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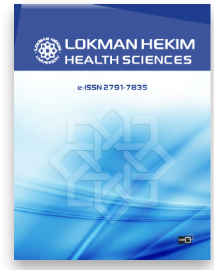

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ORIGINAL ARTICLE

Formaldehyde Reliance, Alternative Embalming Adoption, and Occupational Safety in Turkish Anatomy Laboratories: A Multi-Centre Cross-Sectional Survey

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Abstract

Introduction: Formaldehyde remains the default fixative in anatomy laboratories despite well-documented health risks. This study assessed the current reliance on formaldehyde in Turkish anatomy laboratories, awareness of alternative methods, and institutional practices regarding personal protective equipment (PPE) and training.

Methods: A cross-sectional online survey was conducted at the anatomy laboratories of medical schools in Türkiye between June and July 2024. Quantitative data were analysed descriptively and with appropriate statistical tests ($\alpha=0.05$). Free-text responses underwent reflexive thematic analysis.

Results: The study included 71 anatomy professionals from 37 medical schools. Formaldehyde was reported in 91.9% of laboratories. PPE provision for students was inadequate, and 77% of participants had received no formal training on chemical safety.

Discussion and Conclusion: Turkish anatomy laboratories remain highly dependent on formaldehyde. Although alternative fixation methods are known, current evidence does not confirm that they are safer or sustainable under local conditions. Therefore, improving protective measures—effective ventilation, mandatory safety training, and adequate PPE provision—represents the most urgent priority for reducing exposure risks and strengthening occupational safety.

Keywords: Embalming; Formaldehyde; Occupational exposure; Personal protective equipment; Tissue fixation; Türkiye

Donor body–based dissection is a fundamental component of anatomical education, enabling students to develop spatial understanding and acquire essential clinical skills. The long-term preservation of donated bodies is particularly critical in countries with limited body donation for the sustainability of these programs. For more than a century, formaldehyde has remained the most widely used fixative due to its low cost, effectiveness, and accessibility.[1] However, its use has increasingly been questioned because of both short- and long-term health risks, including ocular and respiratory irritation, DNA damage, and carcinogenicity.[2]

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Formaldehyde exposure is associated with acute effects such as ocular and respiratory irritation and long-term consequences, including DNA damage and carcinogenesis.[3] Therefore, ensuring a safe environment in dissection halls has become an educational necessity.[4] International authorities (EU, OSHA) and the Turkish Ministry of Health have established exposure limits, and the 2014/5 circular mandates regular monitoring of laboratories for formaldehyde and xylene levels.[5,6] Nevertheless, comprehensive data regarding the frequency and effectiveness of inspections specific to anatomy laboratories remains limited.

Complete substitution of formaldehyde remains difficult. Alternatives such as Thiel's method, phenol-based solutions, plastination, and fresh-frozen donor bodies have been reported in the literature, yet each carries context-dependent advantages and limitations.[7] The Thiel method contains low concentrations of formaldehyde along with numerous other chemicals and shows limited long-term histological stability.[8] Phenol-based solutions can cause hepatotoxic and nephrotoxic effects when exposure exceeds threshold levels.[9,10] Plastination, while useful as a supplementary educational material, reduces tissue realism and eliminates the possibility of multi-plane dissection.[11] Fresh-frozen donor bodies, on the other hand, are prone to deterioration after repeated thawing and present infection risks.[12] Consequently, these methods cannot be universally regarded as "safer"; their applicability depends on available resources, infrastructure, and body donation systems.

In Türkiye, multi-center data regarding formaldehyde use and occupational safety in anatomy laboratories are limited. While pathology laboratories are regularly monitored under Ministry of Health regulations, systematic oversight of anatomy facilities is lacking.[6] In addition, low body donation rates necessitate prolonged use of available donor bodies, reinforcing reliance on formaldehyde.[13] This situation creates particular risks for student safety. To our knowledge, it represents one of the first national multi-center surveys addressing these issues with an emphasis on student safety.

This study aimed to evaluate preservation practices, awareness of formaldehyde hazards and alternative methods, training deficiencies, and the provision of personal protective equipment in Turkish anatomy laboratories.

Materials and Methods

This cross-sectional, descriptive study was conducted between June and July 2024 using an online survey administered to anatomy professionals employed in medical and health sciences faculties throughout Türkiye, as well as to residents and postgraduate (master's/PhD) trainees in anatomy programs. Invitations were distributed via the Turkish Anatomy and Clinical Anatomy Society's e-mail lists and WhatsApp groups, and participation was reinforced with two follow-up reminders after the initial call. The survey instrument is provided as Appendix 1. Participants were recruited from 27 public and 10 foundation universities.

The study protocol received approval from the Medipol University Clinical Research Ethics Committee (Decision No. 514; 22 May 2024) and was performed in accordance with the Declaration of Helsinki. The purpose of the research, data-privacy measures, and the voluntary nature of participation were explained in detail within the online form, and electronic informed consent was obtained from all respondents. The study received no financial support, and the authors declare no conflicts of interest. The final sample size was 71 participants, which may limit the generalizability of the findings; this issue is further discussed in the Limitations section.

