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# Toxic effects of formalin-treated cadaver on medical students, staff members, and workers in the Alexandria Faculty of Medicine

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ABSTRACT

*Background:* Formaldehyde can be toxic, allergenic and carcinogenic. Evaporation of formaldehyde from formalin-treated cadavers in the anatomy dissection rooms can produce high exposure. This study was conducted to assess acute and chronic toxic effects of formalin-treated cadavers on medical students, staff members, and workers at the Anatomy department in the Alexandria Faculty of Medicine (AFM).
*Methods:* A cross sectional approach was adopted to investigate medical students (n = 454). Staff members and workers at the Anatomy department (n = 16), and unexposed staff members and workers in the AFM (n = 19) were included in the study. Medical students filled self-administered predesigned questionnaire. Formalin-exposed and unexposed staff members filled a questionnaire and a Complete Blood Count was done for them.
*Results:* The most frequently reported symptoms by medical students were unpleasant smell (91.2%), itching in the eyes (81.3%), and excessive lacrimation (76.1%). Majority of them reported duration of relief within one hour (>80%), and more than two thirds reported wearing laboratory coats and hand gloves. Formalin-exposed staff reported symptoms of skin disorders as drying (75%), eczema (68.8%), and allergic contact dermatitis (87.5%), besides, eye irritation (68.8%), respiratory tract irritation (93.8%), and work-related bronchial asthma (53.3%). The mean RBCs and platelets counts were significantly lower among formalin-exposed staff ($4.08 \pm 0.65 \times 10^6$/ul and $237{,}375 \pm 71745.73$/ul respectively) compared with unexposed staff ($4.95 \pm 0.50 \times 10^6$/ul and $280473.68 \pm 54456.27$/ul respectively). WBCs count was abnormal (low or high) among formalin-exposed staff members (6.2%, and 18.8% respectively), while all unexposed staff had normal WBCs counts.
*Conclusion:* The research highlighted the irritating action of formalin on medical students, and chronic toxic effects on staff members. This necessitates re-evaluation of the concentration of formalin, proper ventilation and assessment of working practices in the dissecting rooms at the Anatomy department.


## 1. Introduction

Formaldehyde was discovered in 1867 by the British chemist, August Wilheld Von Hofmann. It is a simple aldehyde with the molecular formula $CH_2O$. At room temperature, it is a colorless gas, has flammable properties and irritating repugnant odor.[1] Formalin, an aqueous form of formaldehyde, contains 37% by weight or 40% by volume of formaldehyde gas in water. Formalin is the chemical most commonly used for embalming.[2] Despite the widespread usage of formaldehyde in tissue fixation and embalmment, a major concern about formaldehyde is safety.[1]

Formaldehyde can be toxic, allergenic and carcinogenic.[3,4] Exposure occurs primarily by inhalation, or via skin absorption of formaldehyde containing fluids. Disorders of exposure include airway irritation and obstructive disorders such as bronchial asthma,[3] ocular irritations, corneal clouding,[2] leukemia, nasopharyngeal cancers,[5] spontaneous abortions, congenital malformations,[2] and menstrual irregularities.[6] Moreover, it has been documented as an allergic skin sensitizer that may lead to dermatitis.[7]

The toxicity of formaldehyde gets worse by the tendency of the exposed individuals to develop tolerance within a few hours of exposure. Accordingly, those individuals remain in environments of gradually raised formaldehyde concentrations without being

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appreciative of the increased exposure levels and consequent hazards.[8] The Occupational Safety and Health Association (OSHA) recommended permissible exposure limit (PEL) of formaldehyde is 0.75 ppm averaged over an eight-hour work shift and 2 ppm not to be exceeded during any 15-min work period. The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) of formaldehyde is 0.016 ppm averaged over a 10-h work shift and 0.1 ppm not to be exceeded during any 15-min work period.[9,10]

Amongst the groups who are at risk of the effects of formaldehyde exposure are medical students and staff members at the Anatomy department. Studies have shown that evaporation of formaldehyde from formalin-treated cadavers in the anatomy dissection rooms can produce high exposures[8] which may be due to poor ventilation of dissection rooms, poor working practices that may lead to spillage of formaldehyde during embalming, using high concentrations of the embalming fluid, leak out of formaldehyde due to poor conditions of the cadavers, lack of strict guidelines for handling embalmed cadavers and specimens, and ignorance of consequences of formalin exposure.[11,12]

During the last decade, at the department of Anatomy at the Alexandria Faculty of Medicine (AFM), high number of deaths, at different age groups, has been noticed among the staff members and workers who had duration of employment ranged from 15 to 20 years. Some of them were diagnosed before death, while others died suddenly without diagnosis. For example, two workers died after they had cancer pancreas and renal failure respectively. Moreover, a young staff member died after he had been diagnosed as having multiple myeloma. Another professor died shortly after she has been subjected to investigations that revealed a retrosternal mass, she died before completion of the diagnosis (Agwany, personal communication, June 4th, 2014).

