

# Survey Effect of Exposure to Formaldehyde on Pulmonary Function Test in Hospital Staffs

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## Abstract

**Background and Aim:** Air pollutants such as formaldehyde can affect lung functions and make distortion in gas changing of lungs. The volumes and the flows of each breath can be measured with spirometer test. The aim of this study was to assess the effects of formaldehyde exposure on the pulmonary function test in hospital staffs. **Material and Methods:** This cross-sectional study was conducted in a hospital and involving 60 participants (30 staffs in exposed group and 30 staffs in control group). The measurement of formaldehyde concentration was using method 3500 national institute for occupational safety and health. In this study, a questionnaire was used to evaluate and determine the prevalence of respiratory symptoms. Spirometry test was used to evaluate the parameters of pulmonary function in two groups. *t*-tests and Chi-square as statistics tests were used to create data analysis. **Results:** The respiratory symptoms showed a significant difference between exposed group and control group ( $P < 0.05$ ). Furthermore, parameters of pulmonary function forced vital capacity, forced expiratory volume in the first second, and peak expiratory flow in the exposed group and the control group were significantly different ( $P < 0.05$ ). **Conclusion:** Our study showed that exposed group with formalin has complex disorder of both restrictive and obstructive types.

**Key words:** Formaldehyde, pulmonary function test, spirometer

## INTRODUCTION

Air pollutants such as formaldehyde can affect lung functions and make distortion in gas changing of lungs. The volumes and the flows of each breath can be measured with spirometer test. As a natural substance in the environment, formaldehyde is composed of carbon, oxygen, and hydrogen. With the chemical formula of HCHO, formaldehyde is a colorless and odorless gas with the high potential of flammability and reaction.<sup>[1]</sup> This gas can be the by-product of natural events (for instance forest fire) or human activities (smoking, automobile fuel combustion, fire made on wood, etc.).<sup>[1-3]</sup> Formaldehyde is used in two forms: A liquid form called formalin dissolved in water and methanol that is light yellow in color and a solid powder form known as paraformaldehyde.<sup>[4]</sup> Formaldehyde is used in hospitals, laboratories, and universities for the

preservation and mummification of corpse and as a sterilizing agent.<sup>[3]</sup> Due to its reactivity, stability, and low cost, it is widely used in many industrial processes such as resin production, adhesive and plastic production, photography, pharmacy, leather production, antiseptic production, and petrochemical industries. Formaldehyde is a potent irritating compound and has strong odor even in low concentrations that are irritating for eyes, skin, and respiratory system.<sup>[5,6]</sup> Various symptoms occur during exposure to formaldehyde including irritation of eyes, nasal cavity and upper respiratory tract and nervous toxicity in low concentrations<sup>[7]</sup> and higher concentrations

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it can cause irritation of lower respiratory tract, pulmonary dysfunction and asthma,<sup>[8]</sup> nasopharynx cancer,<sup>[9,10]</sup> and myeloid leukemia has been observed if exposed for a long time.<sup>[11,12]</sup> Formaldehyde has been known to cause acute toxicity that has stimulatory and other immunotoxic effects. Acute inflammation of epithelial membrane is the most prevalent side effect of exposure to formaldehyde that often leads to skin dryness, dermatitis, tearing, sneezing, and coughing.<sup>[13]</sup> Gastrointestinal toxicity due to formaldehyde leads to mouth and throat burning, burning, and ulcers of digestive system, nausea, vomiting, diarrhea, and digestive system hemorrhage.<sup>[14]</sup> The international agency for research on cancer has categorized formaldehyde as human cancerous agent based on adequate observation and documents on human and laboratory animals.<sup>[15-17]</sup> Regarding the effects of formaldehyde on respiratory system function, Alexanderson and Hedenstierna (1989) showed a relationship between impaired pulmonary function and exposure to formaldehyde. Therefore, exposure to formaldehyde for more than one working shift causes a transient dysfunction of the lungs that are cumulative over the year.<sup>[18]</sup> Based on the studies carried out by Neghab *et al.*, exposure to formaldehyde results in some respiratory symptoms and causes semi-acute reversible and chronic irreversible reduction of pulmonary function.<sup>[19]</sup> Since the vast majority of personnel in the hospitals are exposed to formaldehyde and its adverse effects and because this group of society provides service to save people's life and to promote health level of the society, improving the health measures of this group seems to be one of the most important tasks of health and treatment authorities so that the damage to these people can be kept at the minimum level during their professional career. The aim of this study was to assess the effects of formaldehyde exposure on the pulmonary function test (PFT) in hospital staffs.