The questionnaire was developed following an extensive literature review and consultation with three anatomists experienced in donor-body conservation and one public-health specialist in occupational safety (FTK, HYG, NA, ANBY); its face validity was assessed by an independent anatomist who was not involved in the study. The final instrument comprised 23 structured items across four domains: (1) demographic characteristics; (2) donor-body (body donation) use and laboratory infrastructure; (3) formaldehyde exposure, related health risks, and protective measures; and (4) personal protective equipment (PPE) use and institutional policies. Items included closed-ended, multiple-choice, Likert-scale, and open-ended formats. Responses to open-ended questions were collected for thematic analysis of the perceived advantages, disadvantages, and barriers associated with donor-body conservation techniques. Safety was queried as perceived health-related safety during routine laboratory activities and rated on a 5-point Likert scale (1=very unsafe, 5=very safe) for each preservation approach. Efficacy denoted perceived preservation performance/long-term maintenance (1=very poor, 5=very good).

Participants without prior donor body dissection experience were not excluded; this is acknowledged as a limitation of the study and discussed in the Limitations section.

Data were analysed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA) and R software, version 4.4.2 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables are presented as mean±standard deviation or median (minimum–maximum), and categorical variables as frequencies and percentages. Associations between categorical variables were tested with Pearson's χ^2 or Fisher's exact test. The normality of Likert-scale data was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests; normally distributed variables were compared with independent-samples t-tests and one-way ANOVA, whereas non-normally distributed variables were analysed with the Mann–Whitney U and Kruskal–Wallis tests. Open-ended responses were thematically coded following Braun and Clarke's six-phase approach.[14] A significance level of $p<0.05$ was adopted for all statistical tests.

Results

Participant Characteristics and Formaldehyde Exposure

Seventy-one anatomy professionals from 37 higher-education institutions in Türkiye completed the survey (Table 1). Women represented 55.0% (n=39) of respondents and men 45.0% (n=32). The mean age was 33.7±7.5 years for women and 41.1±12.6 years for men. The largest academic subgroup was specialist physicians (19.7%, n=14), followed by residents (18.3%, n=13) and doctoral candidates (16.9%, n=12). Nearly half of the participants (47.9%, n=34) reported ≤ 5 years of professional experience, whereas 16.9% (n=12) had ≥ 21 years (Appendix 1).In this study, professional experience refers to the total years of work in the Anatomy Department.

Weekly contact time with formaldehyde-fixed donor bodies was most commonly 0–3 h (40.8%, n=29). Contact durations of 4–6 h, 7–9 h, and ≥ 10 h were reported by 23.9% (n=17), 18.3% (n=13), and 16.9% (n=12) of participants, respectively. Exposure duration did not differ significantly by sex (p=0.93), age group (p=0.31), academic rank (p=0.86), or length of professional experience (p=0.79).

Laboratory Resources, Preparation, and Storage Methods

According to survey responses, most anatomy laboratories reported having 3-D model sets (36/37, 97.3%) and fixed donor bodies (34/37, 91.9%). Dry bone collections were also common (31/37, 83.8%). In contrast, less common resources included fresh-frozen specimens, reported by only nine institutions (24.3%), and plastinated preparations, reported by eight (21.6%) (Fig. 1).

Table 1. Gender and age distribution of participants

Category	Sample size and percentage	Mean age (years)
Female	39 (55%)	33.72±7.52
Male	32 (45%)	41.13±12.62

This table summarizes the gender distribution and mean age of the participants.

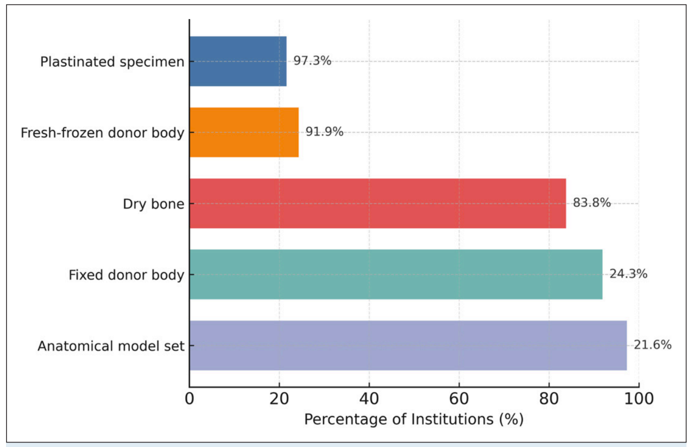

Figure 1. Adoption rates of major physical teaching materials in Turkish anatomy laboratories (n=37 institutions).

Adoption rates of physical teaching materials in Turkish anatomy laboratories (n=37 institutions). Horizontal bars indicate the proportion of medical faculties that reported regular access to each material in their laboratory facilities, irrespective of curricular frequency of use: anatomical model sets, fixed cadavers, dry bone collections, fresh-frozen cadavers, and plastinated specimens. Percentages at the bar termini represent the share of institutions (out of 37) confirming access.

All respondents reported self-reported awareness of the formaldehyde-based fixation method (71/71). Awareness rates for other techniques were lower: fresh-frozen (49%), ethanol-based (37%), phenol-based (33%), Thiel/silicone-based (~33%), and PEG/saturated-salt methods (<4%) (Fig. 2a).

Reported institutional use followed a similar pattern: formaldehyde-based 91.9%, phenol-based 29.7%, fresh-frozen 27.0%, ethanol-based 18.9%, and silicone/polymer-based 16.2% (Fig. 2b).

When asked which storage options they knew, 57.7% of participants selected a combination of storage tanks and cold rooms, 40.8% selected storage tanks only, and 1.4% selected cold rooms only. In their own institutions, 45.9% reported using only storage tanks, 43.2% a hybrid system (tank + cold room), and 10.8% only cold rooms (Fig. 3).

