



Original Review Article

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## THE HEALTH EFFECTS OF FORMALDEHYDE-TREATED CADAVERS ON THE HUMAN BODY EXPOSED IN GROSS ANATOMY DISSECTION LABORATORY

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**ABSTRACT:** Formaldehyde is a colorless and highly flammable gas that is widely used in cadaver preservation and is encountered by millions of people in occupational and educational settings. Exposure levels are commonly measured in parts per million (ppm). This review aimed to evaluate the possible health consequences associated with exposure to formaldehyde-preserved cadavers in gross anatomy dissection laboratories. Evidence from previous studies indicates that repeated or long-term exposure to formaldehyde may result in toxic, allergenic, and carcinogenic effects. Individuals frequently exposed, including medical students, anatomists, embalmers, histologists, and laboratory personnel, may experience both acute and chronic health problems affecting multiple body systems, primarily through inhalation. Reported adverse effects include the characteristic pungent odor of formaldehyde, irritation of the eyes and upper respiratory tract, fatigue, skin reactions, alterations in serum testosterone levels, kidney damage characterized by glomerular degeneration and tubular dilation, hematological disorders such as leukemia, reproductive complications including spontaneous abortion, sperm abnormalities and reduced implantation rates, as well as respiratory diseases such as pneumonia. Prolonged exposure has also been associated with an increased risk of throat cancer and symptoms related to sick building syndrome. The severity of these health effects generally increases with higher concentrations and longer durations of exposure. Consequently, the consistent use of appropriate personal protective equipment and the implementation of effective laboratory ventilation and cadaver preservation practices are essential to minimize formaldehyde-related health risks in anatomy laboratories.

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## **1. INTRODUCTION**

Formaldehyde is a colorless, highly flammable gas characterized by a strong, pungent odor and a tendency to polymerize under normal environmental conditions. It is widely used in industrial applications and is recognized as a major indoor air pollutant, resulting in daily exposure for millions of individuals worldwide. Formaldehyde occurs naturally in the environment but is also produced from numerous anthropogenic sources. Owing to its disinfectant and preservative properties, it has long been used to sterilize medical instruments and preserve biological materials. In anatomy, histology, pathology, forensic science, zoology, and other biological laboratories, formaldehyde is commonly used for embalming, tissue fixation, organ preservation, and long-term storage of cadavers, either alone or in combination with substances such as methanol, glycerin, thymol crystals, and water [1,23]. This review aimed to evaluate the potential health effects associated with exposure to formaldehyde-preserved cadavers in gross anatomy dissection laboratories. Human exposure to formaldehyde occurs primarily through inhalation, although absorption can also take place through skin contact and the gastrointestinal tract. Following exposure, formaldehyde is rapidly absorbed by the upper respiratory tract and other tissues. The body efficiently metabolizes formaldehyde into less harmful compounds, mainly formate, which is subsequently excreted in urine or further converted into carbon dioxide and eliminated through respiration [18]. Due to its high water solubility, formaldehyde readily dissolves in mucosal surfaces upon contact, and environmental concentrations are typically measured in parts per million (ppm) [31]. Although formaldehyde remains an essential chemical in medical and scientific practice, numerous studies have documented its potential adverse health effects. Both acute and chronic exposure have been associated with toxic, allergenic, and carcinogenic outcomes among individuals who regularly encounter the chemical, including medical students, anatomists,

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laboratory technicians, embalmers, histologists, and workers in wood-processing industries. Inhalation is considered the principal route of occupational exposure. Once inhaled, formaldehyde is absorbed through the respiratory tract and metabolized to formic acid, which may contribute to various biological and physiological effects observed in exposed individuals [1,10].

