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Original

Occupational Exposure to Nickel in Glaze Workers

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Abstract

Background: Nickel is a toxic metal used as a pigment in ceramics industries. The purpose of this study was to assess inhalation exposure to nickel in the breathing zone of glazers and non-exposed group of workers. We also compared pulmonary function between ceramic glazers and the non-exposed group. **Methods:** In this cross-sectional study, 49 glazers and 55 office workers were investigated. Air sampling in the breathing zone of each glazer was taken on a cellulose ester membrane filter with 37-mm diameter. The samples were then analyzed by inductively coupled plasma-atomic emission spectroscopy (ICP-AES). All the participants were required to fill out questionnaires on descriptive information. The parameters of pulmonary function were measured for both exposed and non-exposed participants. **Results:** The mean nickel concentration in the breathing zone of glazers was 0.09 mg/m^3. Glazers had a significantly lower parameters of pulmonary function than office workers (p<0.05). Level of nickel was significantly higher in tile glazers in comparison with pottery glazers. **Conclusion:** In factories where local or general control is not feasible, workers must use personal protective equipments. Workers also should not be allowed to eat or smoke in the workplaces with toxic materials.

Keywords: Nickel; Occupational Exposure; Inhalation Exposure; Air Pollution

Introduction

Nickel (Ni) is a toxic metal used in manufacturing of stainless steel, electroplating, batteries, pigments, catalysts, and ceramics.[1] Primary substances of ceramic industry are frits and clay, which are sources of quartz, talc, feldspar, silica (SiO2), and alumina (Al2O3). These raw materials are dispersed in water and should be molded to produce ceramic biscuit. To increase the beauty, chemical and mechanical resistance, impermeability, and sanitation of ceramics, glazes are applied on biscuit. The glaze can be applied on the ceramic before cooking in the furnace by brushing, sponging, dripping, or spraying. Glazes are composed of quartz, feldspar, and various metal oxides such as nickel oxide which has been used in glazes traditionally. Yellow, green, brown, and black colors can be produced with a nickel oxide.[2] Glazers are occupationally exposed to nickel by inhalation of nickel-containing dust and fumes or dermal contact while weighting, mixing, handling, and heating operations.[1, 2]

The skin is a major target organ in chronic nickel exposure. Several studies reported cases of contact

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dermatitis among enamellers and decorators in the ceramics industry that can show high levels of nickel in such industries.[3-5] About 25% to 35% of the inhaled nickel is absorbed from respiratory tract into the blood.[1] The International Agency for Research on Cancer (IARC) classifies nickel as respiratory tract carcinogen based on evidence in humans and animals.[6] Various studies also confirm the association of exposure to nickel containing dust with lung and nasal cancer in workers chronically exposed to this chemical.[7, 8]

The aim of this study was to determine the nickel concentration in the breathing zone of glazers of ceramic industry. We also aimed to explore the association of work characteristics such as morning/evening shifts and job titles with concentration of nickel in breathing zone of the workers. We also measured and compared lung functions in glazers and the non-exposed participants.

Methods

This cross-sectional study was performed in glazing workshops of a ceramic industry. The study was approved by local institutional ethics board. The study population consisted of a total of 49 male glazers (33 tile glazers, 16 pottery glazers) occupationally exposed to nickel containing raw materials and a non-exposed group of 55 male office workers without any known history of occupational exposure to nickel. All the participants filled out a researcher-made questionnaire containing questions about job title, work shift, age, weight, and height. Prior to data collection, the participants received written and verbal explanation of the project aims and accepted to participate in the study. They also signed a written informed consent.

Eight hours air samples were taken from the breathing zone of glazers by a personal sampling pump. The nickel was collected on a cellulose ester membrane filter of 37-mm diameter. The flow rate of the pump (SKC 224) was adjusted to 2 liters/min. Before taking the samples, the pumps were calibrated by an electronic bubble meter. During the sampling, blank samples were collected from workplaces. The concentration of nickel was measured by inductively coupled plasma absorption emission spectrophotometry (ICP-AES) (SPECTRO, ARCOS, Germany) in accordance with a NIOSH 7300 method.

The lung function tests were performed according to American Thoracic Society (ATS) recommendation on exposed and non-exposed subjects with a spirometer (Vitalograph; model 2120). The spirometer was calibrated daily with one-liter calibration syringe and operated within a temperature range of 20-25° C. Tests were performed in a standing position and Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), and Forced Expiratory Flow of 25% - 75% of the FVC (FEF_{25-75}) were measured. The FEV_1/FVC ratio was then calculated as percentage. Statistical analysis was performed using SPSS software (Version 16). T-test was used to analyze the difference between mean inhalational exposure of the groups. The level of significance was considered as $p<0.05$.