In addition to the frequently reported deaths, three female staff, who have been working at the Anatomy department for a considerable period of time, had cancer breast. Another professor has been diagnosed as having lymphoma. Furthermore, a worker had lung fibrosis and left the department after diagnosis (Agwany, personal communication, June 4th, 2014). This research was conducted to assess the acute toxic effects of formalin-treated cadaver on medical students, as well as chronic toxic effects of formalin exposure on staff members and workers at the Anatomy department in the AFM.

## 2. Material and methods

At the Anatomy department in the AFM, there are three dissecting rooms, one of them has been transformed into cadaver storage area where refrigerators are located. Dissecting rooms are located in the basement of the building. The rooms have few windows located in the upper third of the walls, which represents natural ventilation. Artificial ventilation comprised of few number of suction devices fixed on the wall as well as fans attached to the roof of the dissecting rooms. During anatomy sections, body parts of the cadaver are sometimes kept drenched in 10% formalin solution in open containers or basins to be readily used for demonstration and teaching purposes.

A cross sectional approach was adopted to investigate medical students on the first, second, and third year (n = 454) on their first exposure to formalin or within the first 14 days of exposure at dissection room at the Anatomy department in the AFM. In addition, all staff members and workers at the Anatomy department were invited to participate in the study. Similarly, staff members and workers at the Community Medicine department were asked to participate to represent an unexposed group in the present study. However, those who agreed to participate in the research were 16 formalin-exposed and 19 unexposed staff members and workers. The fieldwork was carried out from September 2015 through February 2016.

### 2.1. Research tools

The medical students were subjected to a self-administered predesigned questionnaire to collect information about symptoms of acute exposure to formalin-treated cadavers such as unpleasant smell, dry or sore nose, running or congested nose, unusual thirst, itching in the eyes, redness in the eyes, excessive lacrimation, disturbance in sight, nausea, headache, syncope, unusual tiredness or dizziness, dry or sore throat, GIT disturbances, itching of the hands, skin eruptions on the face/neck, and respiratory distress and disturbed nocturnal sleep. All these symptoms were graded on a scale of 1–4; grade (1): not at all, not recognizable, grade (2): barely recognizable, grade (3): strong, prominent and irritating, and grade (4): intolerable. Moreover, they were asked to report the duration of relief of symptoms on first exposure to formalin-treated cadavers, and the use of personal protective devices (PPDs) to prevent toxic effects of formalin.

Regarding formalin-exposed and unexposed staff members and workers who participated in the present study, they filled a predesigned questionnaire to collect information about their personal and occupational characteristics, as well as symptoms of systemic disorders. Additionally, blood samples were collected from them and a Complete Blood Count (CBC)[13] was done at the Clinical Pathology department at the AFM.

Before collection of data, a pilot study was conducted on a randomly selected number of medical students and staff to examine the suitability of the questionnaire forms and estimate the average time needed to fill the questionnaire and carry out the investigation.

### 2.2. Statistical analysis

The collected data were coded and typed onto computer files using. SPSS/Pc+ software program version 20.0.[14] Descriptive and analytic statistics including frequency, percentages, arithmetic mean ($\overline{X}$), standard deviation (S), Fisher's Exact test, Mann Whitney test, *t* test, and Monte Carlo test were used to demonstrate the distribution of the medical students and staff according to their symptoms of acute and chronic exposure to formalin as well as CBC findings.

### 2.3. Ethical clearance

The work was performed at the AFM. The study was approved by the Research Ethics Committee at the AFM. The overall study objectives, procedures, and publication were explained and written informed consent was obtained from each participant in the study. Collected data were dealt with great confidentially.