## **2. Literature Review**

Repeated and long-term exposure to formaldehyde vapors has been associated with a wide range of adverse health effects involving multiple organ systems. Studies have shown that excessive exposure may negatively affect the central nervous, respiratory, cardiovascular, and immune systems. Reported health consequences include respiratory disorders, contact dermatitis, headaches, nausea, dizziness, vomiting, reproductive complications, bronchitis, pneumonia, visual impairment, and several forms of cancer, including malignancies of the nasal cavity and throat [25,39]. Formaldehyde exposure has also been linked to sick building syndrome, a condition characterized by symptoms such as mucosal irritation, headaches, nausea, and respiratory discomfort. Acute exposure to formaldehyde can induce inflammatory, degenerative, and hyperplastic changes in the mucosal lining of the eyes and upper respiratory tract. Neurological manifestations resembling alcohol intoxication, including altered mental status, have also been reported. The severity of adverse effects generally increases with rising airborne concentrations of formaldehyde. Approximately 95% of inhaled formaldehyde is absorbed within the upper respiratory tract, particularly at concentrations exceeding 1 ppm, leading to symptoms such as nasal irritation, congestion, burning sensations, itching, and throat discomfort. In some individuals, temporary adaptation to these effects may occur after one to two hours of exposure [4]. Common acute symptoms reported among exposed individuals include eye irritation, nasal irritation, headache, rhinorrhea, skin itching, shortness of breath, sore throat, chest tightness, and wheezing, particularly when exposure levels are elevated [19,28]. Formaldehyde may also aggravate pre-existing respiratory conditions, including asthma. Chronic exposure has been associated with more serious outcomes, such as persistent bronchitis, pneumonia, nasopharyngeal cancer, ocular melanoma, lung cancer, brain cancer, and leukemia [20–22]. Ingestion of formaldehyde or exposure to extremely high concentrations can result in severe toxicity and, in rare cases, death [29]. Even relatively low concentrations of formaldehyde (approximately 0.05 ppm) may affect the eyes, upper respiratory tract, and nervous system, whereas concentrations around 5 ppm or higher can cause irritation and injury to the lower respiratory tract [38]. Increasing concentrations are associated with dose-dependent symptoms, including dryness of the nose, throat, and

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conjunctiva. Exposure levels exceeding 5 ppm can rapidly induce coughing, chest tightness, and wheezing, while concentrations above 50 ppm may trigger severe pulmonary complications such as pulmonary edema, bronchospasm, and pneumonia, potentially leading to fatal outcomes within a short period [3]. Long-term exposure to formaldehyde has also been implicated in neurobehavioral and cognitive disturbances. Reported symptoms include chronic fatigue, headaches, mood alterations, reduced attention span, impaired concentration, and memory deficits [10]. Additional studies suggest that prolonged exposure may contribute to immunological alterations, changes in neurofilament proteins, demyelination processes, eye irritation, excessive tearing, burning sensations of the respiratory mucosa, dizziness, and chest discomfort [11–13]. More recently, cases of poisoning, allergic reactions, asthma exacerbations, pulmonary injury, cancer, and mortality have been linked to formaldehyde contamination in food products, drinking water, and indoor air environments [24]. In gross anatomy dissection laboratories, exposure to formaldehyde-preserved cadavers may result in a variety of acute symptoms among students and staff. Frequently reported complaints include an unpleasant odor, excessive tearing, headaches, nausea, eye redness, ocular discomfort, increased salivation, breathing difficulties, vomiting, muscle spasms, and, in severe cases, convulsions. Formaldehyde can also promote the formation of neoantigens, potentially contributing to respiratory conditions such as asthma and bronchitis. Other reported symptoms include dry throat, unusual fatigue, skin irritation of the hands, blurred vision, prolonged sleep duration, and occasional fainting episodes during or after dissection sessions [1,16]. Individuals working in anatomy and biological science laboratories—including anatomists, embalmers, histopathology personnel, laboratory technicians, and medical students—are routinely exposed to formaldehyde. The magnitude of exposure depends on factors such as formaldehyde concentration, duration of exposure, ventilation efficiency, and workplace conditions. Consequently, the anatomy dissection laboratory may represent both a physical and psychological challenge for many medical students and laboratory workers [5,6]. Furthermore, epidemiological evidence, including surveys conducted by the National Cancer Institute, suggests that occupational groups with frequent formaldehyde exposure, particularly anatomists and embalmers, may have a higher risk of developing leukemia and certain brain cancers compared with the general population [44]. Therefore, understanding the health risks associated with formaldehyde-preserved cadavers is essential for improving occupational safety and implementing effective exposure-control measures in gross anatomy laboratories.