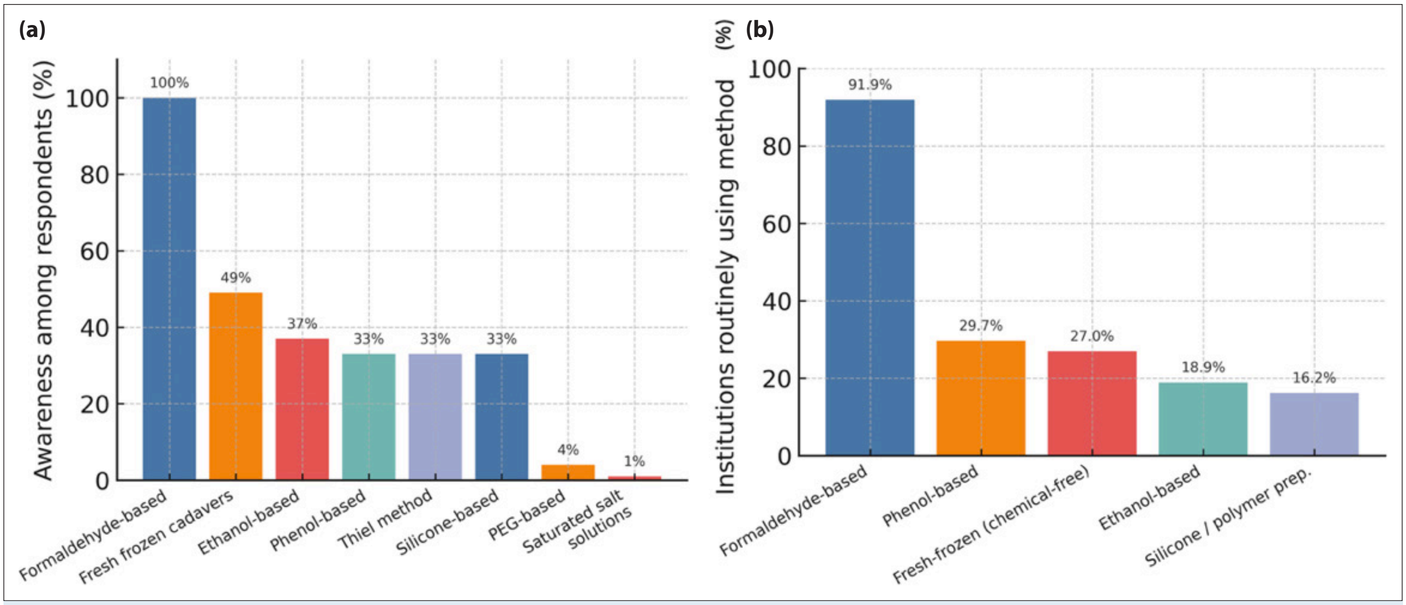

Figure 2. Correlation between FEV 1 and vitamin D level. **(a)** Awareness levels among academic staff (n=71 respondents); **(b)** Proportion of institutions routinely employing each method (n=37 medical faculties).

Values above bars denote percentages. PEG- based: Polyethylene glycol–based soft-fix solution.

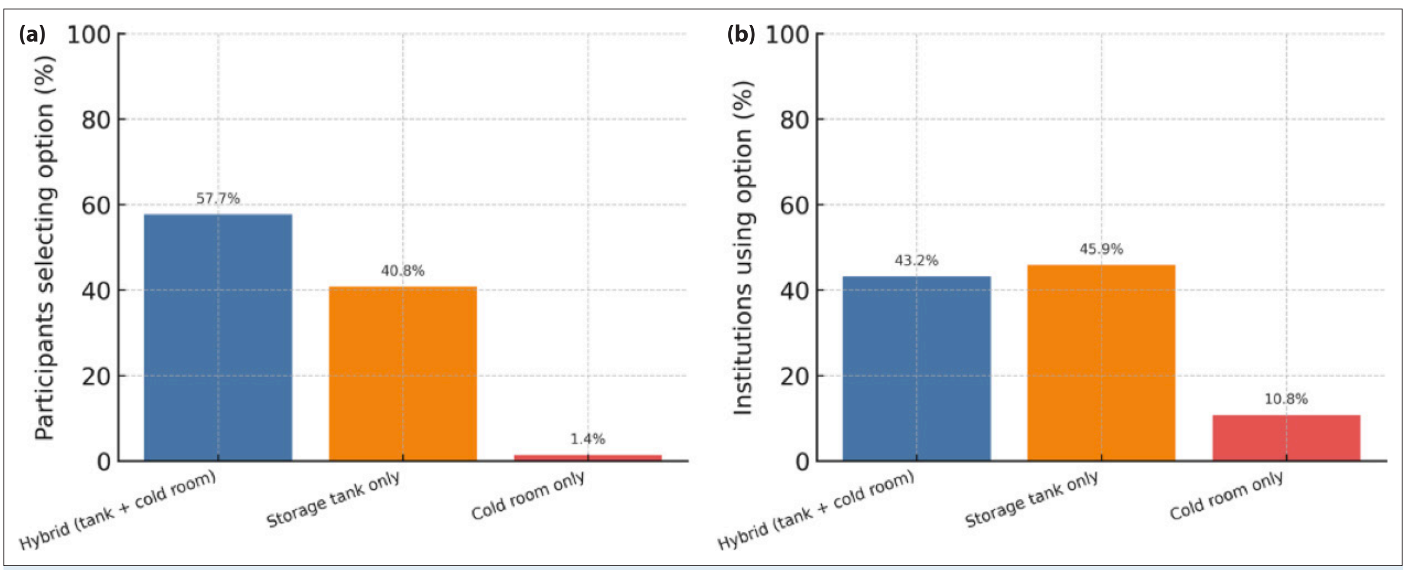

Figure 3. Preferred versus actual storage strategies for preserved donor bodies in Turkish anatomy laboratories. **(a)** Percentage of survey participants (n=71) who indicated that donor bodies can be maintained using each storage option. **(b)** Percentage of medical faculties (n=37) that currently employ the option in routine practice. Values atop bars denote percentages.

