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Inhalation Health Risk Assessment of Formaldehyde Exposure among Staff and Students in the Gross Anatomy Laboratory

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Abstract

Staff members, and students are potentially exposed to formaldehyde vapors emitted by cadavers during gross anatomy sessions. This study aimed to assess the inhalation risk of formaldehyde exposure among individuals in gross anatomy laboratories, focusing on both carcinogenic and non-carcinogenic effects. A total of 101 participants, comprising staff, pre-clinical students, and public health students, completed a structured questionnaire to provide demographic and exposure-related data. Simultaneously, five continuous indoor air samples were collected during 8-hour laboratory sessions following NIOSH Method 2541. The samples were analyzed at the Department of Disease Control, Ministry of Public Health. Risk assessments were conducted based on hazard quotient (HQ) and cancer risk values. Descriptive statistics, including frequency, percentage, minimum, maximum, mean, and standard deviation, were applied in the data analysis. The results indicated that the formaldehyde content ranged from 54 to 74 µg/m³, with a mean ± SD of 65±10 µg/m³. Staff members exhibited the highest HQ at 4.07, exceeding the safety threshold (HQ > 1), indicating significant non-carcinogenic risk. In contrast, pre-clinical students and public health students showed HQ values below 1, suggesting relatively lower but notable exposure. Cancer risk values for all participants ranged from 7.40×10^{-8} to 1.27×10^{-9}, all below the accepted threshold of 1×10^{-6}, implying an acceptable level of carcinogenic risk. The findings are significant as they highlight a measurable health risk for staff regularly working in gross anatomy laboratories. It is recommended that institutions establish policies for the implementation of efficient ventilation systems, enforce the use of personal protective equipment, and consider formaldehyde alternatives where possible. In addition, future studies should look into DNA adducts and their effects on cells, particularly those related to blood disorders and long-term cancer risks linked to formaldehyde exposure.

Keywords: *formaldehyde; gross anatomy; laboratory; inhalation risk; cadavers*

1. Introduction

Formaldehyde is a functional chemical compound that finds extensive application in various industries, including medicine, chemistry, furniture manufacturing, home appliances, and construction (Yang et al., 2024; Peng et al., 2023; Sarika et al., 2020; Bunjong et al., 2023). It is a volatile organic compound (VOC) that exhibits high volatility and toxicity, posing a significant risk to human health even at low concentrations (Jafari & Zeinali, 2020). It is a significant contributor to sick building syndrome, resulting in symptoms such as eye irritation, coughing, headaches, nausea, and respiratory problems (Tiruneh, 2021).

Exposure to formaldehyde remains a considerable health risk in medical and educational settings, particularly inside anatomy and pathology laboratories. Khoshakhlagh et al. (2023) report that formaldehyde concentrations in these laboratories may reach 4237.5 μg/m³, indicating a significant risk for both staff and students. Prolonged exposure at these levels may result in various health consequences. Chaiklieng et al. (2021) observed that 21.21% of medical laboratory workers experienced non-carcinogenic health problems associated with formaldehyde exposure, such as ocular and respiratory irritation and general malaise. Nonetheless, evidence indicates that the cancer risk for students may remain within acceptable ranges provided adequate ventilation and preventive measures are implemented. A study by Pahasupanan (2020) found that dentistry students exposed to formaldehyde during gross anatomy lessons had an average lifetime cancer risk of 2.16×10^{-7}, which corresponds to fewer than one additional case per one million students. This illustrates that with sufficient safety measures, the carcinogenic risk to students can remain within tolerable limits, despite staff potentially encountering elevated health risks from extended exposure.