**Table 1: The potential health effect of formaldehyde exposed with different routinely respondents and durations.**

Authors	Number of respondents routinely exposed to formaldehyde	Mean duration of formaldehyde exposed	Observations (after post- formaldehyde exposure)
Sharma RP. <i>etal.</i> [1]	50 respondents	2 hours daily for 6 days in a week	Refractive error for distant vision in 42% and 9%, near vision in formaldehyde exposed group
Khaliq F. and Tripathi P.[4]	20 respondents	2 hours	Complained mild irritation in the nose, tears in the eyes
Nisa G. <i>etal.</i> [26]	150 respondents	2 hours every day	Watering of eyes 88.1%, running nose with tingling sensation 30.7 %, redness of eyes 20%, irritation of throat 11.2 %, cough 12 %, skin problems 10.8%, difficulty in breathing 1.3%, tiredness/dizziness 6.2% and lack of concentration in 31.2% students
Kundu S. and Gangrade P.[33]	100 respondents	2 hours each day for 6 days a week	Prolonged sleeping time in 18.09%, blurred vision 23.41% , unusual thirst 18.08% , disturbed respiration 23.45%, nausea 38.3% , headache 62.77%, deviated appetite 25.54%, restless 18.08% and vomiting 4.26%, nausea5.32% and redness of the eyes 72.34% as post dissection
Binawara BK. <i>etal.</i> [34]	80 respondents	2 hours of dissection	Mild irritation in nose and eyes, decreased forced vital capacity reduced pulmonary function including decreased values of forced vital capacity (FVC), forced expiratory volume in <sup>1st</sup> second (FEV1), and peak expiratory flow rate (PEFR)
Selemun H. <i>etal.</i> [36]	96 respondents	2 hours per day and 2 days a week regularly	Burning /watering of eye 67.7% , Irritation of upper respiratory tract,54.2%, tiredness/dizziness 65.6%, abdominal pain 17.7%, vomiting 16.7%, unpleasant smell in 84.4% , tingling sensation of nose 78.1%,cough 43.8%, lack of concentration 44.8%, headache 55.2%, difficulty in breathing 62.5% and fainting episode 6.25%
Elshaer NS. and	454 respondents	14 days	Dry or sore nose 74.2%, congested nose 69.5%, unusual thirst 53.9%, itching in the eyes 81.3%, redness in the eyes

Mahmoud MA.[37]			72.4%, excessive lacrimation 76.1%, disturbance in sight 58.6%, sore throat 47.9%, itching of hands 36.6%, skin eruptions on the face/neck 31.9%, and respiratory distress and disturbed nocturnal sleep 34.5%
Onyije FM. and Avwioro OG.[2]	93 respondents	6 hours/week	Intolerable unpleasant smell in 15%, congested nose 11%, redness of the eyes 11%, dizziness 24%, excessive lacrimation 21%, prolonged sleeping time 16%, sore eyes, 23%, disturbance of sight 8%, unusual thirst 4%, respiratory distress 13%
de Lucena JD. <i>etal.</i> [35]	37 respondents	4 hours / week	Unpleasant and irritating smell 70.3%, excessive lacrimation 54%, itching eyes 48.5%, redness of the eyes 40.6%, congested nose 35.2%, and respiratory distress 29.7%
Pietrzyk Ł. <i>etal.</i> [42]	198 respondents	4 hours/ week for 30 weeks	Lacrimation in 85.9%, red eyes, dry and itchy eyes, runny nose, sneezing, and headache in > 50% of students, cough in 44%, and throat irritation in 42% of students
Alnagar FA. <i>etal.</i> [45]	104 respondents	8 hours/ week for 28 weeks	Nasal itching in 75%, itching eyes 42%, eyes burning 75%, excessive lacrimation 73%, eyes redness 58%, headache 62% and respiratory distress 59%, Temporary loss of the ability to smell or to see 38%, dry mouth 41%, unusual thirst 37%, Cough 46%, GIT disturbances 34%, Nausea 35%, low assimilation 50%
Daksha D. <i>etal.</i> [46]	338 respondents	6 hours dissection	Irritation of mucous membranes of the pharynx, upper respiratory tract and eyes.
Roy PP. <i>etal.</i> [47]	60 respondents	6 months	Unpleasant smell in 33.3%, irritation and watering of eyes 58.3%, sore throat 21%, running or congested nose 28.3%, lack of concentration 16.6%, disturbance of sleep 20%, unusual tiredness or dizziness 30%