## 3. Results

### 3.1. Acute toxic effects of formalin-treated cadaver on exposed medical students (n = 454)

Most of medical students complained of symptoms of acute exposure to formalin-treated cadavers such as unpleasant smell (91.2%), dry or sore nose (74.2%), running or congested nose (69.5%), unusual thirst (53.9%), itching in the eyes (81.3%), redness in the eyes (72.4%), excessive lacrimation (76.1%), disturbance in sight (58.6%), and headache (53.6%). To a less extent, students reported syncope (29.1%), unusual tiredness or dizziness (45.2%),

**Table 1**
Response of medical students to symptoms of acute exposure to formalin-treated cadavers (n = 454).

| Symptoms of acute exposure to formalin-treated cadavers | Grade zero[a] | | Grade 1[b] | | Grade 2[c] | | Grade 3[d] | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| • Unpleasant smell | 33 | 7.3 | 104 | 23 | 228 | 50.3 | 81 | 17.9 |
| • Dry or sore nose | 102 | 22.5 | 182 | 40.2 | 11 | 26.7 | 33 | 7.3 |
| • Running or congested nose | 125 | 27.6 | 172 | 38 | 107 | 23.6 | 36 | 7.9 |
| • Unusual thirst | 195 | 43 | 156 | 34.4 | 70 | 15.5 | 18 | 4 |
| • Itching in the eyes | 71 | 15.7 | 143 | 31.6 | 149 | 32.9 | 76 | 16.8 |
| • Redness of the eyes | 110 | 24.3 | 162 | 35.8 | 116 | 25.6 | 50 | 11 |
| • Excessive lacrimation | 94 | 20.8 | 146 | 32.2 | 136 | 30 | 63 | 13.9 |
| • Disturbance in sight | 170 | 37.5 | 156 | 34.4 | 85 | 18.8 | 26 | 5.7 |
| • Nausea | 224 | 49.4 | 142 | 31.3 | 59 | 13 | 15 | 3.3 |
| • Headache | 199 | 43.9 | 165 | 36.4 | 54 | 11.9 | 24 | 5.3 |
| • Syncope (fainting episode) | 306 | 67.5 | 100 | 22.1 | 25 | 5.5 | 7 | 1.5 |
| • Unusual tiredness/dizziness | 231 | 51 | 146 | 32.2 | 47 | 10.4 | 12 | 2.6 |
| • Dry or sore throat | 215 | 47.5 | 147 | 32.5 | 60 | 13.2 | 10 | 2.2 |
| • GIT disturbances | 256 | 58.5 | 115 | 25.4 | 44 | 9.7 | 11 | 2.4 |
| • Itching of the hands | 271 | 59.8 | 118 | 26 | 38 | 8.4 | 10 | 2.2 |
| • Skin eruptions on the face/neck | 292 | 64.5 | 108 | 23.8 | 31 | 6.8 | 6 | 1.3 |
| • Respiratory distress & disturbed nocturnal sleep | 285 | 62.9 | 100 | 22.1 | 41 | 9.1 | 15 | 3.3 |

Abbreviations: GIT: gastro-intestinal tract.
[a] Grade zero: not at all, not recognizable.
[b] Grade 1: barely recognizable.
[c] Grade 2: strong, prominent and irritating.
[d] Grade 3: intolerable.

dry or sore throat (47.9%), nausea (47.6%), GIT disturbances (37.5%), itching of the hands (36.6%), skin eruptions on the face/-neck (31.9%), and respiratory distress and disturbed nocturnal sleep (34.5%) (Table 1).

Moreover, most of medical students reported that; on first exposure to formalin-treated cadavers, they got relieved from eye symptoms, nose symptoms, and skin symptoms within one hour (84.8%, 81.7%, and 84.8% respectively). Moreover, 65.2%, and 62.4% of medical students reported bodily adaptations to eye symptoms and nose symptoms respectively, on the other hand, 45.9% of medical students reported bodily adaptations to skin symptoms following subsequent exposure to formalin-treated cadavers (45.9%). In addition, medical student reported wearing laboratory coats (78.1%), and hand gloves (73.7%), however, only 9.7% reported wearing eye goggles. As regards the frequency of wearing PPDs during dissection, 31.6% reported wearing the PPDs regularly/always. Students who often, sometimes, occasionally, and rarely use PPDs were (22.5%, 22.3%, 5.3%, and 8.8% respectively). On the other hand, 4.2% of the medical students did not wear PPDs at all (Table 2).

### 3.2. Chronic toxic effects of formalin-treated cadaver on exposed staff members and workers at the department of Anatomy (n = 16)

About 44% of the formalin-exposed staff members and workers were males and 56% were females. More than 50% of them had a duration of employment at the Anatomy department of more than 10 years (Table 3).