The United States Environmental Protection Agency (U.S. EPA) has designated formaldehyde as a potential human carcinogen in instances of significant or extended exposure (Golden, 2011). To prevent harm to workers from the short- and long-term health consequences of formaldehyde exposure, various international organizations have instituted legal or recommended standards for its use in the workplace. Additionally, the quantitative risk assessment suggested by the U.S. EPA was employed for the health risk evaluation of formaldehyde, and the individual lifetime cancer probability was recognized as an acceptable global methodology. Moreover, formaldehyde concentrations can be measured by numerous methods, including the absorbent tube method (a laboratory-based approach) and direct reading equipment. Laboratory-based methods are frequently formulated, disseminated, and accepted by international or national standards organizations. These procedures are broadly acknowledged for their precision, uniformity, and reliability. Nevertheless, these methodologies continue to demonstrate certain constraints, including analytical expenses, processing duration, and sample movement (Soonklang et al., 2025). Previous research utilized formaldehyde detector tubes in conjunction with gas-piston hand pumps or direct-reading instruments to evaluate formaldehyde concentrations (Baldelli et al., 2020; Durongphan et al., 2020; Chaiklieng et al., 2021; Shetty et al., 2024).

The College of Medicine and Public Health at Ubon Ratchathani University has an anatomy laboratory designed for academic purposes. Approximately 200 individuals, including both staff and students, may be at risk of exposure to formaldehyde every semester (Aung et al., 2021; Adamović et al., 2021; Durongphan et al., 2023). Annually, around 10–12 liters of formaldehyde are utilized to preserve 20-35 cadavers per semester. In the past, there was insufficient data on the assessment of formaldehyde concentrations in the laboratory's indoor air by a laboratory-based methodology, presenting a possible exposure risk for staff and students. Consequently, this study aims to evaluate the potential risk of inhaling formaldehyde in the gross anatomy laboratory, specifically with regard to both cancerous and non-cancerous effects.

2. Objectives

This study aims to assess the inhalation risk of formaldehyde for staff, pre-clinical students, and public health students in the gross anatomy laboratory through laboratory-based sampling, focusing on both the hazard quotient (HQ) and cancer risk, utilizing risk assessment methodologies approved by the United States Environmental Protection Agency (U.S. EPA).

3. Materials and Methods

This cross-sectional study is designed to evaluate the inhalation risk of formaldehyde for staff, pre-clinical students, and public health students in the gross anatomy laboratory at the College of Medicine and Public Health, Ubon Ratchathani University, from April 2023 to December 2023. Five samples of indoor air were collected continuously over a period of 8 hours during laboratory activities. The layout of the formaldehyde measurement area is shown in Figure 1. The samplers were sent to the Department of Disease Control's laboratory at the Ministry of Public Health to determine the concentration of formaldehyde. This analysis was conducted using gas chromatography (GC) in accordance with NIOSH Method 2541. The assessments of both cancer and non-cancer risks were conducted using the risk assessment methodologies approved by the United States Environmental Protection Agency.

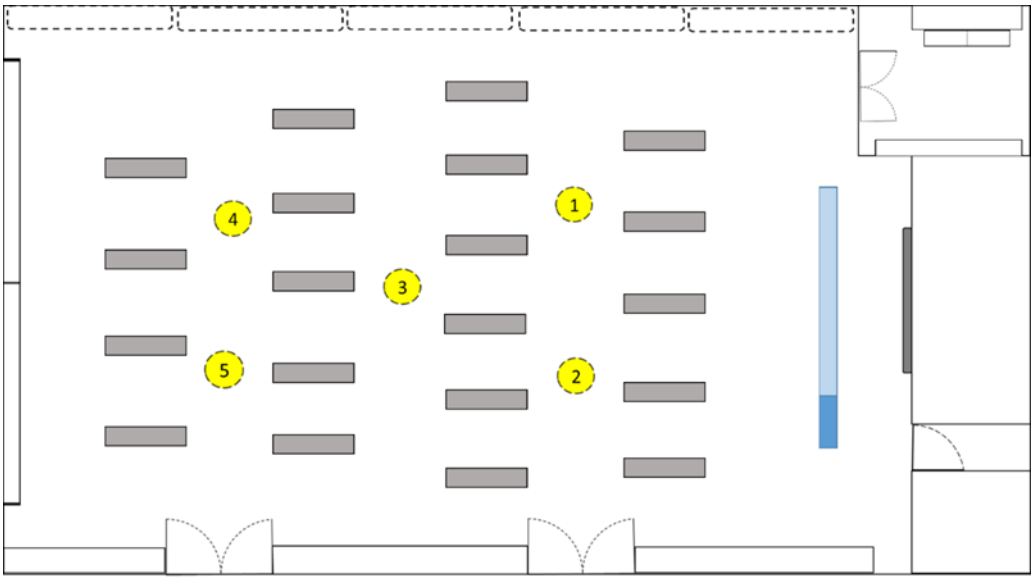

Figure 1 The layout of the formaldehyde measurement area

Remark

1 Refers to formaldehyde measurement point

Refers to double-panel glass sliding door

Refers to the cadavers

Refers to the desk

Refers to single-panel glass sliding door

Refers to the glass window.