Hybrid=combined use of a fixed-storage tank filled with preservative solution and a temperature-controlled cold-room facility.

Safety Perceptions and Training

The health-related safety and preservation efficacy of each preservation approach (fixation or storage) were rated on a five-point Likert scale (Appendix 1). Formaldehyde-based fixation was perceived as the most hazardous option (1.45±0.91), yet its long-term preservation efficacy was rated relatively high (3.49±1.17). Fresh-frozen donor bodies received the highest safety score (3.40±1.17) but the lowest efficacy score (2.44±1.00). Thiel- and silicone-based techniques yielded balanced scores for both safety and efficacy.

Self-awareness of health risks was reported as moderate by 56% of participants (n=40) and high by 14% (n=10); professional experience showed a positive correlation with awareness (ρ=0.402; p=0.0005) (Appendix 2).

Table 2. Institutional provision of, and self-reported use of, personal protective equipment in Turkish anatomy laboratories

PPE item	Institutional supply – staff n / 37 (%)	Institutional supply – students n / 37 (%)	Individual use n / 71 (%)
Surgical gloves	31 / 37 (83.8)	22 / 37 (59.5)	59 / 71 (83)
Surgical masks	26 / 37 (70.3)	17 / 37 (45.9)	48 / 71 (68)
Cotton laboratory gown (standard)	20 / 37 (54.1)	11 / 37 (29.7)	36 / 71 (51)
Fluid-resistant gown	17 / 37 (45.9)	4 / 37 (10.8)	34 / 71 (48)
Formaldehyde-vapour filtering mask	23 / 37 (62.2)	3 / 37 (8.1)	34 / 71 (48)
Protective goggles	22 / 37 (59.5)	0 / 37 (0)	32 / 71 (45)
Nitrile gloves	—	—	2 / 71 (3)
Scrubs	—	—	1 / 71 (1)
No PPE provided	3 / 37 (8.1 %)	13 / 37 (35.1 %)	—

Values are given as n / total (%). Institutional columns indicate the number of laboratories (n=37) that report providing each item for staff or students; the individual-use column reports the number of respondents (n=71) who state that they personally use the item. "—"=item not queried at the individual level. PPE=personal protective equipment; vapour-filtering mask=respirator fitted with a formaldehyde-specific cartridge. Institutional provision and individual use of personal protective equipment (PPE) by academic staff and undergraduate students in Turkish anatomy laboratories. Percentages are based on self-reported responses. Figures may not sum to 100% because not all participants marked every option or selected their most frequently used type. "Student" refers to undergraduate medical students. The "No PPE provided" line reflects participants' perceptions of institutional provision and may vary across universities.

The majority of respondents (77%; n=55) indicated that they had not received formal training on the hazards of preservative chemicals at their institution, whereas 23% (n=16) had undergone such training.

Institutional data revealed that 32 of 37 anatomy laboratories (86.5%) were equipped with a ventilation system, while five laboratories (13.5%) had none. Among facilities with ventilation, half of the respondents (50.7%) rated the system as inadequate, 38.0% as partially adequate, and only 11.3% as fully adequate.

For staff, the most commonly supplied personal protective equipment (PPE) was surgical gloves (31/37; 83.8%). This was followed by surgical masks (70.3%), half-/full-face respirators with formaldehyde cartridges (62.2%), safety goggles (59.5%), cotton laboratory coats (54.1%), and fluid-resistant gowns (45.9%) (Table 2).

For students, glove provision fell to 59.5% (22/37) and surgical mask provision to 45.9% (17/37). Thirteen laboratories (35.1%) provided no PPE to students. Cotton coats were supplied by 29.7%, fluid-resistant gowns by 10.8%, and respirators with formaldehyde filters by only 8.1% (Table 2).

Regarding personal use, 83% of respondents reported wearing surgical gloves, 68% surgical masks, 51% cotton laboratory coats, and 48% fluid-resistant gowns.

Perceived Benefits and Barriers to Adopting Safer Fixatives

Among the 71 respondents, four benefit themes emerged (Table 3). Long-term durability and specimen longevity were the most frequently cited advantages (32/71, 45.1%). Ease of use ranked second (15/71, 21.1%), followed by economic affordability (12/71, 16.9%) and reliability/self-reported awareness with established protocols (4/71, 5.6%).

Chemical exposure dominated the list of disadvantages, highlighted by 44 respondents (62.3%). Acute irritant effects and unpleasant odour were noted by 28/71 participants (39.4%), whereas long-term carcinogenic or toxic risks were emphasised by 16/71 (22.8%). Operational difficulty was reported in 18/71 surveys (25.4%). Environmental impact and short shelf-life were mentioned only sporadically (<5%).

Six categories of obstacles to adopting techniques perceived by participants as less hazardous were identified (Appendix 3). The most prevalent being lack of materials or infrastructure (35/71, 49.3%). Financial constraints were the second most common barrier (23/71, 32.4%), followed by insufficient knowledge or training (12/71, 16.9%). Cultural or habit-based resistance (7/71, 9.9%), logistical challenges (4/71, 5.6%), and entrenched commitment to the current method (3/71, 4.2%) were less frequently reported.