They reported symptoms of *skin disorders*, such as burning (68.8%), drying (75%), cracking (56.2%), scaling (50%), erythema (56.2%), edema (31.2%), eczema (68.8%), and allergic contact dermatitis (87.5%). However, these symptoms were not encountered among the unexposed group (n = 19) ($^{FE}p = 0.00$). Moreover, formalin-exposed female staff who reported menstrual disorders and anemia were 33.3% and 44.4% respectively, compared with 0.00%, and 6.25% of the unexposed female staff respectively. Besides, 44.4% of formalin-exposed female staff had history of spontaneous abortion and 22.2% gave birth to a baby with congenital anomalies, compared with 12.5%, and 6.25% of the unexposed female staff respectively ($^{FE}p = 0.00$) (Table 4).

Additionally, regarding *ocular disorders*, 68.8% of formalin-exposed staff had eye discomfort and irritation, 12.5% had corneal clouding and 18.8% had permanent alteration of vision. As regard *respiratory disorders*, all of them reported upper airway irritation. Also, they had lower respiratory tract irritation (93.8%), work-related bronchial asthma (53.3%), and exacerbation of pre-existing bronchial asthma (46.7%), on the other hand, these findings were not encountered among the unexposed staff ($^{FE}p = 0.00$). Regarding *gastrointestinal (GIT) disorders*, 18.8% of formalin-exposed staff had nausea and 12.5% had GIT hemorrhage. One staff member at the Anatomy department had *cancer* and received treatment (Table 4).

The mean RBCs count was significantly lower among formalin-exposed staff ($4.08 \pm 0.65 \times 10^6$/ul) compared with unexposed staff ($4.95 \pm 0.50 \times 10^6$/ul) ($Z^{Mann\text{-}Whitney} = -3.77$, $p = 0.00$). Moreover, the mean Ht% was significantly lower among the formalin-exposed staff ($35.10 \pm 5.70\%$), compared with unexposed staff ($39.40 \pm 3.13\%$) ($Z^{Mann\text{-}Whitney} = -2.74$, $p = 0.00$). Additionally, significantly higher mean corpuscular volume MCV (fl), mean corpuscular hemoglobin MCH (pg), and mean corpuscular hemoglobin concentration MCHC (g/dl) were recorded among formalin-exposed staff ($Z^{Mann\text{-}Whitney} = -2.53$, $p = 0.00$; ($Z^{Mann\text{-}Whitney} = -4.76$, $p = 0.00$); and ($Z^{Mann\text{-}Whitney} = -5.03$, $p = 0.00$ respectively). Furthermore, the mean platelets count was significantly lower among the formalin-exposed staff (237,375 ± 71745.73/ul) compared with unexposed staff (280473.68 ± 54456.27/ul) ($t = 2.01$, $p = 0.05$) (Table 5). In the current research, 6.2% of the formalin-exposed staff had abnormal (low) WBCs count and 18.8% had abnormal (high) WBCs count, on the other hand, all unexposed staff had normal WBCs count ($^{Monte\ Carlo}p = 0.03$) (Table 6).

## 4. Discussion

*On studying acute toxic effects of formalin-treated cadaver*, medical students in the current study (n = 454) reported symptoms such as unpleasant smell (91.2%), itching in the eyes (81.3%), excessive lacrimation (76.1%), dry or sore nose (74.2%), redness in the eyes (72.4%), and running or congested nose (69.5%). In agreement with the results of the current research, in India, Dixit et al. (2005)

**Table 2**
Distribution of medical students according to the duration of relief of symptoms on first exposure to formalin-treated cadavers, bodily adaptations to symptoms, and use of PPD (n = 454).

| Duration for relief of *symptoms* on first exposure to formalin-treated cadaver | | No. | % |
|---|---|---|---|
| Duration for relief of *eye symptoms* | <1 h | 384 | 84.8 |
| | Hours | 43 | 9.5 |
| | 6 h to 1 day | 3 | 0.7 |
| | >1 day | 7 | 1.5 |
| Duration for relief of *nose symptoms* | <1 h | 370 | 81.7 |
| | Hours | 44 | 9.7 |
| | 6 h to 1 day | 7 | 1.5 |
| | >1 day | 10 | 2.2 |
| Duration for relief of *skin symptoms* | <1 h | 384 | 84.8 |
| | Hours | 20 | 4.4 |
| | 6 h to 1 day | 9 | 2 |
| | >1 day | 11 | 2.4 |
| Bodily adaptations to *symptoms* following subsequent exposure to formalin-treated cadaver | | No. | % |
| Bodily adaptations to *eye symptoms* | Nil | 133 | 29.4 |
| | Mild | 205 | 45.3 |
| | Moderate | 82 | 18.1 |
| | Severe | 8 | 1.8 |
| Bodily adaptations to *nose symptoms* | Nil | 146 | 32.2 |
| | Mild | 185 | 40.8 |
| | Moderate | 88 | 19.4 |
| | Severe | 10 | 2.2 |
| Bodily adaptations to *skin symptoms* | Nil | 218 | 48.1 |
| | Mild | 149 | 32.9 |
| | Moderate | 47 | 10.4 |
| | Severe | 13 | 2.9 |
| Use of PPD | | No. | % |
| *Use the following PPD* | | | |
| Eye goggles | | 44 | 9.7 |
| Hand gloves | | 334 | 73.7 |
| Laboratory coat | | 354 | 78.1 |
| *Frequency of wearing PPD* | | | |
| Always/regularly | | 143 | 31.6 |
| Often | | 102 | 22.5 |
| Sometimes | | 101 | 22.3 |
| Occasionally | | 24 | 5.3 |
| Rarely | | 40 | 8.8 |
| Never | | 19 | 4.2 |

