Asian Pacific Journal of Environment and Cancer
Vol 5 No 1 (2022), 45-48
Original Research

Effect of Occupational Exposure to Crystalline Silica on Pulmonary Indices in Tile and Ceramic Workers

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Objective: The ceramic industry has developed rapidly in recent decades and the exposure of workers in this industry to dust containing crystalline silica has also increased. the aim of this study was the evaluation of worker's exposure to crystalline silica and its impact on pulmonary indices in a tile and ceramic industry.
Method: In this descriptive and analytical study, 60 repairable samples from six sections of tile and ceramic workers were collected and analyzed by NIOSH 7601 sampling method. Pulmonary parameters were measured using a spirometer. The tests were performed according to the criteria of ATS 2005 Finally data analysis was performed.
Result: The mean age in the exposed group to dust and control group was 38.91 ± 5.96 years and work experience was 6.58 ± 1.74 years. 25% of them was smokers and 30% of the workers used respiratory protection devices. The highest average exposure rate to silica were in the stone crusher section (0.43 mg/m^3) the lowest average exposure rate to silica dust was in the packing section.
Discussion: the result show 95 percent of samples were higher than the NIOSH occupational exposure limit FVC and FEV1 in the groups exposed to silica dust decreased significantly, which could be due to the presence of dust in the working environment.

Introduction

The word silica is a common name for minerals that have the chemical formula of silicon oxide sio_2. There are subgroups of these chemical compounds of various minerals with different physical and chemical characteristics. These minerals can be in different geological conditions as crystalline silica with a regular molecular structure and arrangement (quartz, cristobalite, tridymite (and non-crystalline silica with a structure and Irregular molecular arrangement (opal) exists in nature. Quartz is the second most common mineral on the planet [1]. Inhalation of silica in crystalline form can lead to diseases such as silicosis, tuberculosis and lung cancer. [2]. Silica is known as a toxic agent in work environments, so International Agency for Research on Cancer (IARC) has included this substance as a group A1 of carcinogenic substances (definitely carcinogenic to humans) [3]. Many workers in various industries such as casting [4], stone crushing, grinding [5], construction activities [6], cement production [4] are exposed to dust caused by crystalline silica particles. Throw Exposure to crystalline silica causes silicosis, that is one of the oldest occupational diseases. In addition to silicosis, exposure to silica is associated with lung cancer [7], benign respiratory diseases [8], benign kidney diseases [8], and autoimmune diseases [9].

Since silicosis is an incurable, but preventable disease, awareness of the quantitative and qualitative conditions of reparable crystalline silica dust in the air of the work environment to provide effective ways of prevention, control and efforts to minimize the adverse effects has particular importance Based on estimates of the National Institute for Occupational Safety and Health (NIOSH), more than 1.7 million workers in the United States and each year more than 250 of them die from silicosis. Also, 3 million in the European and 350,000 in Canada are exposed to crystalline silica. Several recent epidemiologic studies have shown that the current values of standard silica exposure levels are insufficient to protect and prevent chronic silicosis in workers. Studies have shown that in Asia, nearly 11.5 million in India and 23 million worker in China are expose to silica dust [10].

Anlar and colleagues carried out a study on Turkish ceramic workers to assess their health in which blood indices, pulmonary enzymes, and pulmonary indices were employed to compare the ceramic workers with control group. the results show, blood indices like ALT, AST, PLT, WBC, and CR were reported to be higher among the ceramic workers than the control group while the levels of hematocrit were lower in the ceramic workers than the control group. Thirty-eight of these workers were diagnosed with silicosis, nine were suspected of having silicosis, and only 52 were healthy [11]. The aim of this study was the evaluation of worker’s exposure to crystalline silica and its impact on pulmonary indices in the tile and ceramic industry.

Materials and Methods

In this study, occupational exposure to dust containing crystalline silica in a tile and ceramic factory was investigated. Also, according to the results of preliminary studies, the number of samples was estimated to be 60 samples. In this study, to determine the exposure of workers to crystalline silica dust, sampling was conducted based on the NIOSH7601 method [12].

Due to the difference of the environmental conditions in terms of temperature and pressure with the standard conditions (T= 25^{o}C, pressure 760 mm Hg) in the place of sampling pump calibration and location, the volume of air sampled in standard conditions has been corrected according to the following formula.

V_{stp} = volume of air in standard conditions in liters.

V_{mes} = sampling air volume in liters

P_{bar} = barometric pressure in millimeters of mercury.

P_w = saturated water vapor pressure at temperature t in mm Hg.

T= ambient temperature in degrees Celsius

to remove moisture and reduce the error, the filters were placed in a desiccator 24 hours before and after sampling and weighed with a0.00001 gram-, also the pump flow rate was set to 1.7 liters per minute. The concentration of crystalline silica in the samples calculated through the following formula.

Where C is the concentration of crystalline silica in mg/m^3, A is the absorption rate in the original

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sample, B is the absorption rate in the control sample, m is the slope of the calibration curve and V is the corrected volume of the sampling air in liters.

Pulmonary parameters (FEV1’FVC) were measured using a spirometer (Vitalograph 2120, ENNIS, Ireland). The spirometry test was repeated 3 to 5 times to obtain acceptable results. The tests performed according to the criteria of ATS 2005. The evaluated spirometry variables were FVC, FEV1, FEF25-75% and PEF. The Pulmonary indicators of exposed people were compared with the control group that was selected from the administrative department and their exposure level was much lower than the standard. The Kolmogorov-Smirnov test was used to check the normality of the variables. After making sure that the variables were normal, ANOVA test was used for analysis and comparison of the different groups mean.