## MATERIALS AND METHODS

This descriptive cross-sectional study was performed in an educational hospital in Ahvaz, Iran. Participants included 30 persons of operation room with exposure to formaldehyde (exposed group) and 30 persons of officials not usually exposed to formaldehyde (control group). Exclusion criteria in this study were respiratory symptoms such as asthma, a cold, and influenza.

The procedure No. 3500 of the national institute for occupational safety and health (NIOSH) was used to determine occupational exposure to formaldehyde in the studied unit.<sup>[20]</sup> 17 air samples were collected from the hospital environment. To this end, individual sampling pump (SKC-224-44MTX) and impinger bottles containing sodium bisulfite 1% and PTFE type filter connected to pump to prevent contamination of samples with aerosols were used. After collection, samples were heated at 95°C with chromotropic acid solution (as marker) in 96% sulfuric acid medium to form a chromatic substance. The chromatic substance was then injected to VIS

spectrophotometer, and color density was read at 580 nm wavelength to determine formaldehyde concentration in samples.

Examination of respiratory symptoms: Personnel was interviewed at workplace to complete a questionnaire containing respiratory symptom checklist according to recommendations of the American society of pulmonologists<sup>[21]</sup> with little modifications. The checklist contained questions about probable respiratory symptoms (including coughing, Phlegm, wheezing, sense of pressure on the chest, tearing, sore throat, and mouth dryness), occupational background, medical and familial background, smoking, and current and previous professions.

## PFT

PFTs including forced vital capacity (FVC), forced expiratory volume in the first second (FEV1) and peak expiratory flow (PEF) were performed in individuals of both groups using a portable calibrated spirometer (MIR, model Spirolab III). In the experimental group, spirometry was performed immediately before and after working hours every day. The mean values of pulmonary function parameters were calculated based on age, weight, height, and sex of volunteers using spirometer. Individuals were asked to avoid bathing, smoking, and eating heavy meals at least 2 h before spirometry. Immediately before the test, volunteers were asked to take a resting position on a seat for 5 min during which necessary tips for the better performance of spirometry were given to individuals. Spirometry was repeated for 3–8 times on every individual and the best performance was considered as acceptable. *t*-test was used to investigate the homogeneity of quantitative variables such as height, weight, and occupational background between two groups of individuals and to assess the qualitative variable (smokers vs. nonsmokers) Chi-square test was used. For the comparison of means of pulmonary function parameters between two groups, independent *t*-test was used, and means of parameters before and after the exposure to formaldehyde was compared using paired *t*-test. In addition, to investigate the association between exposure to formaldehyde and pulmonary function parameters, linear regression analysis was performed. Data were analyzed using SPSS software version 23.

## RESULTS

The mean age, weight, height, and working experience in exposed group were  $36.1 \pm 6.7$  years,  $69.3 \pm 15.3$  kg,  $167.8 \pm 8.4$  cm, and  $11.3 \pm 6.1$  years, respectively, and in control group was  $32.9 \pm 8.24$  years,  $68 \pm 15.4$  kg,  $165.5 \pm 9.8$  cm, and  $9.4 \pm 7.3$  years, respectively. No significant difference was observed between two groups regarding any of demographic characteristic ( $P > 0.05$ ). Furthermore, the number of smoker individuals was not significantly different between two

groups ( $P > 0.05$ ). The mean concentration of formaldehyde vapors in 17 samples taken was  $0.15 \pm 0.07$  ppm that is higher than the short-term maximum level recommended by NIOSH (0.1 ppm). The results of PFTs and the mean values for FVC, FEV1, FEV1/FVC, and PEF are presented in Table 1. Results indicate a significant reduction in FVC, FEV1, FEV1/FVC, and PEF in experimental compared to the control group. Results of paired T-test showed a significant decrease in FVC, FEV1, FEV1/FVC, and PEF values at the end of daily working hours compared to those obtained at the start of work in the experimental group ( $P < 0.05$ ) [Table 2]. Table 3 showed the frequency of all respiratory symptoms is higher in the exposed group compared to the control. Furthermore, the prevalence of all symptoms including (coughing, phlegm, shortness of breath, tearing, mouth dryness, nasal discharge, sore throat, throat dryness, and nasal irritation) was significantly higher in experimental group than the control ( $P < 0.05$ ) with the exception of wheezing and phlegm coughing that was not significant. According to Table 4, among all pulmonary function parameters, only FVC was significantly associated with exposure to formaldehyde ( $P = 0.01$ ). The regression equation is as follows:

$$\text{FVC} = 80.74 - 13.14 (\text{CX})$$

That CX is concentration of formaldehyde.

