

## ORIGINAL ARTICLE

# Respiratory Effects Induced by Occupational Exposure to Formaldehyde among Health Care staff

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## ABSTRACT

Formaldehyde is a common indoor pollutant with irritant properties. The present case control study was undertaken among 37 exposed staff with formaldehyde and 19 non exposed (referent) ones to study the acute and chronic effects of it in two educational hospitals. All subjects were tested for respiratory function by a portable alpha Vitalograph-UK. In addition using a respiratory questionnaire, data on demographic information and respiratory symptoms were collected. The results showed that exposed medical staff had high prevalence rates of regular cough, wheezing and itching and burning sensations of the nose on acute exposure to formaldehyde. These effects were higher on chronic exposure. On the other hand, although the respiratory function parameters such as FVC (Forced Vital Capacity), FEV1 (Volume that has been exhaled at the end of the first second of forced expiration) and PEF (The highest forced expiratory flow measured with a peak flow meter) diminished in some exposed subjects, the respiratory function in two groups of subjects did not indicate any significant differences ( $p < 0.05$ ). In conclusion the respiratory function test cannot be always exact criteria to demonstrate adverse health effect of formaldehyde exposure.

**Keywords:** Formaldehyde, Respiratory function, Medical staff, Prevalence

## INTRODUCTION

Formaldehyde is a ubiquitous and important occupational and air pollutant to which millions are daily exposed. Because of high solubility of this compound, it can cause irritation of upper respiratory system [1-3]. Occupational data recommends that small but significant changes may occur in lung functions following prolonged exposure to formaldehyde [3]. Upper airway irritation is the most common respiratory effects reported by the exposed workers and occurred in

some workers with exposures to formaldehyde at very low concentrations. Symptoms of upper airway irritation include dry or sore throat, itching and burning sensations of the nose and nasal congestion as well as regular cough, wheezing and shortness of breath [1, 4]. Potential effects of exposure to formaldehyde on respiratory system are a controversial issue that needs more researches and studies. While some studies reported high prevalence of upper airway disorders or decrease of forced expiratory volume at first second as a symptom of formaldehyde exposure comparing case and control groups, others did not show any significant change in pulmonary function parameters [5-10]. On the other hand, other results showed irritation and

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sensitization effects of formaldehyde on eye, throat and upper respiratory system and significant changes in spirometry parameters [11-12]. In a retrospective cohort study done in Finland, carcinogenicity hypothesis of formaldehyde in making respiratory system cancer related to this compound was confirmed. Moreover, this research showed that carcinogenetic effect of formaldehyde on upper respiratory system was higher than pulmonary one [13].

The main route of occupational exposure to formaldehyde in the body is inhalation [1]. It has several applications and used widely in different industries such as adhesive and resin, melamine and plastic, wood and rubber industry, etc. [4]. One of the widely usages of formaldehyde is in a way of formal solution or formalin [aqueous solution of formaldehyde contain of 37 to 50 percent formaldehyde and about 10 to 15 percent methanol] in health care centers and hospitals [3]. It has been used for disinfection or sterilization of instruments used for medical purposes as well as cadavers and as a preservative of biological specimens. Formaldehyde can cause physiological changes of respiratory system [1-2].

Therefore, in recent years, much attention was paid to potential health hazards of this compound in occupational exposure situations [13]. In spite of all global and federal limitations and inhibitions related to work and health were established till now, unfortunately, we can yet see usage of formaldehyde in some medical services for example in hospitals and gross anatomy laboratories in order to disinfection of floor, equipments, as well as cadavers and as a preservative of biological specimens.

Formaldehyde is extremely irritant and inhalation of concentrations less than 1 ppm (0.3 to 0.7) can introduce upper air way irritation for human [14]. Therefore, exposed persons including nurses, medical technicians and cleaner workers in hospitals and similar works situations depending their duties are probably at risk from inhalation route. So, this study was done for two main objects: 1. Determining the prevalence of respiratory symptoms in exposed and non exposed persons and 2. Evaluation of changes of pulmonary function parameters of exposed persons in one educational hospital used formaldehyde comparing another hospital without any use of this compound but use of all the same compounds (as a control group).