Results

Demographic characteristics of participants are shown in Table 1. Means of age, height, and weight were not significantly different between two groups ($P>0.05$). Nickel concentration in the breathing zone was analyzed in 49 glazers. Mean nickel concentration was 0.09 mg/m^3, ranged from 0.04 mg/m^3 to 0.44 mg/m^3. The results obtained from the analysis of nickel in the breathing zone of glazers presented in Table 2.

Table 1. Population characteristics of the study groups

Parameter	Glazers (n=49) Mean (SD)	Non-exposed (n=55) Mean (SD)	*p*-value
Age (Year)	32.60 (7.10)	30.67 (5.88)	0.12
Height (Cm)	176.42 (9.06)	174.52 (8.61)	0.26
Weight (Kg)	78.25 (10.60)	77.44 (11.70)	0.70
BMI (kg/m2)	25.33 (4.29)	25.59 (4.39)	0.76

Table 2. Means and standard deviations of nickel in breathing zone of glazers according to work characteristics of participants

Factor	n	Mean(SD)	*p*-value
Working shift			
Morning	23	0.10(0.10)	0.23
Evening	26	0.07(0.06)	
Job title			

Pottery Glazer	16	0.06(0.01)	0.05	Tile Glazer	33	0.10(0.10)	

Table 3. Lung function among exposed and non-exposed participants

Parameter	Glazers (n=49)				Non-exposed (n=55)				*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
FVC(liter)	4.24	0.67	2.86	5.65	4.74	0.66	3.20	5.80	<0.001
FEV_1(liter)	3.50	0.70	2.10	5.28	4.25	0.70	2.57	5.74	<0.001
FEV_1%	80.99	8.16	58.00	98.00	88.85	5.60	80.00	99.00	<0.001
FEF25-75(liter)	3.47	0.80	2.18	5.60	4.49	0.69	2.35	5.50	<0.001

No significant differences were found in the Ni concentrations of morning and evening shifts (0.1 mg/m^3 vs 0.07 mg/m^3) (p>0.05) (Table 2).

A statistically significant difference was detected for job titles (p<0.05). Tile glazers had statistically higher nickel concentration than pottery glazers (0.1 mg/m^3 vs 0.06 mg/m^3).

Mean values of FVC, FEV_1, FEV_1/FVC, and FEF_{25-75} were lower in the exposed group than non-exposed group (Table 3). Analysis of the lung function tests revealed significant differences in all spirometric parameters between the glazers and non-exposed group (p<0.05) (Table 3).

Discussion

The results of this study showed that level of exposure to nickel is close to the ACGIH threshold limit value of 0.1 mg/m^3.[9] High level of urinary nickel also reported in some of pigment industry workers in comparison with not exposed individuals which is in agreement with the findings of our study.[10] The higher amount of nickel found for tile glazers is probably due to the use of nickel in the glazes, various nickel containing raw materials used in the workshops, and difference in working conditions such as ventilation system.[11] Since condition of workplaces such as ventilation system and glaze constituents did not change in the shifts, there was no significant difference between the two groups in terms of working shifts.

There was difference in all spirometric measures between the two groups. The difference in FEV_1 and FEV_1/FVC was higher in those exposed to nickel than the non-exposed group. The findings of this study showed that working in the glazing unit is associated with a decline in lung function; could be result in obstructive syndrome in the future. However, this result cannot be related only to nickel. Indeed, in the glazing unit workers are exposed to coloring agents such as nickel as well as silica that are exposure to them also are related to reduced lung function. The glazers had been exposed simultaneously to heavy metals and silica dusts. The studies carried out over the effects of silica on tile or pottery workers indicated a significant difference in lung function measurements between those exposed to silica dust and those not exposed. Several studies in Iran reported that exposure to silica is related to reduction in pulmonary function and chronic obstructive pulmonary disease.[12, 13]

In addition to glazers, the general population may be exposed to nickel when using glazed ceramics to prepare food. In Nigeria, the release of nickel in dishes imported from China was reported.[14] Their results showed that the acidic foods can release heavy metals from the ceramics into food substances. In another study, nickel release value of ceramic glazes was measured under different conditions. The findings represented that for tea at 80° C and orange juice at room temperature the release of nickel were 70–80 µg/l and 70–134 µg/l respectively.[15] In order to reduce toxicity of black pigments containing nickel, substitution of magnesium, zinc, and low amount of chromium is recommended.[16]

Consequently, pre-employment examinations must be carried out and the results as well as the

recorded working histories of individuals should be done regularly at glazing workshops. Workers with suspected test results or a history of asthma and allergies should be prevented from more exposure to nickel. Furthermore, in factories where local or general controls are not feasible, workers must use personal protective equipments. Workers also should not be allowed to eat or smoke in the workplaces with toxic materials.

Conflict of interest

The authors declare no conflict of interest.

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