## DISCUSSION

The aim of the present study was to examine respiratory symptoms and spirometric indices in individuals occupationally exposed to formaldehyde in an educational hospital. All individuals including those in experimental or the control group were identical regarding demographic characteristics such as age, height, weight, professional experience, and smoking. Therefore, these factors did not confound the results in this experiment ( $P > 0.05$ ). Based on results of spirometry, pulmonary function parameters such as FVC, FEV1, and PEF were statistically different between two groups. Since none of individuals had medical or familial experience of respiratory disease, defects or surgery on the chest area, it can be concluded that the significant differences in spirometry parameters between two groups can only be attributed to formaldehyde exposure. Alexanderson and Hedenstierna (1989) reported decreased pulmonary function parameters due to exposure to formaldehyde vapors in wood industry workers.<sup>[18]</sup> Furthermore, Neghab *et al.* investigated the effect of formaldehyde on the prevalence of respiratory disease symptoms and pulmonary function parameters and reported semi-acute reversible and chronic irreversible reduction in pulmonary function parameters.<sup>[19]</sup> A reduced FVC due to exposure to formaldehyde has also been reported by Akbar-Khanzadeh *et al.* who investigated formaldehyde effects on the personnel of the anatomy lab.<sup>[22]</sup> The results of our experiment confirm those of above-mentioned studies. In the present study, pulmonary function parameters were

**Table 1: Comparative PFT between two groups**

Variables	Mean±SD		P
	Exposed group	Control group	
FVC	82.6±5.4	102±6.7	0.000
FEV1	83.1±5.8	98±5.6	0.000
FEV1/FVC	94.3±7.1	98.6±4.9	0.04
PEF	83.3±5.1	93±7	0.000

PFT: Pulmonary function test, SD: Standard deviation, FVC: Forced vital capacity, FEV1: Forced expiratory volume in the first second, PEF: Peak expiratory flow

**Table 2: PFT before and after exposure to formalin in exposed group**

Variables	Mean±SD		P
	Before	After	
FVC	84±4.5	83±5.5	0.001
FEV1	85±5	83±5.8	0.001
FEV1/FVC	95.3±6.6	94±7	0.04
PEF	84.6±4.5	83.3±5	0.002

PFT: Pulmonary function test, SD: Standard deviation, FVC: Forced vital capacity, FEV1: Forced expiratory volume in the first second, PEF: Peak expiratory flow

**Table 3: Respiratory symptoms in two groups**

Respiratory symptoms	n=30 (%)		P
	Exposed group	Control group	
Persistent cough	9 (29)	0 (0)	0.000
Phlegm	8 (25.4)	0 (0)	0.001
Wheezing	3 (10)	2 (6.7)	0.6
Dry throat	13 (45)	0 (0)	0.01
Shortness of breath	13 (42)	3 (10)	0.004
Cough with phlegm	5 (16)	1 (3.3)	0.07
Nasal irritation	19 (62)	0 (0)	0.001
Rhinorrhea	11 (35.5)	0 (0)	0.001

measured either before or after the working hours every day in the experimental group. We observed a significant decrease in FVC, FEV1, and PEF between 2 time points due to formaldehyde exposure. The prevalence of respiratory symptoms such as coughing, phlegm, wheezing, shortness of breath, tearing, mouth dryness, nose and throat irritation, nasal discharge, and throat dryness was significantly higher in the experimental group compared to the control ( $P < 0.05$ ) with the exception of wheezing and phlegm coughing which was not significant ( $P > 0.05$ ). The effects of formaldehyde on the respiratory symptoms and diseases have been extensively studied. Yaacob *et al.* reported eye and nose irritation among medical students and anatomy lab personnel due to formaldehyde exposure.<sup>[23]</sup> Our results have also been confirmed by other studies.<sup>[24-26]</sup> The linear regression

**Table 4:** Relationship between occupational exposure to formalin and respiratory function in exposed group

Variables	Number of samples	Exposure range (ppm)	P value
FVC	17	0.05–0.31	0.01
FEV1	17	0.05–0.31	0.08
FEV1/FVC	17	0.05–0.31	0.08
PEF	17	0.05–0.31	0.59

FVC: Forced vital capacity, FEV1: Forced expiratory volume in the first second, PEF: Peak expiratory flow

analysis of pulmonary function data from experimental group revealed a significant association only between formaldehyde exposure and FVC. Neghab *et al.* showed that formaldehyde significantly affects FVC, VC, and FEV1 parameters<sup>[19]</sup> that is in agreement with our results.

## CONCLUSIONS

Our study showed that exposed group with formalin has a complex disorder of both restrictive and obstructive type. We also found a decrease in pulmonary function parameters due to short-term exposure to formaldehyde.

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