3.1 Population and Sample

1) The population for this study consists of 215 people, including staff, pre- clinical students, and public health students enrolled in the semester of 2023.

The desired sample size was calculated to estimate the proportions of populations using Eq. 1

$$n = \frac{NZ^2_{\alpha/2}\,[p(1-p)]}{[e^2\,(N-1)] + [Z^2_{\alpha/2}\,[p(1-p)]]} \qquad \text{Eq.1}$$

$$n = 101.89 \approx 101$$

where:

n = sample size

N = population size (215 individuals)

$Z\alpha/2$ = the coefficient under the standard normal curve at 95% confidence level. Z (0.025) = 1.96

P = proportion estimates; 0.67 obtained from literature reviews (Zain et al., 2019)

e = precision of estimate (0.067)

2) Due to funding constraints for formaldehyde evaluation in the standard laboratory, this study collected and analyzed a total of five indoor air samples to determine the concentration of formaldehyde.

3.2 Research Tools

A questionnaire was developed by referencing pre-existing, published questionnaires on formaldehyde exposure and risk assessment in accordance with the U.S. Environmental Protection Agency (2011) guidelines. The questionnaire comprises two parts: the first providing the demographic information of participants, including gender, age, weight, duration and frequency of exposure, time of exposure, use of personal protective equipment during laboratory work, and annual health check-ups; the other addressing symptoms following exposure to formaldehyde.

3.3 Research Tool Quality Assessment

The questionnaire responses were validated by three subject experts, and the questionnaire itself was assessed on the Index of Item Objective Congruence. Each item was assigned a score ranging from 0.67 to 1.

To ensure the precision of the air sampling equipment, the TSI 4100 series calibrator was used to adjust the flow rate at the personal pump in accordance with NIOSH Method 2541.

3.4 Data Collection

The steps for gathering the data are as follows:

1) Participants from both groups, comprising staff and students, completed a self-administered paper-based questionnaire regarding personal characteristics and the effects of formaldehyde exposure.

The inclusion criteria are as follows: Staff members employed in the gross anatomy laboratory of the College of Medicine and Public Health at Ubon Ratchathani University must have a minimum of one year of experience. Additionally, pre-clinical and public health students must be enrolled in the anatomy course offered by the College of Medicine and Public Health during the current semester. Furthermore, the exclusion criteria encompassed staff and students who refused to participate in this study.

2) Air sampling was performed to assess the levels of formaldehyde in the workplace during regular working hours, which spanned from 8:30 a.m. to 4:30 p.m. This was done to determine the average concentration of formaldehyde over an 8-hour period, known as the time-weighted average (TWA8). The sampling methodology and preparation were conducted according to the NIOSH 2541 guidelines, specifically targeting the breathing zone of the laboratory staff. Two blank tubes were created. The sorbent tube, containing 10% (2-hydroxymethyl) piperdind on XAD-2, (front=120 mg; back=60 mg), was used to sample formaldehyde with personal sampling pump flow rate of 0.10 L/min with flexible connecting tubing. The samples were kept at a freezing temperature (2 degrees Celsius) and examined in the laboratory of the Department of Disease Control, the Ministry of Public Health, within 21 days to guarantee that the sample's stability period was not exceeded (Zain et al., 2019). Following the collection of samples, researchers delivered them using a typical public bus transit system that offers parcel delivery services on the same day of collection. The samples will be transported from Ubon Ratchathani Province to Bangkok, arriving within 8 hours. The testing laboratory personnel will pick up the samples from the public transport store location the following day. The sample was confirmed to be preserved in accordance with the laboratory standard procedures.

3.5 Data Analysis

1) Descriptive statistics were used to analyze general data, formaldehyde exposure data, and risk assessment data including frequency and percentage. Quantitative data are typically given with measures such as the average, standard deviation (SD), maximum value, and minimum value.

