(International Print/Online Journal)

SJIF IMPACT FACTOR: 6.829
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 8, Issue 6 , Page No: 506-511
November-December 2025

IJMSCR

Adverse Effects Of Formaldehyde Vapors Exposure In Medical College Students During Anatomy Dissection: A Cross-Sectional Study

[1]Sana Rehman, [2]Arpita Mahajan, [3]Pallavi Arora
[1]Department of Pharmacology, [2,3]Department of Anatomy,
[1,2]Hamdard Institute of Medical Sciences & Research, Jamia Hamdard, New Delhi
[3]Shri Mata Vaishno Devi Institute of Medical Excellence &
Shri Mata Vaishno Devi Narayana Superspeciality Hospital, Katra

***Corresponding Author:**
Sana Rehman
Department of Pharmacology, Hamdard Institute of Medical Sciences & Research, Jamia Hamdard, New Delhi

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Background: Formalin is widely used as a fixative, preservative, and disinfectant in medical colleges, particularly in anatomy dissection halls. Despite its extensive use, formalin exposure is associated with several adverse health effects, especially among students who are repeatedly exposed during dissection practices.

Aim: To study the adverse health effects of formalin exposure among first-year medical students.

Materials and Methods: This cross-sectional, questionnaire-based study was conducted over a period of one year in the Department of Anatomy, Hamdard Institute of Medical Sciences and Research, New Delhi. A total of 220 first-year medical students participated in the study. Data regarding formalin-related symptoms were collected using a validated, self-administered questionnaire. The results were expressed as frequency and percentage and analyzed using Microsoft Excel 2019.

Results: Unpleasant smell was the most frequently reported complaint among the students. Several ocular, respiratory, neurological, and gastrointestinal symptoms were also observed following exposure. The findings of the present study were compared with those of previously published studies.

Conclusion: Formalin toxicity remains a significant concern for individuals who are regularly exposed to it, including embalmers, anatomists, and medical and dental students. Increasing awareness regarding its harmful effects and implementing appropriate preventive measures can help reduce health risks. Continued research in this area will further contribute to the prevention of occupational hazards and protection of exposed individuals.

Keywords: Formalin, adverse effects, grading of severity symptoms, dissection hall, medical students, PEL of formalin

Introduction

Cadaveric dissection has long been regarded as the cornerstone of anatomy education and remains an indispensable component of medical training. Despite the evolution of various alternative teaching methods for gross anatomy, research continues to emphasize the irreplaceable educational value of human cadaver dissection. In addition to imparting anatomical knowledge, the dissection hall plays a pivotal role in nurturing compassion and empathy among medical students, thereby contributing to the development of humane and empathetic physicians of the future [1].

For the effective utilization of cadavers in medical education, appropriate preservation is essential to prevent decomposition and ensure safe handling. Hence, embalming using chemical preservatives such as formaldehyde (FA) has been widely adopted across the world [2]. Formalin, the commercial aqueous

solution of formaldehyde, has been used extensively as a fixative in anatomy, pathology, and embalming practices for several decades. Owing to its ready availability, low cost, rapid tissue penetration, and long-term preservative properties, formaldehyde remains the most commonly used embalming agent [3,4]. Commercial formalin contains approximately 37–50% dissolved formaldehyde in water (37% by weight or 40% by volume), with methanol added as a stabilizer [5]. Formaldehyde was first discovered by the British chemist August Wilhelm von Hofmann in 1856 [6]. It is a colorless, flammable, highly water-soluble gas with a strong pungent odor, and formalin vapors are known to be highly irritating at room temperature [7].

The Occupational Safety and Health Administration (OSHA) has established regulatory standards to protect individuals occupationally exposed to formaldehyde. The permissible exposure limit (PEL) for formaldehyde is 0.75 parts per million (ppm) as an 8-hour time-weighted average, while the short-term exposure limit (STEL) is 2 ppm over a 15-minute period [8].

Exposure to formaldehyde occurs primarily through inhalation and is known to produce both acute and chronic adverse health effects. Animal studies have demonstrated that inhalation of formaldehyde can result in dyspnea, vomiting, hypersalivation, muscle spasms, epithelial damage to the nasal cavity, altered learning and memory, reduced exploratory behavior, impaired spontaneous motor activity, and neural and immune dysfunctions [9–11]. Human studies have similarly reported that exposure to formaldehyde is associated with irritation of the eyes, nose, and throat, along with respiratory complications such as bronchoconstriction and pneumonia [12].