Abbreviations: PPD: Personal Protective Devices.

evaluated formaldehyde's toxic effects on medical students; his study revealed that the three most disturbing symptoms were unpleasant smell, itching of the eyes, and excessive lacrimation.[12] Moreover, Emue et al. (2011), conducted a study on Nigerian medical students, and found that the most common feelings and symptoms among studied medical students on first exposure included general discomfort (81%), eye irritation/itching (48%) and nasal irritation/itching (50%).[8]

In the current research, fewer students reported skin symptoms such as itching of the hands (36.6%), and skin eruptions on the face/neck (31.9%). Similarly, in Emue et al. (2011), only 1% of studied medical students experienced skin irritation/itching following their first exposure to formalin-treated cadaver.[8] This was explained by the fact that formalin has local skin irritant abilities,[7] besides, medical students infrequently get in contact with formalin during cadaver dissection as they use hand gloves and laboratory coats at dissections.[8]

Most of medical students in the present research reported that, on first exposure to formalin-treated cadavers, they got relieved from eye, nose, and skin symptoms within one hour (84.8%, 81.7%, and 84.8% respectively). On the contrary, in the study conducted by Emue et al. (2011) in Nigeria, only one third of the medical students reported relief from eye, nose, and skin symptoms within one hour (38%, 37%, and 0.9% respectively) and the rest two thirds of the studied students reported time interval for the relief of symptoms of more than one hour.[8] The difference between the results of both studies might be attributed to the difference in the concentration of formalin to which medical students were exposed to during cadaver dissection.

Moreover, in the present study, medical students who reported no eye, nose, and skin symptoms following subsequent exposure were 29.4%, 32.2%, and 48.1% respectively. On the other hand, in Emue et al. (2011), it was remarkable that as many as 47% and 88% of studied medical students reported no eye and nasal symptoms respectively on their subsequent exposures to formalin-treated cadavers, and the rest of medical students reported mild to moderate eyes and nasal symptoms.[8] The medical students in Emue et al. (2011), might be exposed to lower concentration of formaldehyde that lead to tolerance overtime.

In the current research, 78.1% of medical students reported wearing laboratory coats, and 73.7% reported wearing hand gloves. In agreement with the results of the current study, a large number of Nigerian medical students reported using laboratory coats (86%) and hand gloves (78%) to reduce toxic effects of formalin.[8] Additionally, in Dixit et al. (2005), in India, 69.2% of medical students were using gloves during cadaver dissection.[12] On the other hand, only 9.7% of medical students in the current study reported wearing eye goggles, while 62% of Nigerian medical students reported using eye goggles during dissection.[8]

*On studying the chronic toxic effects of formalin-treated cadaver*, in the present study, the frequency of systemic disorders was significantly higher among formalin-exposed staff members compared with unexposed staff. For example, they reported symptoms of *skin disorders*. Similarly, other studies reported symptoms such as burning, drying, cracking, blistering, scaling of the skin,[2] erythema, edema, and hives.[15,16]

Moreover, in the present study, formalin-exposed females staff had menstrual disorders (33.3%), history of spontaneous abortion (44.4%), and gave birth to babies with congenital anomalies (22.2%). Formaldehyde crosses the placental barrier and can affect the embryo,[17] however, the teratogenic effect of formaldehyde in humans is disputed because research results are still inconclusive.[18]

Besides, staff members at the Anatomy department reported upper and lower airway irritation, as well as bronchial asthma. Formaldehyde irritates the upper airway; upper airway soreness is the most common respiratory effect reported by workers exposed to formaldehyde,[10] however, whether formaldehyde gas is a pulmonary sensitizer that can cause work-related asthma remains controversial.[2]

In the present research, few formalin-exposed staff members reported *GIT disorders*. Another study reported that formaldehyde ingestion by anatomy instructors or students is uncommon because it has unpleasant odor and irritant effect,[19] however, it was reported that gastrointestinal hemorrhage and gastric outlet obstruction are late complications of formaldehyde ingestion.[20]

Only one staff member at the Anatomy department, in the current study, had *cancer*. This could be attributed to the fact that formalin-exposed staff members who had been diagnosed as having cancer, had left their jobs after being diagnosed or died, so they were not included in the current study. Survival bias is one of limitations of cross sectional approach.