2) Formaldehyde analysis (based on the NIOSH Method 2541) : A total of 5 samples of formaldehyde were taken from the gross anatomy laboratory of the College of Medicine and Public Health, Ubon Ratchathani University. The samples were gathered, placed in Ziploc bags, stored at a freezing temperature (2 degrees Celsius), and transported to the Department of Disease Control's laboratory at the Ministry of Public Health. The front section (120 mg) of the sampling tube was transferred to a 2-mL vial, whereas the back section (60 mg) was placed in a separate vial. Desorbing solution with an internal standard was prepared by adding 20 µL of dimethylformamide to 100 mL of toluene. Then 1 mL of desorbing solution was added to each vial. The vials were then sealed with crimp caps, placed in an ultrasonic bath, and allowed to desorb for 60 minutes prior to analysis. The analysis was conducted using a gas chromatograph (GC) (GC Agilent 8890). Calibration curves were linear over the studied range (1, 2, 5, 15, 30, 60, and 120 µg/mL) and were prepared to generate the calibration curve with correlation coefficients of 0.999. The limit of detection (LOD) was 0.577 mg/L and the limit of quantitation (LOQ) was 2.023 mg/L.

3) The daily exposure to formaldehyde was assessed using Eq.2 (Adamović et al., 2021)

$$I=\frac{C\times IR\times ET\times EF\times ED}{BW\times AT} \qquad \text{Eq.2}$$

where:

C = concentration of formaldehyde (µg/m^3)

IR = inhalation rate for an average adult = 20 m^3/day (U.S. Environmental Protection Agency, 2011)

ET= exposure time (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW= body weight (kilograms)

AT = average time affected; AT = ED × 365 days for noncancer risk, or AT = 70 years × 365 days for cancer risk (Zain et al., 2019)

4) The risk level was computed using an equation based on cancerous effects using Eq. 3 (Widiana et al., 2019).

$$\text{Cancer risk}=I\times IUR \qquad \text{Eq.3}$$

where:

I = daily exposure to formaldehyde (µg/m^3)

IUR = inhalation unit risk (IUR) to formaldehyde (1.3×10^{-5}μg/m^3) (U.S. Environmental Protection Agency, 1990)

Hence:

- If cancer risk is > 1×10^{-6}, it indicates carcinogenic effects of concern.

- If cancer risk is ≤ 1×10^{-6}, it indicates: an "acceptable" range as determined by the EPA (U.S. Environmental Protection Agency, 2005).

The quantification of the non-cancer human health risk associated with the inhalation of formaldehyde was determined by calculating the hazard quotient (HQ) parameter. (Eq.4)

$$HQ = I/Rf\,C \qquad \text{Eq.4}$$

where:

HQ = hazard quotient

I = daily exposure to formaldehyde (μg/m^3)

RfC = reference concentration of formaldehyde, which is an estimate of the level of ongoing inhalation exposure that leads to detrimental, non-cancerous health effects over an individual's lifetime (mg/ m^3).

RfC = 9.8 μg/m^3 (U.S. Environmental Protection Agency, 2015).

- If HQ is ≥ 1, there is a possibility of a health risk resulting from exposure.

- if HQ is < 1, it is probable that the risk of a non-carcinogenic health effect is acceptable (U.S. Environmental Protection Agency, 2009).

This study was approved by the Human Research Ethics Committee of Ubon Ratchathani University (code UBU-REC-138/2566).

4. Results

The participants consisted of 69.3% females. The average age of a pre-clinical student is 20.65±0.60 years, a public health student is 20.01±0.60 years, and a staff member is 52.20±5.31 years. Every participant employed personal protective equipment (PPE) while conducting laboratory tasks. The personal protective equipment (PPE) used included a face mask, gown, and rubber gloves, with a utilization rate of 100%. Only 1% of the participants used safety eyewear throughout laboratory work. Additionally, 91.1% of the participants had never undergone an annual health check (Table 1).

The participants reported the following symptoms following their exposure to formaldehyde: skin irritation (23.8%), headache (17.8%), eye irritation (15.8%), and nasal irritation (14.9%). The information is shown in Table 2.