## DISCUSSION

The use of formaldehyde for cadaver preservation in gross anatomy laboratories can result in the continuous release of formaldehyde vapors into the surrounding environment, creating an important source of occupational exposure for medical students, instructors, anatomists, and

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laboratory personnel [20,27,30]. Exposure occurs primarily through inhalation and skin contact during dissection and anatomical examinations. As a result, individuals frequently report adverse symptoms such as an unpleasant odor, eye irritation, conjunctival redness, nasal congestion, respiratory discomfort, fatigue, skin irritation, and reduced pulmonary function [2,4,15]. Exposure to elevated concentrations of formaldehyde has been associated with both short-term and long-term health effects. Acute exposure commonly causes excessive tearing, eye irritation, headaches, dizziness, sore throat, and respiratory tract irritation. Students participating in cadaver dissection often identify lacrimation as one of the most distressing symptoms, particularly during their initial exposure to formaldehyde vapors. Persistent exposure may impair visual comfort and negatively influence learning and concentration during laboratory sessions, as symptoms such as fatigue, headaches, and dizziness can reduce attention and cognitive performance [2,4,15]. Several studies have documented the prevalence of these symptoms among individuals exposed to formaldehyde in educational and occupational settings. In an investigation involving 37 students, Thrasher et al. [31] reported that more than two-thirds of participants experienced discomfort from the irritating odor of formaldehyde. Excessive tearing, itchy eyes, eye redness, nasal congestion, and respiratory difficulties were among the most frequently reported complaints, with some symptoms persisting throughout laboratory sessions. Similarly, Farah et al. [4] found that eye irritation was reported by 88% of exposed individuals, while nasal, throat, and airway irritation affected 74%, 29%, and 21% of participants, respectively. In addition to its respiratory and ocular effects, formaldehyde exposure may adversely affect reproductive health. Taskinen et al. [14] observed an increased risk of spontaneous abortion, delayed conception, and endometriosis among female workers occupationally exposed to formaldehyde. Likewise, studies involving male subjects have demonstrated significant hormonal alterations following exposure. A reduction in serum testosterone levels accompanied by an increase in follicle-stimulating hormone (FSH) concentrations has been reported among individuals exposed to formaldehyde during cadaver dissection, suggesting potential reproductive toxicity [9]. Evidence from both clinical and experimental studies indicates that formaldehyde can affect multiple organ systems, including the urinary, respiratory, nervous, hematopoietic, and reproductive systems. The severity of adverse effects is largely dependent on exposure concentration. Low concentrations (0.05–1.0 ppm) have been associated with neurophysiological disturbances, sensory irritation, and respiratory discomfort, whereas higher concentrations may result in significant pulmonary injury. Exposure levels between 50 and 100 ppm have been linked to pneumonia and pulmonary edema, while

