B Rathod, Smita and R. Sorte [24] it was found that there is a significant inverse relationship between years of exposure to occupational quartz and PFTs, particularly FVC, FEV_1 and the ratio of FEV_1/FVC. Mohammad Golshan et al, during 6 years longitudinal study found that the decrease in FVC, FEV_1, $FEFE_{75}$ and FEF_{25-75} is 8.17 %, 10.6 %, 10.7 %, and 13.4 % respectively from normal (predicted) values with the p-value of < 0.001 which reflects a highly significant association between the two variables. They also report in this study that for yearly age advancing the predicted decrease of FEV_1 is 25-30 ml for normal American adults while the measurements noted in their study was 61.95 ml which are double the normal values [25]. While S. Smilee Johncy et al determined that percent decrease in FVC, FEV1, FEV1/FVC %, PEFR and FEF25-75 % is 27, 31.46, 15.36, 24.93 and 27.01 respectively in construction workers who are exposed to dust (silica) [26]. All these findings strongly support the findings of our study of the association of prolonged exposure to silica dust and compromised PFTs.

In our study, it was observed that PFTs are more deranged in the workers who also smoke and particularly where the intensity of smoking is more. It was also observed that as the intensity of cigarette smoking increases the prevalence of abnormal PFTs increases. Prevalence of abnormal PFTs was 21 % in the non-smokers, 32 % in the occasional smokers, 53 % in those who smoke 5-10 cigarettes per day and 44 % in those who smoke one pack or more per day. It was concluded that there is a strong evidence (p-value < 0.016) that smoking is associated with abnormal PFTs in the stone crushing industries workers. Harkirat Kaur et al also had the same results in a cross-sectional study in which they found that as the number of cigarettes packs smoked per year increases the pulmonary functions decreases and the negative association was largest and most progressive in FEV_1, FEV_1/FVC [27]. It was also assessed that smokers with silicosis were two times more at risk of developing lung cancer than non-smokers with silicosis [19]. The results of our study are also much similar to the results of Rubeena Bano et al [28] and Sunita Nighute and Abhijit Awari [29] who found that the risk of impaired lung functions is 17 to 18 times more in smokers than the non-smokers.

CONCLUSION

Workers at stone crushing industries are exposed to silica and carbon-containing pollutants which are considered to have an argumentative effect on their pulmonary functions. It was found in this study that stone crushing industries workers were exposed to high concentration of dust which adversely affects their lungs. The high prevalence of silicosis could be attribute to this exposure. A strong association between exposure duration, smoking and deranged PFTs and silicosis was observed. A considerable number of the three types of silicosis namely simple, advanced and complicated silicosis were seen in these participants. The values for FVC, FEV_1, and the ratio of FEV_1 and FVC were lower than the predicted values. Among those who had deranged PFTs, three fourth showed a restrictive pattern and one-fourth obstructive pattern in their PFTs.

The risk of developing COPD and lungs cancers is also high in these workers. A strong dose response relationship between dust and PFTs was noted. It was found in this study that the already lowered lung functions due to dust exposure are further deranged by smoking. There is a strong substantiation that smoking augments the silica dust effect on airflow obstruction and deranging PFTs and causing silicosis. A strong association was found between increase in the working years and working hours of the workers and abnormal PFTs and silicosis.

The labor class people are very less aware and keen about health and particularly the prevention from stone dust (silica) and its complications. The symptoms of silicosis are less considered by these workers as the cause of ill health because they believe these disorders are part of the job risk. These workers do not adopt respiratory protecting measures during working hours which increased the exposure and eventually increased the risk of chronic airflow limitations, lungs impairment and silicosis. Therefore for prevention of silica dust associated chronic obstructive pulmonary disease, reducing or eliminating both dust and smoking is essential.

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