Although a British cohort study did not show any association between exposure to formaldehyde and development of malignancies,[21] several studies conducted on workers exposed to formaldehyde have detected an increased risk of leukemia, mainly myeloid leukemia as well as lymphoma.[22–24] Moreover, cohort studies on

**Table 3**
Personal and occupational characteristics of the studied formalin-exposed and unexposed staff members.

| Personal and occupational characteristics | Formalin exposed staff (n = 16) | | Unexposed staff (n = 19) | |
|---|---|---|---|---|
| | No. | % | No. | % |
| *Sex* | | | | |
| • Male | 7 | 43.8 | 3 | 15.8 |
| • Female | 9 | 56.2 | 16 | 84.2 |
| *Current occupation* | | | | |
| • Demonstrator | 3 | 18.8 | 3 | 15.8 |
| • Assistant lecturer | 1 | 6.2 | 3 | 15.8 |
| • Lecturer | 2 | 12.5 | 1 | 5.3 |
| • Assistant professor | 0 | 0.00 | 2 | 10.5 |
| • Professor | 2 | 12.5 | 7 | 36.8 |
| • Worker | 6 | 37.5 | 2 | 10.5 |
| • Secretary | 1 | 6.2 | 0 | 5.3 |
| • Technician | 1 | 6.2 | 0 | 0.00 |
| *Duration of employment (years)* | | | | |
| • 2 to <4 | 1 | 6.2 | 3 | 15.8 |
| • 4 to <6 | 5 | 31.2 | 1 | 5.3 |
| • 6 to <8 | 0 | 0.00 | 2 | 10.5 |
| • 8 to <10 | 1 | 6.2 | 0 | 0.00 |
| • >10 | 9 | 56.2 | 13 | 68.4 |

**Table 4**
Distribution of formalin-exposed and unexposed staff members and workers according to reported systemic disorders.

| Systemic disorder | Formalin-exposed staff (n = 16) | | Unexposed staff (n = 19) | | Test of sign. (p-value) |
|---|---|---|---|---|---|
| | No. | % | No. | % | |
| Skin disorder | 16 | 100% | 1 | 5.3% | $^{FE}p = 0.00$[b] |
| • White discoloration | 2 | 13.3 | 1 | 5.3 | |
| • Burning | 11 | 68.8 | 0.0 | 0.0 | |
| • Drying | 12 | 75 | 0.0 | 0.0 | |
| • Cracking | 9 | 56.2 | 0.0 | 0.0 | |
| • Scaling | 8 | 50 | 0.0 | 0.0 | |
| • Erythema | 9 | 56.2 | 0.0 | 0.0 | |
| • Edema | 5 | 31.2 | 0.0 | 0.0 | |
| • Eczema | 11 | 68.8 | 0.0 | 0.0 | |
| • Allergic contact dermatitis | 14 | 87.5 | 0.0 | 0.0 | |
| Reproductive disorder[a] | 8 | 88.9% | 3 | 18.8% | $^{FE}p = 0.00$[b] |
| • Menstrual disorders | 3 | 33.3 | 0 | 0.0 | |
| • Anemia | 4 | 44.4 | 1 | 6.25 | |
| • History of spontaneous abortions | 4 | 44.4 | 2 | 12.5 | |
| • History of LBW babies | 2 | 22.2 | 0 | 0.0 | |
| • Delivery of a baby with congenital anomalies | 2 | 22.2 | 1 | 6.25 | |
| Ocular disorder | 14 | 87.5% | 1 | 5.3% | $^{FE}p = 0.00$[b] |
| • Discomfort & irritation | 11 | 68.8 | 1 | 5.3 | |
| • Corneal clouding | 2 | 12.5 | 0.0 | 0.0 | |
| • Permanent alteration to vision | 3 | 18.8 | 0.0 | 0.0 | |
| • Blindness | 1 | 6.2 | 0.0 | 0.0 | |
| Respiratory disorders | 16 | 100% | 2 | 10.6% | $^{FE}p = 0.00$[b] |
| • Upper airway irritation | 16 | 100 | 2 | 10.5 | |
| • Lower respiratory tract irritation | 15 | 93.8 | 0.0 | 0.0 | |
| • Work-related bronchial asthma | 8 | 53.3 | 0.0 | 0.0 | |
| • Exacerbation of pre-existing bronchial asthma | 7 | 46.7 | 0.0 | 0.0 | |
| GIT disorder | 6 | 37.5% | 0 | 0. 0% | $^{FE}p = 0.00$[b] |
| • Nausea | 3 | 18.8 | 0.0 | 0.0 | |
| • Vomiting | 1 | 6.2 | 0.0 | 0.0 | |
| • Severe abdominal pain | 1 | 6.2 | 0.0 | 0.0 | |
| • GIT hemorrhage | 2 | 12.5 | 0.0 | 0.0 | |
| • Gastric outlet obstruction | 1 | 6.2 | 0.0 | 0.0 | |
| Cancer | 1 | 6.2% | 0 | 0.0% | $^{FE}p = 0.45$ |
| • Nasal sinus cancer | 0.0 | 0.0 | 0.0 | 0.0 | |
| • Leukemia or lymphoma | 0.0 | 0.0 | 0.0 | 0.0 | |
| • Cancer breast | 1 | 6.2 | 0.0 | 0.0 | |