Discussion

This study examined the awareness levels, practical applications, and occupational safety measures regarding the use of formaldehyde and alternative donor body preservation methods in anatomy laboratories in Türkiye. Our findings indicate that, although the toxic profile of formaldehyde is widely recognized, this awareness does not consistently translate into the adoption of alternative methods and protective practices. This gap appears to stem partly from deficiencies in training, limited access to

Table 3. Perceived advantages and disadvantages of formaldehyde-based cadaver preservation

Category	Theme	Subtheme	Example Comments	Frequency and percentage
Advantages	Ease of Use	Dissection Ease	"Participant 12: Tissue flexibility and ease of dissection are notable advantages."	5 (7.04%)
Advantages	Ease of Use	Practicality	"Participant 71: Ease of application is a significant advantage."	6 (8.45%)
Advantages	Ease of Use	Infection Risk Reduction	"Participant 52: Formaldehyde-based fixation is advantageous in terms of hygiene due to its effectiveness in preventing bacterial and fungal growth."	4 (5.63%)
Advantages	Long-Term Use and Durability		"Participant 4: We use formaldehyde-based materials, and their advantage is their long-term usability."	32 (45.07%)
Advantages	Reliability and Familiarity	Reliability and Familiarity	"Participant 6: Its advantage is being the most reliable and widely used method."	2 (2.82%)
Advantages	Reliability and Familiarity	Habitual Use	"Participant 42: It is effective in fixing cadavers for long-term usability and is a method we are accustomed to applying."	2 (2.82%)
Advantages	Economic Feasibility		"Participant 8: It is inexpensive."	12 (16.9%)
Disadvantages	Usage Difficulties	Dissection Difficulty	"Participant 7: Dissection is more challenging with specimens fixed in formaldehyde."	5 (7.04%)
Disadvantages	Usage Difficulties	Changes in Cadaver Quality	"Participant 41: The material becomes excessively rigid and darkened."	5 (7.04%)
Disadvantages	Usage Difficulties	Maintenance and Storage Needs	"Participant 19: It requires constant maintenance."	4 (5.63%)
Disadvantages	Usage Difficulties	Protective Equipment and Working Conditions	"Participant 30: It requires the use of masks and protective equipment."	3 (4.23%)
Disadvantages	Usage Difficulties	Short-Term Use	"Participant 53: Toxicity and short usability are significant disadvantages."	1 (1.41%)
Disadvantages	Chemical Exposure	Short-Term Effects: Symptomatic Effects: Eye Irritation	"Participant 15: When there is no washing unit for cadavers removed from the formaldehyde tank, the intense and irritating odor, along with its eye-watering effect, makes dissection challenging."	5 (7.04%)
Disadvantages	Chemical Exposure	Short-Term Effects: Symptomatic Effects: Headache	"Participant 28: Disadvantage includes headaches and eye irritation during dissection due to prolonged exposure."	4 (5.63%)
Disadvantages	Chemical Exposure	Short-Term Effects: Symptomatic Effects: Respiratory Irritation	"Participant 48: Respiratory irritation, cancer risks, and long-term usability were highlighted."	5 (7.04%)
Disadvantages	Chemical Exposure	Short-Term Effects: Symptomatic Effects: Dizziness	"Participant 35: It causes irritation in the eyes and nose, allergic reactions, and symptoms like headaches and dizziness due to prolonged exposure."	1 (1.41%)
Disadvantages	Chemical Exposure	Short-Term Effects: Sensory Discomfort - Odor	"Participant 15: The odor from cadavers removed from the formaldehyde tank makes dissection difficult when no washing unit is available."	14 (19.72%)
Disadvantages	Chemical Exposure	Long-Term Effects: Carcinogenic	"Participant 5: Formaldehyde is carcinogenic, and we are unable to measure the current concentration levels in the tanks."	14 (19.72%)
Disadvantages	Chemical Exposure	Long-Term Effects: Toxic	"Participant 63: The toxic effects of formaldehyde are a significant disadvantage."	11 (15.49%)
Disadvantages	Chemical Exposure	Long-Term Effects: Teratogenic	"Participant 16: Its teratogenic and hepatotoxic effects are notable disadvantages."	1 (1.41%)
Disadvantages	Chemical Exposure	Health Risks	"Participant 70: The advantage is the long-term preservation capability."	19 (26.8%)
Disadvantages	Environmental Impacts		"Participant 51: It has harmful effects on both human health and the environment."	1 (1.41%)

This table presents the thematic analysis of participants' perceptions regarding the advantages and disadvantages of formaldehyde-based cadaver preservation. The advantages include ease of use (7.04-8.45%), long-term durability (45.07%), reliability and familiarity (5.64%), and economic feasibility (16.9%). The disadvantages primarily focus on usage difficulties (4.23-7.04%), chemical exposure risks (1.41-26.8%), and environmental concerns (1.41%). Short-term health effects include eye irritation (7.04%), headaches (5.63%), and respiratory discomfort (7.04%), while long-term risks involve carcinogenicity (19.72%), toxicity (15.49%), and teratogenic effects (1.41%). These findings highlight both the practicality and significant health risks associated with formaldehyde use in cadaver preservation.

resources, and the scarcity of body donation in Türkiye. Due to the limited number of donated bodies, the necessity of multi-year utilization requires that the choice of fixatives be evaluated in terms of toxicity, preservation duration, cost, and available infrastructure.

Use of Formaldehyde and Perceived Hazards

Formaldehyde remains the most commonly used agent for donor body fixation despite its well-documented adverse health effects.[15,16] Our findings confirm this trend: formaldehyde was reported to be in use in 92% of participating institutions.