The anatomy laboratory's formaldehyde levels were assessed according to the National Institute for Occupational Safety and Health's (NIOSH) guidelines utilizing gas chromatography (GC) analysis at the Pollution Control Department laboratory, the Ministry of Public Health. The area sampling, conducted with a total of 5 samples, revealed an average formaldehyde content of 65±10 μg/m^3 (Table 3).

Table 1 Demographic information of the participants (n = 101)

Characteristics	Frequency	Percentage
Gender		
Male	31	30.7
Female	70	69.3
Age (year)		
Staff (n = 5)	mean±SD = 52.20±5.31, minimum = 48, maximum = 58	
Pre-clinical students (n = 32)	mean±SD = 20.65±0.60, minimum = 20, maximum = 22	
Public health students (n = 64)	mean±SD = 20.01±0.60, minimum = 19, maximum = 22	
Utilizing PPE during laboratory work		
Yes	101	100.0
Categories of personal protective equipment (PPE) utilized		
Face mask	101	100.0
Gown	101	100.0
Rubber gloves	101	100.0
Safety glasses	1	1.0
Hair covering cap	96	95.0
Annual health checks		
Yes	9	8.9
No	92	91.1

Table 2 Participants reporting symptoms following their exposure to formaldehyde (n=101)

Symptoms (Many answers are possible)	Frequency	Percentage
Irritation to the eyes	16	15.8
Skin irritation	24	23.8
Smell	10	9.9
Irritated nose	15	14.9
Throat irritation	8	7.9
Mouth irritation	7	6.9
Headache	18	17.8
Squeamishness	8	7.9
Vomiting	5	5.0
Shortness of breath/difficulty breathing	9	8.9
Wheezing	4	4.0
Cough with mucus	5	5.0
Tightness in the chest	8	7.9

Table 3 Formaldehyde concentration in each sampling point

Sampling point	Formaldehyde concentration (μg/m³)	Comparison with NIOSH Standards (1 ppm or 1,228 μg/m³)
No.1	70	✓
No.2	59	✓
No.3	66	✓
No.4	74	✓
No.5	54	✓
Range	54-74	✓
Mean±SD	65±10	✓

Remark: 1) The National Institute for Occupational Safety and Health (NIOSH) designates 1 ppm (1,228 μg/m³) the maximum permissible concentration of formaldehyde in indoor air, a threshold that must not be exceeded at any time (Baldelli et al., 2020), ✓ = complied with the standard

Table 4 Parameters used to calculate formaldehyde exposure

Variable	Values	
	Range of values	Mean±SD
Formaldehyde Concentration (mg/m³)	0.054-0.074	0.065±0.01
Body weight (BW)(kilograms)		
Lecturer, officer (n= 5)	56-80	71.20±9.95
Pre-clinical students (n=32)	47-68	55.25±5.23
Public health students (n=64)	44-78	53.92±7.12
Exposure duration (ED) (years)		
Lecturer, officer	1-5	2.20±1.78
Pre-clinical students	3	3.00±0.00
Public health students	1	1.00±0.00
Exposure frequency (EF) (days/year)		
Lecturer, officer	30-150	72.00±58.48
Pre-clinical students	36	36.00±0.00
Public health students	15	15.00±0.00
Exposure time (ET) (hours/day)		
Lecturer, officer	1-4	2.00±1.41
Pre-clinical students	4-5	4.81±0.39
Public health students	3	3.00±0.00
Average time (AT) (days)	For non-cancer risk	For cancer risk
Lecturer, officer	365-1,825	25,550
Pre-clinical students	1,095	25,550
Public health students	365	25,550

Table 5 Participants' daily exposure to formaldehyde

Participant groups	Daily exposure to formaldehyde (μg/m^3)		
	Minimum	Maximum	Mean±SD
Lecturer, officer	0.008193	0.207889	0.10061±0.09641
Pre-clinical students	0.04916	0.07112	0.06101±0.00554
Public health students	0.01071	0.01899	0.01572±0.00187