Abbreviations: LBW: low birth weight; GIT: gastro-intestinal tract; FE: Fisher's Exact test.
[a] Number of formalin-exposed females = 9, number of unexposed females = 16.
[b] Statistical test is significant at $p < 0.001$ (2-tailed).

formaldehyde exposed workers continues to suggest a possible link between formaldehyde exposure and mortality due to lymphohematopoetic malignancies, particularly myeloid leukemia.[25,26] Additionally, several surveys have shown that anatomists are at greater risk for leukemia than are individuals in the general population.[5]

**Table 5**
Distribution of the studied formalin-exposed and unexposed staff members according to CBC findings.

| CBC parameters | | Formalin exposed staff (n = 16) | Unexposed staff (n = 19) | Test of significance (p-value) |
|---|---|---|---|---|
| Hb (g/dl)% | Min-Max | 7.60–16.90 | 11.40–16.00 | $Z^{Mann\text{-}Whitney} = -1.32$ (0.18) |
| | Mean ± SD | 13.9 ± 2.27 | 13.4 ± 1.22 | |
| | Mean Rank | 20.5 | 15.89 | |
| RBCs ($\times 10^6$/ul) | Min-Max | 2.24–5.00 | 4.01–5.83 | $Z^{Mann\text{-}Whitney} = -3.77$[b] (0.00) |
| | Mean ± SD | 4.08 ± 0.65 | 4.95 ± 0.50 | |
| | Mean Rank | 10.88 | 24.50 | |
| Ht (%) | Min-Max | 18.8–43.00 | 34.5–45.8 | $Z^{Mann\text{-}Whitney} = -2.74$[b] (0.00) |
| | Mean ± SD | 35.10 ± 5.70 | 39.40 ± 3.13 | |
| | Mean Rank | 12.81 | 22.37 | |
| MCV (fl) | Min-Max | 74.00–95.00 | 89.2–89.6 | $Z^{Mann\text{-}Whitney} = -2.53$[a] (0.01) |
| | Mean ± SD | 86.5 ± 69 | 79.9 ± 7.09 | |
| | Mean Rank | 22.78 | 13.97 | |
| MCH (pg) | Min-Max | 28.5–38.60 | 19.7–30.9 | $Z^{Mann\text{-}Whitney} = -4.76$[b] (0.00) |
| | Mean ± SD | 34.16±.72 | 27.28 ± 2.80 | |
| | Mean Rank | 27.00 | 10.42 | |
| MCHC (g/dl) | Min-Max | 38.60–41.50 | 32.4–35.6 | $Z^{Mann\text{-}Whitney} = -5.03$ (0.00)[b] |
| | Mean ± SD | 39.67 ± 0.71 | 34.09 ± 0.96 | |
| | Mean Rank | 27.5 | 10.00 | |
| Platelets (/ul) | Min-Max | 127,000–382,000 | 190,000–363,000 | t = 2.01[a] (0.05) |
| | Mean ± SD | 237,375 ± 71745.73 | 280473.68 ± 54456.27 | |
| | Mean Rank | 13.88 | 21. 47 | |
| WBCs (/ul) | Min-Max | 3400–10,900 | 4170–10,710 | t = −0.98 (0.33) |
| | Mean ± SD | 7225 ± 2118.01 | 6554 ± 1919.5 | |
| | Mean Rank | 20.25 | 16.11 | |

Abbreviations: CBC: Complete blood counts; Hb: hemoglobin; RBCs: red blood cells; WBCs: white blood cells; MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin; MCHC: mean corpuscular hemoglobin concentration MCHC (g/dl); SD: standard deviation; t: student *t* test;
[a] statistical test is significant at $p \leqslant 0.05$ (2-tailed);
[b] statistical test is significant at $p \leqslant 0.001$ (2-tailed).