However, the fact that 77% of respondents had not received formal chemical safety training and that 47.9% had ≤5 years of experience may limit the reliability of their safety and efficacy ratings regarding preservation methods. These ratings reflect perceptions rather than measured exposure, and given that many respondents lacked formal training and extensive hands-on experience, they should therefore be interpreted with caution. Although formaldehyde is classified as a Group 1 carcinogen by the World Health Organization,[17] its ability to ensure long-term preservation and its low cost[18] remain decisive factors for its continued use, particularly in the context of limited body donation in Türkiye.

Although 70% of respondents reported feeling adequately informed about chemical safety, 77% stated that they had not received formal training on the risks of formaldehyde. This reflects the historical absence of structured chemical safety content in anatomy curricula. Before 2017, Türkiye's core anatomy curriculum did not include mandatory modules addressing the hazards of formaldehyde, safety protocols, or alternative donor body fixation methods.[19] Although the 2017 revision partially addressed these gaps, many practitioners had completed their training before these standards were introduced. These issues should be interpreted as contextual background rather than direct conclusions from the survey data. Consequently, the gap between awareness and safe practice persists. To keep exposure within acceptable limits, regardless of the fixative used, consistent use of effective ventilation systems and PPE remains critical.[5,6]

It may not be entirely accurate to assume that alternative preservation methods are universally "safer," as each technique carries context-dependent advantages and limitations.[8] The Thiel solution, in addition to containing a low concentration of formaldehyde, includes other chemicals such as 4-chloro-3-methylphenol, propylene glycol, ammonium nitrate, and boric acid, whose combined toxicological profile has only been partially characterized in the literature.[8,20] Moreover, limitations regarding histological integrity (e.g., fiber fragmentation, nuclear loss, reduction in cellular size) and long-term preservation capacity have been reported; in Türkiye, the low rates of body donation and the requirement to reuse donor bodies for multiple years render these limitations particularly relevant in practice.[13,20] Phenol-based fixatives cannot be generalized as safer than formaldehyde, as exposure above threshold limits may result in hepatotoxic and nephrotoxic effects.[9,10,21] Fresh-frozen donor bodies reduce chemical exposure but are not suitable for continuous undergraduate teaching throughout the academic year, due to infection risks and limited tolerance to repeated freeze–thaw cycles.[12] Plastinated specimens, while valuable as durable and odour-free materials, require extensive preparation with toxic chemicals, are costly, and do not allow multi-plane dissection. Fat removal during plastination can also make tissues appear more model-like. Therefore, plastinates should be regarded as complementary teaching tools rather than replacements for donor bodies.[11]

Therefore, the adoption of alternative methods should be evaluated carefully in light of both their toxicological profiles and practical constraints. For anatomy laboratories in Türkiye, the primary priority should be to ensure, independent of the fixative employed, that exposure remains within acceptable levels as defined by OSHA and Turkish Ministry of Health standards, through effective ventilation systems and the consistent use of PPE.

Storage Protocols and Ventilation Infrastructure

Efforts to mitigate formaldehyde exposure should not be limited to fixation methods but must also include storage protocols and laboratory ventilation infrastructure. In our study, only 57.7% of respondents recognized that donated bodies could be stored using both immersion tanks and cold rooms, while 40.8% believed tank storage to be the sole viable option. This limited awareness is notable, as previous studies have demonstrated that cold-room storage can significantly reduce airborne formaldehyde concentrations.[22] Furthermore, the use of disinfectant-level rather than fixative-level concentrations in tank solutions has been shown to lower exposure, although this aspect was not directly assessed in our survey and thus represents a limitation.

Although ventilation systems were reported in 86.5% of institutions, more than half of the respondents considered them inadequate. The WHO indoor air guideline specifies 0.1 mg/m^3 (≈0.08 ppm, 30-min) to prevent mucosal irritation.[17] The European Union has set binding occupational exposure limits at 0.3 ppm (8-h TWA) and 0.6 ppm (STEL),[23] while Turkish Ministry of Health regulations reference 0.75 ppm (TWA) and 2 ppm (STEL).[6] Recent measurements from dissection halls report personal exposures averaging 0.44–0.68 ppm, with peak levels up to 2.11 ppm.[24] The literature further indicates that symptoms such as lacrimation, headaches, and respiratory discomfort are clinical markers that exposure has surpassed acceptable thresholds.[25] Although our survey did not systematically assess symptoms, open-ended responses frequently described such complaints, clearly indicating direct exposure among participants. Collectively, these findings reveal inconsistencies in the implementation of exposure limits within anatomy laboratories in Türkiye and underscore the need for comprehensive prevention strategies.

Personal Protective Equipment (PPE) and Student Safety

The importance of personal protective equipment (PPE) in reducing formaldehyde exposure has been extensively emphasized in the literature. Studies have shown that respirators with formaldehyde cartridges and chemical-resistant gloves reduce inhalational and dermal exposure, while fluid-resistant gowns and protective goggles minimize direct contact.[26,27]

Our findings indicate that PPE usage in anatomy laboratories remains insufficient. The situation is particularly concerning for students: 35.1% of institutions reported providing no PPE to learners. Provision rates for critical items were alarmingly low, with only 3% of institutions supplying respirators with formaldehyde filters and 4% supplying protective goggles. Such deficiencies represent not only a health risk but also a potential impediment to learning performance.[28,29]

The literature demonstrates that formaldehyde exposure can cause eye irritation, headaches, concentration difficulties, and impaired respiratory function, as well as increasing the long-term risk of cancer.[2,24,28,29] Therefore, insufficient student protection constitutes a serious concern from both health and educational perspectives.