## MATERIAL AND METHODS

In this case control analytical descriptive study, 56 occupants from two educational hospitals (Kamkar and Shahid Beheshti Hospitals) including nurses, medical technicians and cleaner workers participate voluntarily at research project. The number of subjects were 37 (case group) and the one for control group were 19 who participated to decrease false positive results. All of them had at least 1 year work history in medical services centers. Any of 19 subjects selected as control group did not have exposure history to formaldehyde. All probably variables in selection of hospitals such as size of hospital and sections, number of beds in each

section, personnel and kinds of medical services which done in each of them were considered precisely and only main difference between two hospitals was consumption of formaldehyde in one hospital and its application inhibition in another one. On the other hand, the demographic properties of all participants (such as sex, age, weight, height, education level, etc.) were gathered and subjects by smoking habit avoided participating in this research. To study respiratory symptoms in two study groups (exposed and non exposed subjects), we used a researcher made questionnaire based on respiratory symptom questionnaire suggested by the American Thoracic Society (ATS) [15, 16], with a few modifications, and after confirmation of its validity and reliability in a pilot study. The questionnaire contained 2 kinds of questions including demographic questions and health effect questions (acute and chronic effects related to formaldehyde exposure), where, acute effects means that adverse health effects induced by formaldehyde just after short term duration of exposure or during usage of this compound, and in case of chronic effects, implies on identical similar effects with acute effects but observed in long term exposure or after long period with no exposure to formaldehyde.

After interviewing of subjects and fulfill the questionnaire, subjects of two groups tested for pulmonary function parameters immediately after two hours of exposure. Pulmonary function tests, including Vital Capacity (VC), Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV1) and Peak Expiratory Flow (PEF), followed guidelines given by the ATS (1979) and measured with a portable calibrated vitalograph spirometer (Vitalograph alpha – England) on site. Finally, the data were statistically analyzed using Mann-Whitney,  $\chi^2$  or Fisher exact (with a preset probability of  $p < 0.05$ ). Statistical tests were conducted using SPSS software (version 11.5).

## RESULTS

### *Demographic data*

Obtained results from demographic data were gathered by asking questions of exposed and non exposed subjects showed that there were no significant differences between two groups of study and all parameters including sex, age, height and job title were similar in two groups. The years of exposure to formaldehyde were the only different parameter between them; it means that, the control group (non exposed subjects) did not have exposure to formaldehyde during years of employment (Table 1).

### *Results of respiratory symptoms*

Respiratory symptoms investigated among study groups showed that in acute exposure to formaldehyde, symptoms such as eye irritation, air way irritation and cough had more prevalence in exposed subjects compared to other individuals (non-exposed group). In addition, other respiratory symptoms including throat

**Table 1.** Demographic data of subjects with or without exposure to formaldehyde (n=37 and n= 19, respectively)

Parameter	Case group	Control group	p-value
	(n=37)	(n=19)	
Age (Mean $\pm$ SD), yr	33.87 $\pm$ 6.91	32.37 $\pm$ 5.94	0.48
Sex, n (%)			
Male	17 (44.7)	12 (63.2)	0.26
Female	21(55.3)	7 (36.8)	
Job, n (%)			
Nurse	17 (44.7)	11 (57.9)	0.5
Medical technician	13 (34.2)	4 (21.1)	
Cleaner worker	8 (21.1)	4 (21.1)	
Height (Mean $\pm$ SD), cm	167 $\pm$ 9.47	162.68 $\pm$ 8.2	0.06
Years of exposure to formaldehyde (Mean $\pm$ SD)	2.86 $\pm$ 1.33	0	< 0.001