**Table 6**
Distribution of the studied formalin-exposed and unexposed staff members and workers according to their RBCs, WBCs, and Platelets counts.

| Blood cells counts | Formalin exposed staff (n = 16) | | Unexposed staff (n = 19) | | Test of significance (p-value) |
|---|---|---|---|---|---|
| | No. | % | No. | % | |
| RBCs count | | | | | $^{MC}p = 0.01$[a] |
| • Normal | 12 | 75 | 16 | 84.2 | |
| • Abnormal (low) | 4 | 25 | 0 | 0.00 | |
| • Abnormal (high) | 0 | 0.00 | 3 | 15.8 | |
| WBCs count | | | | | $^{MC}p = 0.03$[a] |
| • Normal | 12 | 75 | 19 | 100 | |
| • Abnormal (low) | 1 | 6.2 | 0 | 0.00 | |
| • Abnormal (high) | 3 | 18.8 | 0 | 0.00 | |
| Platelets count | | | | | $^{FE}p = 0.45$ |
| • Normal | 15 | 93.8 | 19 | 100 | |
| • Abnormal (low) | 1 | 6.2 | 0 | 0.00 | |

Abbreviations: RBCs: red blood cells; WBCs: white blood cells; FE: Fisher's Exact test; MC: Monte Carlo test.
[a] statistical test is significant $p \leqslant 0.05$ (2-tailed).

In June 2004, based on sufficient epidemiological evidence that formaldehyde causes nasopharyngeal cancer in humans, the International Agency for Research on Cancer (IARC) classified formaldehyde as a known human carcinogen (Group 1). IARC concluded that there was "strong" but not sufficient evidence for a causal association between leukemia and occupational exposure to formaldehyde.[1,27]

Regarding CBC findings, in the current study, the formalin-exposed staff members and workers had significantly lower mean RBCs and platelets counts, and abnormal WBCs count compared with the unexposed staff members. Moreover, among formalin-exposed staff members in the present study, the mean Ht% was significantly lower, while MCV, MCH, and MCHC were significantly higher than the values of the unexposed staff members.

In China, a study was conducted by Zhang et al. (2010), to determine if formaldehyde exposure disrupts hematopoietic function in exposed humans. Lower levels were observed for platelets, and RBCs counts, and the total WBCs counts were significantly lower in workers exposed to formaldehyde compared to controls [mean (SD): 5422 (1529) cells per µl blood vs. 6269 (1422), respectively, $p = 0.0016$].[28] Other studies reported similar results.[29,30] Moreover, Zhang et al. (2010), demonstrated a significantly higher MCV in workers exposed to formaldehyde compared with controls. He concluded that formaldehyde exposure can have an adverse effect on the hematopoietic system and that leukemia induction by formaldehyde is biologically plausible from occupational and environmental exposures.[28]

## 5. Limitations of the study

The study did not include measurement of air concentration of formalin at the Anatomy department. Measuring N-methylenvaline in blood, as biomarker, was not included. The selected study design has a disadvantage of survival bias. The study did not include a comparison group of unexposed students from other colleges, which would enable the researchers to carry out analytic statistics. Although CBC findings in the present research coincide with results of other studies, yet, the study had a limitation; at time of the field work, few number of staff members were available and agreed to participate. A cross-sectional sample comparing 16 exposed staff to 19 unexposed staff would be small for generalization of results of the statistical analysis.

## 6. Conclusion

The current study highlighted the irritating action of formalin-treated cadavers on medical students, which necessitate re-evaluation of the concentration of formalin, proper ventilation in the dissecting rooms, and assessment of working practices conditions at the department of Anatomy at the AFM.

Moreover, it is highly recommended to conduct comparative cross-sectional studies of large sample size to be able to generalize the conclusion that chronic exposure to formalin at the FOM is significantly associated with systemic disorders and disruption of the hematopoietic system. Pathologists in the AFM, and workers in morgue at University hospitals can be included in the formalin-exposed group.

## Conflict of interest

Authors declare that there is no conflict of interest.

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