Institutional support has been repeatedly identified as a critical determinant of PPE adherence.[30] Addressing current deficiencies requires interventions at both institutional policy and individual awareness levels. Building a sustainable culture of safety will necessitate robust procurement systems in tandem with continuous awareness and compliance training.

Moreover, only 23% of respondents reported having received institutional training on the health hazards of formaldehyde, highlighting a major gap in occupational health and safety education. The literature emphasizes that regular and structured training programs are among the most effective strategies for reducing exposure risks and improving safety practices.[16,30] Institutions should therefore implement mandatory, recurring training modules—including coverage of alternative donor-body preservation methods—and update occupational safety policies accordingly. Such measures may facilitate more consistent and sustainable adoption of protective practices.

Limitations

The findings of this study are limited to 71 participants from 37 institutions; therefore, generalizability is restricted. Moreover, the study relied only on survey data, without assessing environmental measurements of formaldehyde exposure, ventilation performance, or biological markers. In addition: (i) Participants reporting “0 hours” of donor bodies contact were not excluded; this should be considered when interpreting the data, (ii) Awareness/familiarity reports reflect self-reported perceptions and do not represent long-term experience, especially for Thiel, phenol-based, and fresh-frozen methods, (iii) As most participants lacked direct training or multi-year experience with alternative methods, the reliability of their evaluations is limited., (iv) The ratios of chemicals in tank solutions (fixative vs. disinfectant level) were not assessed; this may have influenced participants’ reported disadvantages.

Conclusion

This multi-center study revealed the continued reliance on formaldehyde in Turkish anatomy laboratories, the limited awareness of alternative preservation methods, and gaps in occupational health and safety practices. While many respondents reported self-reported awareness of formaldehyde’s health risks, this perception did not consistently translate into safer practices such as regular PPE use or improved ventilation. Formaldehyde remains the predominant fixative due to its perceived cost-effectiveness, preservation efficacy, and structural barriers to adopting alternatives.

The findings suggest that inadequate infrastructure, limited PPE provision, and deficiencies in institutional training may hinder the establishment of safer and more sustainable learning environments. Nevertheless, these conclusions are based on self-reported survey data and should therefore be interpreted with caution.

Promoting safer and more sustainable anatomical education requires a multipronged approach. Priorities include the integration of mandatory, evidence-based training programs, investment in laboratory modernization (particularly ventilation and cold storage), the assurance of minimum PPE standards for students, and the strengthening of national occupational health policies. Coordinated action at the faculty, institutional, and governmental levels is essential to reduce formaldehyde exposure and enhance the quality and safety of anatomy education. These study findings are expected to inform institutional and national strategies for safer anatomy education and contribute to the international discussion on balancing preservation efficacy with occupational health.

Ethics Committee Approval: The Medipol University Clinical Research Ethics Committee granted approval for this study (date: 22.05.2024, number: 514).

Informed Consent: Written informed consent was obtained.

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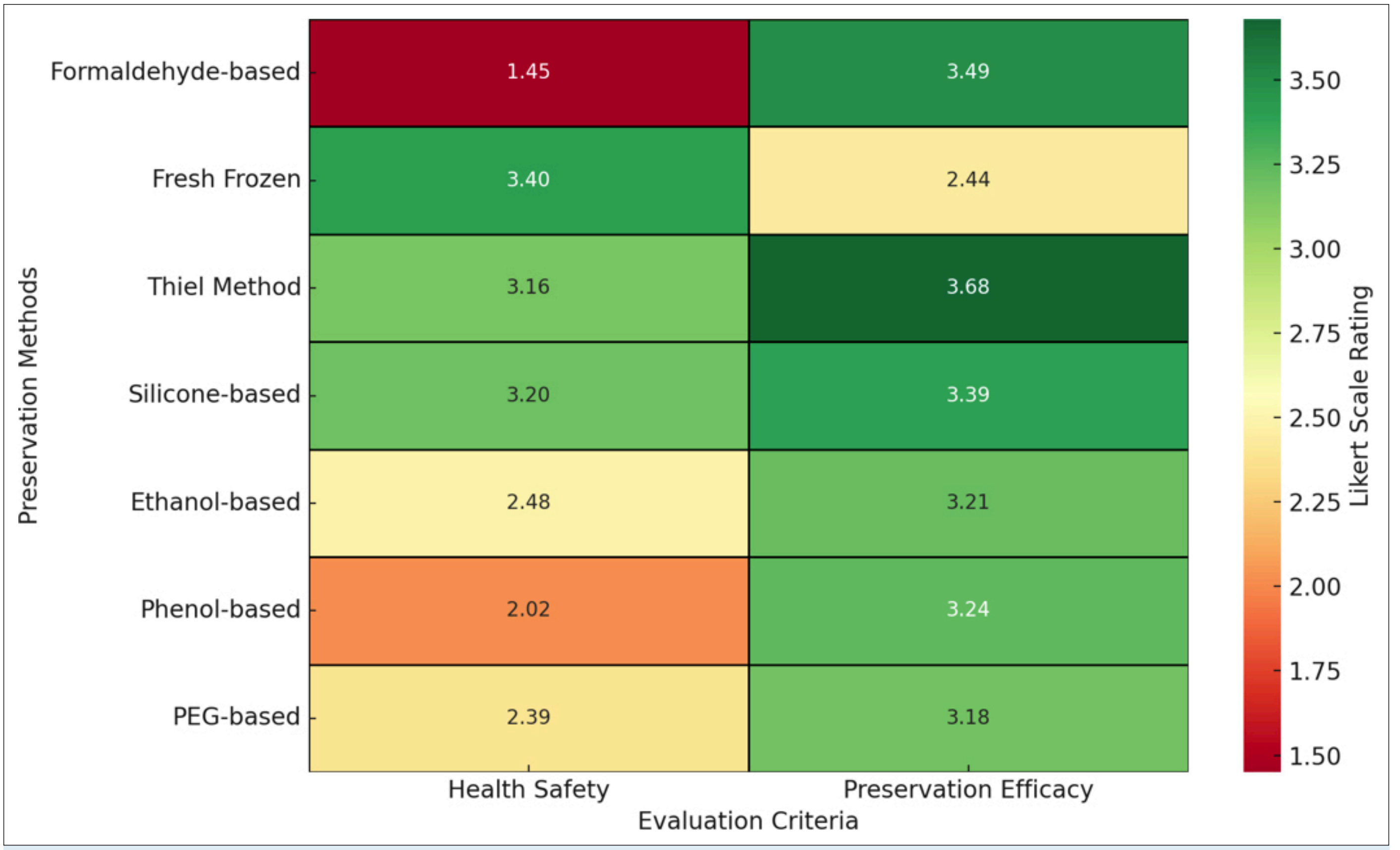
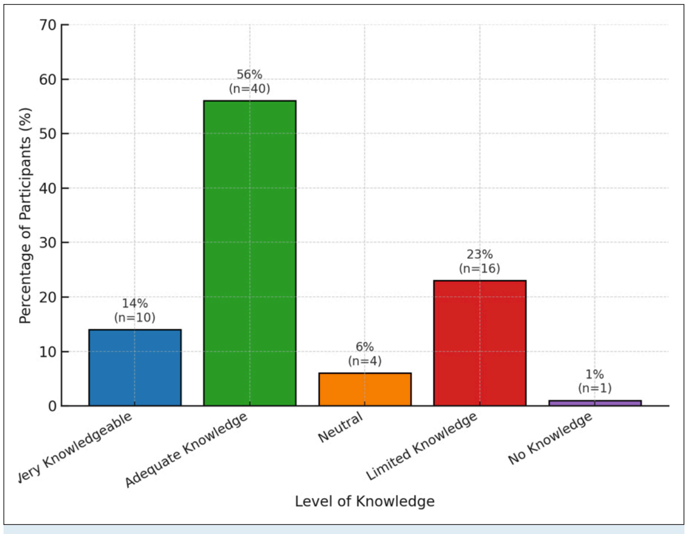
References