Although formaldehyde is an effective biocidal agent with strong germicidal, bactericidal, and fungicidal properties, it is also highly toxic and possesses mutagenic and carcinogenic potential. The International Agency for Research on Cancer (IARC) has classified formaldehyde as a Group 1 human carcinogen based on sufficient evidence linking occupational exposure to nasopharyngeal carcinoma [13]. Additionally, formaldehyde exposure has been implicated in the pathogenesis of leukemia through probable mutagenic mechanisms [14].

Materials And Methods

This study was conducted over a period of two months from February 2023 to April 2023 in the Department of Anatomy, Hamdard Institute of Medical Sciences and Research, New Delhi. Ethical clearance for conducting the study was obtained from the Institutional Ethics Committee prior to initiation of the study (Approval No. HIMSR/IEC/0090/2023). Written informed consent was obtained from all participating students.

The study population consisted of first-year MBBS students who were regularly exposed to formalin vapours in the dissection hall for a mean duration of at least 6 hours per week. A total of 220 students were included in the study.

The formalin solution used for cadaver preservation was of 10% concentration, prepared by diluting one part of 37% aqueous formaldehyde solution with nine parts of water.

Data regarding the acute effects of formaldehyde exposure were collected using a self-administered, structured questionnaire based on previously published literature. The questionnaire assessed the effects of formalin exposure on different systems, including ocular, respiratory, nasal, and other systemic symptoms such as watering of eye, redness in eyes, itching in eyes, disturbance in sight, throat irritation, cough, difficulty in breathing, nasal congestion, running nose, unpleasant smell, nausea, vomiting, feeling thirsty, itching of skin, redness of skin, dryness of skin, skin eruptions, feeling of tiredness, presence of headache, fainting episodes, lack of concentration and disturbance in sleep. The severity of symptoms was graded by the students on a 4-point scale as follows:

Grade 1 – Not at all or not recognizable
Grade 2 – Barely recognizable
Grade 3 – Irritating, prominent, and strong
Grade 4 – Intolerable

Result

Volume 8, Issue 6; November-December 2025; Page No 506-511

Table 1: Response of medical students to the effects of formalin exposure (n=220).

S.No	Symptom	Grade 1		Grade 2		Grade 3		Grade 4	
		No	%	No	%	No	%	No	%
1.	Watering of eye	17	7.7	92	41.8	100	45.5	11	5
2.	Redness in eyes	39	17.7	80	36.4	97	44.1	4	1.8
3.	Itching in eyes	47	21.4	58	26.4	104	47.3	11	5
4.	Disturbance in sight	25	11.4	120	54.8	68	31.1	6	2.7
5.	Throat irritation	129	58.6	52	23.6	32	14.5	7	3.2
6.	Cough	136	63	60	27.8	15	6.9	5	2.3
7.	Difficulty in breathing	116	53	71	32.6	2	12.8	3	1.4
8.	Nasal congestion	125	58.1	62	28.8	19	8.8	9	4.2
9.	Running nose	102	46.8	77	35.5	31	14.2	8	3.7
10	Unpleasant smell	20	9.2	56	25.7	95	43.6	47	21.6
11	Nausea	132	61.4	56	26	23	10.7	4	1.9
12	Vomiting	174	81.7	26	12.2	10	4.7	3	1.4
13	Feeling thirsty	121	55.8	70	32.3	19	8.8	7	3.2
14	Itching of skin	165	77.8	34	16	9	4.2	4	1.9
15	Redness of skin	181	85	21	9.5	8	3.8	3	1.4
16	Dryness of skin	144	67.6	49	23	12	5.6	8	3.8
17	Skin eruptions	176	83	27	12.7	6	2.8	3	1.4
18	Feeling of tiredness	87	40.7	84	39.3	37	17.3	6	2.8
19	Presence of headache	65	29.8	84	38.5	63	28.9	6	2.8
20	Fainting episodes	177	83.1	29	13.6	2	0.9	5	2.3
21	Lack of concentration	67	30.9	98	45.2	39	18	13	6
22	Disturbance in sleep	146	68.2	51	23.8	8	3.7	9	4.2

Discussion

Formaldehyde, commonly used as an aqueous solution (37–50%) in the form of formalin, is widely employed for the preservation of cadavers in dissection halls and for tissue fixation in laboratories. Medical students are primarily exposed to formaldehyde vapours in the anatomy dissection hall, and such exposure has been identified as one of the contributing factors for the development of chemical sensitivity. Although several studies have evaluated the health effects of formaldehyde exposure, only a limited number have incorporated symptom grading, which provides a more accurate representation of symptom severity as perceived by the exposed individuals.

In the present study, the most commonly reported complaint was unpleasant smell. It was graded as strong, prominent, and irritating (Grade 3) by 95 students (43.6%), bearable (Grade 2) by 56 students (25.7%), intolerable (Grade 4) by 47 students (21.6%), and unrecognizable (Grade 1) by 20 students (9.2%).