Table 6 Cancer and non-cancer risk features among the individuals

Participant groups	Risks (Minimum-Maximum)	
	Cancer risk	Non-cancer risk (Hazard quotient)
Lecturer, officer	2.92×10^{-9}-7.40×10^{-8}	0.16-4.07
Pre-clinical students	1.05×10^{-8}-1.52×10^{-8}	0.58-0.84
Public health students	1.27×10^{-9}-2.25×10^{-9}	0.07-0.12
Range	1.27×10^{-9}-7.40×10^{-8}	0.07-4.07

Remark:

1) Cancer risk > 1×10^{-6} = concern risk, cancer risk ≤ 1×10^{-6} = acceptable risk

2) HQ ≥ 1 = potential risk, HQ < 1 = acceptable risk

Upon analyzing the formaldehyde exposure in the sample group based on the characteristics provided in Table 4, it was determined that the staff group had the highest daily exposure to formaldehyde, measuring 0.207889 μg/ m^3. Conversely, public health students had the lowest daily exposure to formaldehyde, measuring 0.01899 μg/m^3 (Table 5).

The assessment of formaldehyde exposure risk among the participants revealed that the staff group had the highest hazard quotient with a value of 4.07, while the students in both groups had a hazard quotient value of no more than 1. Upon considering the carcinogenic risk associated with formaldehyde exposure, it was determined that for staff, the cancer risk ranged from 2.92×10^{-9} to 7.40×10^{-8}; for pre-clinical students, the risk ranged from 1.05×10^{-8} to 1.52×10^{-8}; and for public health students, the risk ranged from 1.27×10^{-9} to 2.25×10^{-9}, all of which are below 1×10^{-6} for all of the participants (Table 6).

5. Discussion

The study's findings reveal that the concentration of formaldehyde in the anatomy laboratory ranged between 54 μg/m^3 (0.044 ppm) and 74 μg/m^3(0.060 ppm), and the average concentration of formaldehyde was 65 μg/m^3 (0.053 ppm). The concentration of formaldehyde exceeded the recommended NIOSH exposure limit (REL) of 0.016 ppm for an 8-hour period. Nevertheless, the results have been compared with the OSHA-prescribed exposure threshold of 0.75 ppm (New Jersey Department of Health, 2016). According to Asare-Donkor et al. (2020), several cosmetic products commonly used in beauty salons release formaldehyde at average concentrations ranging from 88.67 to 170.67μg/m^3 (Asare-Donkor et al., 2020), and the study conducted by Yahyaei et al. (2020) found that the formaldehyde levels in five hospital pathology departments ranged from 0.0192 to 0.326 ppm (Yahyaei et al., 2020). The participants under the study exhibited the following symptoms due to their exposure to formaldehyde: skin irritation (23.8%), headaches (17.8%), eye pain (15.8%), and nose irritation (14.9%). It is possible that staff and students working in the gross anatomy laboratory area may wear loose gowns and often do not utilize eye protection glasses, leading to exposure to formaldehyde emissions. This aligns with the findings of a study conducted by Aung et al. (2021), which documented the presence of unpleasant odors, eye and nasal irritations, and the presence of symptoms associated with formaldehyde exposure among second-year medical students and instructors from the Department of Anatomy at the University of Medicine (Aung et al., 2021), and the study of Tiruneh (2021), found pre-clinical medical students and instructors reported acute adverse effects while being exposed to formaldehyde was runny nose with tingling sensation (30.7%), followed by a lack of concentration (27.3%) and headache (25%) (Tiruneh, 2021), and the participants reported the following symptoms as a result of their exposure to formaldehyde: skin irritation (23.8%), headaches (17.8%), eye discomfort (15.8%), and nasal irritation (14.9%) (Yahyaei et al., 2020). Furthermore, the study revealed that a notable

91.1% of participants did not undergo an annual check-up. It is probable that a majority of the participants were students who did not have health insurance coverage from the university, many not receiving a medical examination.