**Table 2.** Occurrence percentage of acute respiratory symptoms among exposed and non-exposed subjects to formaldehyde

Symptom	Exposed subjects		Non- exposed subjects		P-value
	(n=37), %		(n= 19), %		
	Yes	No	Yes	No	
Feeling short of breath	18.5	81.5	15.5	84.5	0.1
Throat irritation	13	87	10	90	0.05
Eye irritation	23.5	76.5	10.5	89.5	0.06
Nasal irritation	18	82	5.2	94.8	0.02
Wheezing	7.8	92.2	5.2	94.8	0.07
Air way irritation	21	79	10.5	89.5	0.02
Cough	86.8	13.4	15.7	84.3	0.003

irritation, eye irritation, wheezing and feeling short of breath did not illustrate any significant relation between two groups ( $p > 0.05$ ) and the parameter of feeling short of breath had less significant value among all of the other parameters (Table 2). So, by comparison of exposed and non- exposed subjects, we found three parameters in cluding nasal irritation, air way irritation and cough which have higher significant relation in acute exposure.

On the other hand, as mentioned above, the control group had been selected from a hospital without using formaldehyde anywhere; therefore, the personnel had been exposed to all the chemicals similar to interested hospital without any exposure to formaldehyde. Because of no history of exposure to formaldehyde in control group, there were highly significant differences between the chronic respiratory symptoms among exposed and non-exposed subjects (Table 3). Eye, nasal and air way irritation illustrated more occurrence than other symptoms by 47.3, 47.3 and 36.8 percent, respectively. Wheezing had the lowest occurrence among all stated symptoms.

To investigate the effect of demographic variables in observed chronic respiratory symptoms, we considered incident of at least three respiratory symptoms including eye, nasal and air way irritation in a person, simultaneously. These symptoms were selected because they were three of the most prevalent symptoms in chronic exposure to formaldehyde (Table 3).

Accordingly only years of exposure to formaldehyde showed significant relation in two groups with interested respiratory symptoms ( $p < 0.05$ ) and other variables (age, sex, and job) did not show any significant differences (Table 4).

#### Results of pulmonary function test

To illustrate the effect of formaldehyde exposure on pulmonary function parameters (VC, FVC, FEV1, FEV1/FVC and PEF), pulmonary function test (PFT) was done for all subjects (exposed and non- exposed) by at least one year history of work in hospital. To compare the results, we considered only the best measurements of three measuring tests were done for everyone. The obtained results showed that formaldehyde exposure did not have any effects ( $p > 0.05$ ) on pulmonary function parameters (Table 5).

#### DISCUSSION

The main object of this study was to investigate the respiratory effects among health care workers in hospital whom exposed to formaldehyde and the main advantage of this research was consideration of both acute and chronic respiratory effects of formaldehyde. The participants (exposed and non-exposed) were selected as similar as possible based on demographic characteristics such as age, height, length of employment and kind of job. Additionally, none of the

**Table 3.** Occurrence percentage of chronic respiratory symptoms among exposed and non-exposed subjects to formaldehyde

Symptom	Exposed subjects (n=37), %		Non- exposed subjects (n= 19), %		P-value
	Yes	No	Yes	No	
Feeling short of breath	26.3	73.7	0	100	< 0.001
Throat irritation	34.2	65.8	0	100	< 0.001
Eye irritation	47.3	52.7	0	100	< 0.001
Nasal irritation	47.3	52.7	0	100	< 0.001
Wheezing	13.0	87.0	0	100	< 0.001
Air way irritation	36.8	63.2	0	100	< 0.001
Cough	18.4	81.6	0	100	< 0.001