Volume 8, Issue 6; November-December 2025; Page No 506-511

These findings are comparable with those of previous studies. Aung et al. reported that most students experienced an unpleasant smell, although no percentage was specified. Tirunel et al. observed unpleasant smell in 72.7% of students, while Pietrzyk et al. reported moderate unpleasant smell in 80% of students, which reportedly did not affect academic performance [9,16,17]. Hagos et al. documented unpleasant smell in 84.4% of students, and Ahmed et al. in 79.6% of students [18,19].

Several authors have employed a grading system similar to that used in the present study to assess symptom severity. Grading of symptoms gives a more systematic approach to symptoms. Kundu et al. reported unpleasant smell as irritating in 46.81%, bearable in 34.04%, intolerable in 13.83%, and not recognizable in 5.3% of students. Patil et al. reported unpleasant smell as irritating in 39.39%, bearable in 45.45%, intolerable in 11.36%, and unrecognizable in 3.78% of students [20]. Elshaer et al. observed irritation in 50.3%, bearable symptoms in 23%, intolerable symptoms in 17.9%, and unrecognizable symptoms in 7.3% of students [21]. These findings closely resemble the results of the present study and reaffirm that unpleasant smell due to formaldehyde exposure is prominent and irritating for the majority of medical students.

Fahima et al. also reported symptom grading; however, their grading scale ranged from 0 to 5, which differed from the scale used in the present study, thereby limiting direct comparison [22].

We have compared the symptoms that were found commomly in studies showing grading of symptoms. Grade 3 symptoms (irritating and prominent) were analyzed and compared, as Grade 4 (intolerable) symptoms were either negligible or inconsistently reported across most published studies and were therefore excluded.

Redness of eyes was reported in Grade 3 by Kundu et al., Patil et al., and Elshaer et al. in 7.45%, 15.15%, and 25.6% of students, respectively, whereas the present study reported a higher prevalence of 44.1%. Eye itching was reported by Patil et al. in 27.27%, Elshaer et al. in 32.9%, and in 47.3% of students in the present study. However, Kundu et al. reported a much lower prevalence of 8.51%. Watering of eyes was the most common symptom in most of the studies. Grade 3 was reported by Elshaer et al by 30%, Kundu et al by 25.53%, Patil et al by 38.63% and the present study by 45.45%. Exposure of formaldehyde vapors in dissection halls causes acute ocular symptoms manifested as excessive watering, itching and redness. Chronic exposure may lead to infection so the medical advice should be taken if it persists.

Throat irritation or sore throat was reported by Kundu et al. in 15.96%, Patil et al. in 9.09%, and Elshaer et al. in 13.2% of students, whereas the present study reported a similar prevalence of 14.5%. Running nose was observed in 14.2% of students in the present study, compared to 23.6% reported by Elshaer et al., and 8.5% and 8.33% reported by Kundu et al. and Patil et al., respectively. Difficulty in breathing was observed in 12.8% of students in Grade 3 in the present study, whereas most other studies reported values below 10%.

Nausea in Grade 3 was reported in 10.7% of students in the present study, which is comparable to the findings of Kundu et al. (10.64%) and Elshaer et al. (13%). Headache was present in 28.9% of students in the present study, which is markedly higher compared to Elshaer et al. (11.9%), Patil et al. (16.6%), and Kundu et al. (18.09%). A feeling of tiredness in Grade 3 was reported by 17.35% of students in the present study, compared to 7.45% and 10.4% reported by Kundu et al. and Elshaer et al., respectively. Skin manifestations such as eruptions, itching, and redness were reported in less than 7% of students in Grade 3 across all studies. Most other symptoms were reported in less than 10% of students in most studies.

Analysis of data from the present and previous studies suggests that unpleasant smell, ocular symptoms, selected respiratory symptoms, nausea, and headache occur commonly among students exposed to formaldehyde in the dissection hall. The problem of unpleasant smell can be effectively reduced by adopting alternative embalming techniques such as Thiel embalming, which is associated with markedly lower odour. Further reduction in formaldehyde exposure may be achieved by using alternative chemical agents such as glutaraldehyde as a potential substitute. Installation of local exhaust ventilation systems in anatomy dissection halls is strongly recommended. In addition, the availability and routine use of personal protective equipment such as safety goggles and gloves should be ensured to minimize

Volume 8, Issue 6; November-December 2025; Page No 506-511

exposure and prevent adverse health effects among medical students.

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Volume 8, Issue 6; November-December 2025; Page No 506-511

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Volume 8, Issue 6; November-December 2025; Page No 506-511