

## Original Article

## A STUDY OF THE RELATIONSHIP BETWEEN PULMONARY FUNCTIONS TESTS AND DUST IN STONE CRUSHING INDUSTRIES WORKERS IN PESHAWAR

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### ABSTRACT

**Objective:** To evaluate the effect of exposure to silica dust on pulmonary functions and to determine the factors associated with abnormal lung functions tests.

**Material and Methods:** This cross-sectional analytical study was carried out in six months time in 176 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 who were absent on the day of the study, were excluded from the study. They were first interviewed on the questionnaire and then Pulmonary Functions Tests (PFT) were performed by a spirometer. Data were analyzed through SPSS software version 16.0.

**Results:** Out of the total of 176 participants the PFT results of 127 (72.2 %) participants were healthy. Abnormal results were found in 49 (27.8 %) participants. Spirometry results of 41 (23.3 %) participants showed a restrictive pattern and 8 (4.5 %) obstructive. A strong relationship was found 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 ten 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 significant 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.

### 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 essential material for

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infrastructures like building constructions and roads. The operations involved by these units emit process and fugitive dust<sup>1</sup>. 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<sup>2</sup>. Silica is the main component of many materials like rock, mineral ores and sand. Silicon dioxide (SiO<sub>2</sub>) is the generic name of sand which means the chemical compound that is present naturally in different states like amor-

phous, crystalline and glassy forms<sup>3</sup>.

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<sup>4</sup>. 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<sup>5</sup>. In developing countries, due to lack of awareness of the problem and effective preventive measures, workers with these diseases can go undiagnosed and untreated<sup>6</sup>. 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<sup>7</sup>. 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<sup>8</sup>.

Concerning the global and regional scenario, silicosis remains a genuine 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 north-east 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<sup>5</sup>. 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 % who workers for 30 years or more<sup>9</sup>.

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<sup>10</sup>. 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<sup>11</sup>. 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 (FEV1) / FVC ratio and Mid Expiratory Flow rate (MEF) were at a high level<sup>12</sup>. 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."<sup>13</sup>. 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 high risk to their health. The stone crushing workers of Peshawar district are one of the neglected groups, and therefore this study was carried out to measure silica exposure and its effect on human lungs 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 176 workers of stone crushing machines 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 April 2017. So it took almost six months 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.

A 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 the n 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 portable spirometer (Spirolab II). The essential readings of PFTs like Forced Vital Capacity, Forced Expiratory Volume in the first, second and ratio between FEV1 /FVC % were recorded.

The dependent variable like the 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- the value of 0.05 or less was considered for statistical significance. Chi-square test and t-test were applied for calculating proportion and percentages.

**RESULTS**

Out of the total of 176, Pulmonary Functions Tests (PFT) results of 52 (29.5 %) participants showed abnormal readings and 124 (70.5 %) were healthy. Out of the abnormal results, the PFTs of 41 participants (23.3 %) showed a restrictive pattern and 11 (6.2 %) obstructive pattern as shown in the following table.

Job duration of the stone crushing industries workers was divided into three categories. Those working for less than five years, 5-10 years and more than ten years. 62 (35.2 %) workers were there in the first group, i.e., their job duration was less than five years. 71 (40.3 %) participants were working for 5-10 years and 43 (24.4 %) for more than ten years.

When the frequencies of daily working hours of the workers were analyzed most of the workers 107 (60.8 %) were working daily for 6 hours. 46 workers (26.1 %) were working for 8 hours or more and 23 (13.1 %) for 4 hours every day.