The staff group demonstrated the highest hazard quotient (HQ) of 4.07, indicating potential adverse health effects may occur from prolonged inhalation at this concentration (Colas et al., 2022). It is possible that the staff may have had greater frequency and duration of formaldehyde exposure than the student group, as indicated by a higher hazard quotient for noncarcinogenic effects compared to the other groups. Staff may be susceptible to heightened health hazards via breathing pathways. Therefore, it is essential to conduct additional monitoring of formaldehyde in the anatomy laboratory. Efficient procedures should be implemented to mitigate hazards associated with formaldehyde and minimize possible adverse effects. Upon evaluating the cancer risk associated with formaldehyde exposure, it was determined that the range of cancer risk values fell between 2.92×10^{-9} and 7.40×10^{-8}, all of which were lower than 1×10^{-6} for the population. This may be due to the fact that at the time formaldehyde was collected, the cadaver had not yet been dissected, potentially resulting in a lower concentration of formaldehyde. Consequently, the evaluation of the staff's exposure to formaldehyde revealed it to be small, and the associated cancer risk was negligible. The inconsistency may be due to the formaldehyde concentration in this study's laboratory, whereas Jalali et al. (2020), Adamović et al. (2021), and Dugheri et al. (2023) highlight the elevated carcinogenic risk associated with respiratory exposure to formaldehyde among employees (Jalali et al., 2020; Adamović et al., 2021; Dugheri et al., 2023).

Both pre-clinical and public health students had a hazard quotient value of less than 1. The cancer risk associated with formaldehyde exposure fell between 1.27×10^{-9} and 1.52×10^{-8}. This study, consistent with the research conducted by Adamović et al. (2021), found that the average cancer risk among students ranged from 8.94×10^{-7} to 1.83×10^{-6} (Adamović et al., 2021). Additionally, Soonklang & Saowakonet (2022) indicated that the mean cancer risk among students in the dissection room ranged between 0.95×10^{-7} to 9.50×10^{-7} (Soonklang & Saowakonet, 2022). However, in contrast to this, the study by Yahyaei et al. (2020) revealed that the cancer risk in the pathology departments of hospitals exceeded the acceptable level set by the World Health Organization.

This study is valuable because it uses absorbent tube methods, which are very reliable for measuring formaldehyde levels in the gross anatomy laboratory, and it checks formaldehyde concentration at a certified testing facility. Therefore, we can confidently assert the reliability of the documented formaldehyde concentration level at that specific time. The study's limitations include that the formaldehyde sampling was conducted at only five locations, which may not sufficiently represent the actual concentrations experienced by laboratory workers. Moreover, formaldehyde concentration sampling was exclusively conducted during the preparation of the cadavers for instructional purposes. At that time, the cadaver had not yet been dissected, potentially resulting in a lower concentration of formaldehyde compared to the period during which the dissection occurred in the study.

6. Conclusion

The staff members working in the gross anatomy laboratory had the highest hazard quotient of 4.07, whereas the pre-clinical students and public health students had hazard quotient values of less than 1. Furthermore, when the cancer risk related to formaldehyde exposure was assessed, it was found that the cancer risk values ranged from 1.27×10^{-9} to 7.40×10^{-8}, all of which were below 1×10^{-6}. Nevertheless, this study revealed that the participants experienced symptoms after working in the laboratory. Therefore, management and individuals involved in the area where formaldehyde is utilized should contemplate mitigating the risk of formaldehyde exposure to ensure the safety of all personnel involved. It is recommended that students and staff in the gross anatomy laboratory increase their awareness of the potential health risks associated with exposure to formaldehyde. They should also be required to use suitable protective equipment, such as a laboratory coat, protective goggles, and gloves. Direct contact with formaldehyde should be prevented, and adequate ventilation should be ensured. This study presented formaldehyde concentrations measured in an academic year. Future research should focus on how formaldehyde affects molecules, like DNA adduct formation, rather than just looking at formaldehyde levels and survey results. A long-term study is necessary to investigate the potential health risks, such as blood disorders and cancers, associated with continuous exposure to formaldehyde.

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8. CRediT Statement

Laksanee Boonkhao: Conceptualization, methodology, data curation, formal analysis, visualization, writing, original draft, writing, review & editing, supervision, funding acquisition, project administration.
Siriyakorn Porsriya: Resources, data curation, validation, laboratory experiments, formal analysis, visualization, software, statistical analysis, writing, review & editing.
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Tanaporn Thongsim: Conceptualization, methodology, visualization, laboratory experiments, writing, review & editing.

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