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concentrations exceeding 100 ppm may be fatal [40]. Experimental findings have further demonstrated pathological alterations in several organs following formaldehyde exposure. Reported effects include glomerular degeneration, acute tubular necrosis, and tubular dilatation in the kidneys; bladder edema and hematuria; nasal irritation and congestion; asthma and pneumonia; behavioral and neurological abnormalities; brain tumors such as astrocytoma and glioblastoma; hematological changes including leukocyte alterations and leukemia; and reproductive abnormalities such as spontaneous abortion, reduced birth weight, sperm abnormalities, decreased implantation rates, reduced fetal survival, and genetic mutations [40]. Questionnaire-based studies conducted among students exposed to formaldehyde in anatomy laboratories consistently reveal a high prevalence of exposure-related symptoms. Commonly reported complaints include eye irritation, watery nasal discharge, sneezing, chest tightness, wheezing, nasal obstruction, reduced sense of smell, and occasional nosebleeds [41]. Similar findings have been reported in studies involving anatomy students, where unpleasant odor, rhinorrhea, and epistaxis were frequently observed during dissection sessions [2,43]. Another survey involving 226 respondents found that more than 80% experienced general discomfort following initial exposure, while eye and nasal irritation were among the most common symptoms reported [8]. Likewise, Yadav and Yadav [7] reported that first-year medical students frequently experienced eye watering, nasal congestion, sore throat, headaches, skin irritation, and difficulty concentrating during cadaver dissection. Collectively, these findings demonstrate that formaldehyde exposure in anatomy laboratories can adversely affect the health and well-being of medical students and laboratory personnel. Consequently, effective preventive measures are essential to minimize exposure. Recommended strategies include improving laboratory ventilation through increased airflow and local exhaust systems, minimizing direct skin contact by using personal protective equipment such as gloves, masks, and protective aprons, limiting exposure by uncovering only the portion of the cadaver being dissected, and regularly removing excess preservative fluids from dissection tables [17]. Although protective eyewear may provide some benefit, studies suggest that it may not completely eliminate eye irritation and tearing. Additional approaches to reducing formaldehyde exposure include the use of lower concentrations of formaldehyde in embalming solutions and the incorporation of alternative preservatives such as surgical spirit, glycerin, and carbolic acid while maintaining adequate cadaver preservation [32]. Furthermore, arterial injection techniques during embalming have been shown to generate lower airborne formaldehyde concentrations and may therefore represent a safer preservation method with reduced occupational exposure risks [29].

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## 2. CONCLUSION

Individuals who are routinely exposed to formaldehyde, including anatomists, histologists, pathologists, embalmers, laboratory technicians, medical students, and workers in certain industrial settings, are at an increased risk of developing formaldehyde-related health effects. Numerous studies have demonstrated that exposure to formaldehyde vapors can adversely affect multiple organ systems, including the skin, eyes, respiratory tract, gastrointestinal system, central nervous system, and reproductive organs. In addition, occupational exposure has been associated with alterations in visual acuity when compared with non-exposed populations. Frequently reported symptoms include malaise, headaches, gastrointestinal discomfort, sleep disturbances, impaired balance, and cognitive complaints such as difficulties with concentration and memory. The severity of formaldehyde-induced health effects is strongly influenced by both the concentration of exposure and the duration of contact. Higher concentrations and prolonged exposure periods are generally associated with more pronounced adverse outcomes. Although formaldehyde levels in anatomy laboratories are often maintained within recommended limits, repeated exposure may still pose health risks to students and laboratory personnel. To minimize these risks, appropriate preventive and exposure-control measures should be implemented. These include the use of personal protective equipment such as gloves, masks, protective aprons, and eye protection; installation of efficient local exhaust ventilation systems; improvement of laboratory airflow through adequate ventilation; and reduction of direct skin contact with embalming solutions. Additional measures, such as arterial injection techniques during embalming and the incorporation of alternative preservative agents, including surgical spirit, glycerin, and carbolic acid, may help maintain effective cadaver preservation while reducing airborne formaldehyde concentrations. Overall, the available evidence highlights the importance of continuous monitoring and management of formaldehyde exposure in gross anatomy laboratories. Institutions, laboratory managers, and occupational health authorities should prioritize the implementation of effective safety measures to protect students, educators, and laboratory personnel from the potential adverse health effects associated with formaldehyde exposure.

### Abbreviation

ppm; parts per million

FVC; forced vital capacity

FEV1; forced expiratory volume in<sup>1st</sup> second

PEFR; peak expiratory flow rate

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IgG; immunoglobulin G

CNS; central nervous system

### **ETHICS APPROVAL AND CONSENT TO PARTICIPATE**

Not applicable.

### **HUMAN AND ANIMAL RIGHTS**

No animals or humans were used for the studies that are based on this research.

### **CONSENT FOR PUBLICATION**

Not applicable.

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### **AVAILABILITY OF DATA AND MATERIALS**

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### **AUTHORS' CONTRIBUTIONS**

The has proceeded with the literature review and drafted the paper and providing guidance, critical assessment and peer review of the writing. The author has given his final approval of this version to be published. The author read and approved the final manuscript.

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