Out of the total 176 participants, 108 (61.4 %) were non-smokers, 31 (17.6 %) were occasional smokers

**Table-1: Pulmonary Functions Tests (PFT) Results.**

		Frequency	Percent	Cumulative Percent
Valid	Normal	124	70.5	70.5
	Restrictive	41	23.3	93.8
	Obstructive	11	6.2	100.0
	Total	176	100.0	

**Table-2: Relationship of PFTs and job duration (Cross-tabulation).**

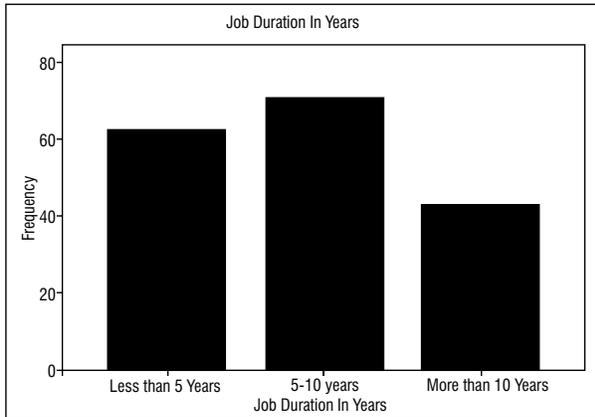
Job duration in years and Result PFTs Cross-tabulation								
		Result PFTs			Total	Chi Sq. value	Degree of freedom	p-value
		Normal	Restrictive	Obstructive				
Job duration in years	Less than 5 Years	55	6	1	62	30.13	4	< 0.001
	5-10 Years	52	15	4	71			
	More than 10 Years	17	20	6	43			
Total		124	41	11	176			

**Table-3: Relationship of daily working hours and PFTs (Cross-tabulation)**

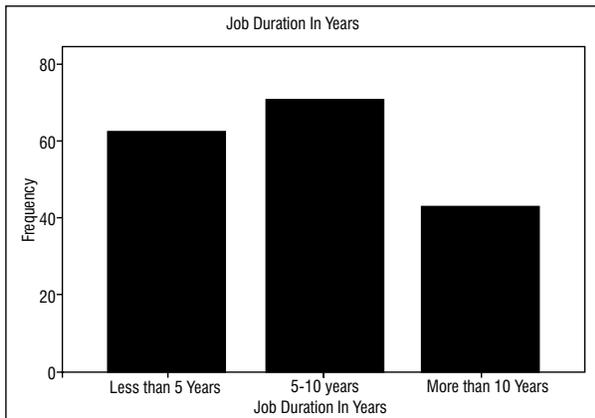
		Result PFTs			Total	Chi Sq. value	Degree of freedom	p-value
		Normal	Restrictive	Obstructive				
Daily Working Hours	4 Hours	18	3	2	23	13.63	4	< .009
	6 Hours	83	19	5	107			
	8Hours or more	23	19	4	46			
Total		124	41	11	176			

**Table-4: Relationship of Smoking status with PFTs (Cross-tabulation)**

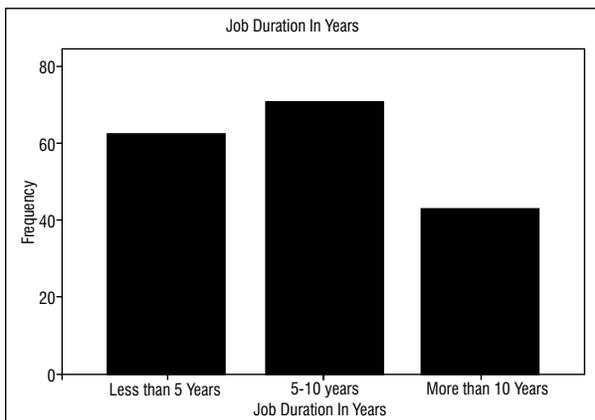
Smoking status	Result PFTs			Total	Chi Sq. value	Degree of freedom	p-value
	Normal	Restrictive	Obstructive				
Non-Smoker	85	19	4	108	15.53	6	< 0.016
Occasional smoker	21	8	2	31			
5-10 Cigarettes per day	13	12	3	28			
One pack or more per day	5	2	2	9			
Total	124	41	11	176			



**Fig 1.** Job duration of the participants.



**Fig 2.** Daily working hours of the workers.



**Fig 2.** Daily working hours of the workers.

ers, 28 (15.9 %) workers were smoking 5-10 cigarettes per day, and 9 (5.1 %) participants were smoking one pack or more per day as is given in the graph above.