Results

The study population included 60 workers of one of the large tile and ceramic industries who are exposed to dust containing crystalline silica, according to Table 1, the average age was 38.91 ± 5.96 years and, work experience was 6.58 ± 1.74 years 25% of them were smokers and 30% of the workers use respiratory protection devices.

Variable	Mean±SD
Age (year)	35.3 ± 4.9
Weight (kg)	72.3 ±9.4
Height (cm)	172.4 ±8.3
Work experience (year)	9.8 ±2.2
Smoking	
Yes	13 (21)
No	47 (79)

Table 1. Demographic Characteristics of Workers.

The results of exposure to crystalline silica for workers in various sections of the tile industry showed in Table 2.

Groups	No. of samples	Mean (mg/m^3)	GM (mg/m^3)	SD
Stone crusher	7	0.43	0.33	0.11
Press	10	0.33	0.21	0.13
Preparation of powder	10	0.32	0.26	0.16
Glaze line	10	0.27	0.18	0.09
Furnace	10	0.16	0.11	0.08
packing	10	0.12	0.1	0.05
SUM	57	0.45	0.196	0.23

Table 2. Average Exposure to Repairable Silica Dust in Different Groups.

As the results show, the highest average the exposure rate to silica was in Stone crusher and press section. Also the lowest average the exposure to silica dust was in packing section. The result showed that 95 percent of samples were higher than the NIOSH occupational exposure limit (P<0.001). Lung function parameters in the workers of the tile factory are shown in Table 3.

	Control group		Working groups			P-value
	Mean	SD		Mean	SD	
FVC, liters	4.1	0.3	Stone crusher	3.1	0.5	0.001
			Press	3.28	0.39	0.001

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			Preparation of powder	3.35	0.68	0.003
			Glaze line	3.7	0/58	0.025
			Furnace	3.87	0.69	0.045
			packing	3.77	0.55	0.033
FEV1, liters	4.7	0.38	Stone crusher	4.2	0.87	0.015
			Press	4.03	0.51	0.001
			Preparation of powder	4.25	0.72	0.018
			Glaze line	4.3	0.65	0.015
			Furnace	4.35	0.63	0.013
			packing	4.28	0.79	0.016
PEF, liters	5.5	7.1	Stone crusher	4.98	0.99	0.12
			Press	4.45	1.02	0.084
			Preparation of powder	4.58	1.12	0.098
			Glaze line	5.1	1.21	0.22
			Furnace	5.3	1.15	0.29
			packing	5.28	1.08	0.25
FEF25-75%, liters	4.08	0.7	Stone crusher	3.45	0.95	0.084
			Press	3.6	1.09	0.01
			Preparation of powder	3.59	0.83	0.015
			Glaze line	3.88	1.24	0.12
			Furnace	3.95	0.87	0.78
			packing	3.84	1.09	0.54

Table 3. Comparison of Lung Function Parameters of Different Working Groups and Control Group.

The results showed a significant difference in FVC and FEV1 between the work groups exposed to crystalline silica dust and the control group ($P<0.05$). Also, there was no significant difference between groups in PEF and forced expiratory flow 25-75% (FEF25-75%) ($P>0.05$).

Discussion

The ceramic industry has developed rapidly in recent decades, and the exposure of workers in this industry to dust containing crystalline silica has also increased.

The aim of this study was the evaluation of workers' exposure to crystalline silica and its impact on pulmonary function in a tile and ceramic factory. The average exposure to silica in this study was higher than the standard exposure limit (0.025 mg/m^3). The highest average exposure to crystalline silica is in the crusher (0.43mg/m^3) press (0.33 mg/m^3) section. In the packing section (0.12 mg/m^3), since the sources of dust production are limited, the average amount of exposure to silica dust was the lowest.

The results of the study showed that the values of FVC and FEV1 in the groups exposed to silica dust decreased significantly, which could be due to the presence of dust in the working environment of the study subjects.Which is consistent with the results of the study conducted by Rahimi Moghadam on concrete workers. In this study, a significant correlation was found in the pulmonary indices between the control and exposure groups, and 22 percent of the workers had an obstructive pattern [13]. In the study conducted by Sirait in ceramics industry workers, result showed there was no significant correlation between dust concentration in the workplace and the lung function [14].

In a study they conducted on rock drillers by Bente et all, compared to the control group the results showed that the pulmonary indices were significantly lower in the exposure group than in the control group Statistically, there was a significant difference between the average pulmonary parameters in the control group and the study group [15].

study by tsao et al in 2017, which examined the pulmonary function on 221 ceramic workers, the result showed 53% of workers experienced restrictive disorders [16]. Although exposure to silica is one of the oldest known causes of lung cancer, it remains one of the leading causes of disease internationally it is rise in workers who use materials with high silica content. The increase in air pollution with fine dust in the community has also been the reason for the increase in jobs that do not use silica. There is currently no effective treatment for silicosis, but it is an entirely preventable lung disease. Worldwide, about five million workers are exposed to crystalline silica. The prevalence of silicosis is high in occupations involving inhalable silica dust, with as many as 55% of workers in India working in jobs such as coal mining, Silicosis has been observed [17]. The results of this study show that exposure to dust has a harmful effect on the functioning of the respiratory system. In addition, the exposed groups had significantly lower pulmonary function than the control group.The limitations of this research can be pointed to the high cost of analyzing dust samples to determine the concentration of crystalline silica. It is suggested to conduct a wider study considering different seasons of the year because the amount of wind speed, temperature, air pressure and general and local ventilation are effective on the concentration of dust exposure.

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