**Table 4.** Relationship between chronic respiratory symptoms occurrence and demographic variables in exposed subjects

Demographic variables	Respiratory symptoms* in exposed persons (n=37)		P-value
	Yes (n=22)	No (n=15)	
Age (mean $\pm$ SD), yr	33.35 $\pm$ 7.02	34.67 $\pm$ 6.9	0.57
Sex, n (%)			
Female (16)	10 (27)	6 (16.21)	0.74
Male (21)	12 (32.43)	9 (24.32)	
Job, n (%)			
Nurse (n=17)	8 (21.62)	9 (24.32)	0.15
Medical technician (n=13)	8 (21.62)	5 (13.51)	
Cleaner worker (n=7)	6 (16.21)	1 (2.7)	
Years of exposure to formaldehyde, n (%)			
1-4 years (n=13)	10 (27)	3 (8.1)	< 0.01
5-9 years (10)	6 (16.21)	4 (10.81)	
10-15 years (n=8)	5 (13.51)	(8.1) 3	
> 15 years (n=6)	1 (2.7)	5 (13.51)	

\* Respiratory symptoms were considered if three of them including *Eye irritation, Air way irritation and Nasal irritation* reported simultaneously.

subjects had past medical or family history of chronic respiratory illnesses.

According to Table 2, respiratory symptoms investigated among study groups showed that in acute exposure to formaldehyde, symptoms including eye irritation, air way irritation and cough had more prevalence rates in exposed subjects compared to other individuals (non-exposed group). It can be concluded that the major effect of formaldehyde in acute exposure was irritation of upper respiratory system which could cause constriction effects. This conclusion is confirmed earlier [16]. Some of these findings are confirmed the obtained results in similar studies for example in a melamine-formaldehyde resin producing plant and gross anatomy laboratory, respectively [16, 17]. National Institute of Occupational Safety and Health (NIOSH) has also reported that respiratory symptoms such as wheezing and chest tightness among formaldehyde exposed workers were common [18]. Exposure to formaldehyde in work place had shown decreased FEV 1 and diffusion capacity in people employed in carpenter shop [19]. Chronic respiratory effects of exposed subjects had significant differences compared

to non exposed ones. So long term exposure to formaldehyde can have chronic respiratory effects on human. This is obviously illustrated in Table 4, where years of exposure, had significant relation to respiratory symptoms in exposed subjects.

The results of pulmonary function tests have shown no significant differences between measured values of exposed and non-exposed subjects immediately after 2 hr exposure of formaldehyde (in case group). These findings are agreed with the some studies done in pathological laboratories employees, filter-manufacturing plant and hospital laboratory workers, respectively [20-22]. Some pulmonary parameters such as FEV1 and PEF have shown some differences in different days of a week based on length of duration of exposure [23, 24]. Although, a little change in the values of FEV1 and VC immediately after 2 hr exposure is observed in exposed subjects but this could not reach the level of significance. This indicates that there may be a transient mild bronchoconstriction which can be confirmed by studying the exposure on larger number of subjects [16, 17].

**Table 5.** Percentage of measuring values in the best test was done in exposed and non-exposed persons.

Parameters	Measuring value in case group (n=37)	Measuring value in control group (n= 19)	P-value
VC (Mean ± SD)	2.99 ± 1.59	2.45 ± 1.35	0.10
FVC (Mean ± SD)	3.31± 1.68	2.99 ± 1.51	0.24
FEV1 (Mean ± SD)	2.78 ± 1.38	2.45 ± 1.27	0.14
FEV1/FVC (Mean ± SD)	0.70 ± 0.31	0.69 ± 0.32	0.83
PEF (Mean ± SD)	389 ± 20.80	323 ± 17.00	0.17

## CONCLUSION

This study does not offer enough evidence to establish relation between occupational exposure to formaldehyde and effects on respiratory system of human. However, this is an approved fact that there are potential adverse health effects especially on respiratory systems that need to pay more attention. Therefore, to improve occupational health conditions in hospitals and reduce respiratory adverse effects of formaldehyde exposure among nurses, medical technicians, cleaner workers and so on, it is recommended that because of lack of proper monitoring of hospitals and similar health care centers, for formaldehyde vapor levels, it should be determined by an approved external independent assessor to ensure compliance with legal limitations for occupational exposure to formaldehyde.

Finally, the authors strongly recommend other researches with larger sample sizes, monitoring ambient concentrations of formaldehyde and longer duration of exposure and follow up of occupants in hospitals.

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