The association of PFTs and job duration in years when calculated, it was found that as the exposure duration, which is the job duration, increases, the PFTs of the participants become more deranged. The Chi-Square value given in the above table is 30.13, with 4 degrees of freedom and p-value < 0.001. The p-value (< 0.001) signifies a strong association between PFTs and increase in the working years in the stone crushing industries workers because the exposure to silica dust increases with the passage of time.

The daily working hours of the participants were divided into three categories. Those working for four hours, those working for 6 hours and those working for 8 hours or more per day. It can be seen in the above table that in the first category out of 23 workers, 5 (21 %) have abnormal PFTs. In the second group, i.e., the participants working for 6 hours, out of 107 workers, 24 (22 %) have abnormal PFTs, and in the third category, out of 46 workers, 23 (50 %) have abnormal PFTs. The Chi-square value is 13.63 for 4 degrees of freedom, and the p-value is < 0.009, which means that there is an overwhelming association between an increase in the working hours of the workers and abnormal PFTs.

It is observed and what is expected that PFTs are more deranged in the workers who also smoke and particularly where the intensity of smoking is more. It is seen from the above Table No. 4 that as the intensity of cigarette smoking increases the prevalence of abnormal PFTs increases. Out of 176 participants, 124 showed normal PFTs results, 41 had the restrictive pattern, and 11 had an obstructive pattern. 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. The Chi-square value is

15.33 for 6 degrees of freedom, and the p-value is < 0.016 which means that there is strong evidence that smoking is associated with abnormal PFTs in these workers.

### 1. Relationship of job duration and Pulmonary Functions tests

### 2. Relationship of daily working hours and Pulmonary Functions tests

### 3. Relationship of Pulmonary Functions tests and smoking

## DISCUSSION

The workers at stone crushing units are exposed to dust and gases comprising mainly silica along with other carbon-containing elements like iron, and manganese. Silica dust is known to hurt 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 higher (45 %) occurrence of respiratory symptoms which is similar to the study of AN Nwibo in Nigeria<sup>14</sup>.

In our study, 29.5 % participants had abnormal 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)<sup>15</sup>. 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<sup>16</sup>. Hertzberg VS et al. observed that as the silica exposure increases in smokers, the percent- predicted FVC and FEV1 and FEV1/FVC are decreased<sup>17</sup>.

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<sup>18</sup> and

Sachin B Rathod, Smita and R. Sorte<sup>19</sup> it was found that there is a significant inverse relationship between years of exposure to occupational quartz and PFTs, particularly FVC, FEV1 and the ratio of FEV1/FVC. Mohammad Golshan et al., during six years longitudinal study found that the decrease in FVC, FEV1, FEFE75 and FEF25-75 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 FEV1 is 25-30 ml for normal American adults while the measurements noted in their research was 61.95 ml which are double the normal values<sup>20</sup>. 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)<sup>21</sup>. All these findings strongly support the results 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 noted 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 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 most significant and most progressive in FEV1, FEV1/FVC<sup>22</sup>. It was also assessed that smokers with silicosis were two times more at risk of developing lung cancer than non-smokers with silicosis<sup>23</sup>. The results of our study are too much similar to the results of Rubeena Bano et al.<sup>24</sup> and Sunita Nighute and Abhijit Awari<sup>25</sup> 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 lung functions. The values for FVC, FEV1, and the ratio of FEV1 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 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. A strong association was found between the increase in the working years and working hours of the workers and abnormal PFTs.

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 and lungs impairment. Therefore for prevention of silica dust associated chronic obstructive pulmonary disease, reducing or eliminating both dust and smoking is essential.

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