1. Mirabelli MC, Holt SM, Cope JM. Anatomy laboratory instruction and occupational exposure to formaldehyde. Occup Environ Med 2011;68(5):375-8. [CrossRef]
2. Adamović D, Čepić Z, Adamović S, Stošić M, Obrovski B, Morača S, et al. Occupational exposure to formaldehyde and cancer risk assessment in an anatomy laboratory. Int J Environ Res Public Health 2021;18(21):11198. [CrossRef]
3. Costa S, Carvalho S, Costa C, Coelho P, Silva S, Santos LS, et al. Increased levels of chromosomal aberrations and DNA damage in a group of workers exposed to formaldehyde. Mutagenesis 2015;30(4):463-73. [CrossRef]
4. Homwutthiwong K, Ongwandee M. Investigation of formaldehyde in gross anatomy laboratory: area-based and exposure levels, ventilation, health risk and clinical symptoms. App Envi Res 2017;39(3):77-90. [CrossRef]
5. Occupational Safety and Health Administration (OSHA). Formaldehyde standard, 29 CFR 1910.1048. Washington (DC): OSHA; 2019. Available at: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1048 Accessed Sep 17, 2025.
6. T.C. Sağlık Bakanlığı. Sağlık kuruluşlarında formaldehit ve diğer uçucu organik bileşiklerin ölçümü ve değerlendirilmesi genelgesi (2014/5). Ankara: T.C. Sağlık Bakanlığı; 2014. Available at: https://dosyamerkez.saglik.gov.tr/Eklenti/38699/0/formaldehit-ve-ksilen-olcum-standartlari-hakkinda-genelgepdf.pdf Accessed Sep 17, 2025.
7. Mrożek A, Sędzik M, Rubin J, Buras S, Tarkowski V, Domagała Z. Cadaver preserving methods-is it possible to do anything better? Med J Cell Bio 2022;10(4):124-8. [CrossRef]
8. Hammer N. Thirty years of Thiel embalming-A systematic review on its utility in medical research. Clin Anat 2022;35(7):987-97. [CrossRef]
9. United States Environmental Protection Agency (EPA). A method for determining the compatibility of hazardous wastes. Washington (DC): US EPA; 2016. Available at: https://www.epa.gov/sites/default/files/2016-03/documents/compat-haz-waste.pdf Accessed Sep 17, 2025.
10. UK Government. Phenol: properties, incident management and toxicology-toxicological overview. 2024. Available at: https://www.gov.uk/government/publications/phenol-properties-incident-management-and-toxicology/phenol-toxicological-overview Accessed Sep 17, 2025.
11. Riederer BM. Plastination and its importance in teaching anatomy. Critical points for long-term preservation of human tissue. J Anat 2014;224(3):309-15. [CrossRef]
12. Song YK, Jo DH. Current and potential use of fresh frozen cadaver in surgical training and anatomical education. Anat Sci Educ 2022;15(5):957-69. [CrossRef]
13. Gürses İA, Coşkun O, Öztürk A. Current status of cadaver sources in Turkey and a wake-up call for Turkish anatomists. Anat Sci Educ 2018;11(2):155-65. [CrossRef]
14. Braun V, Clarke V, Hayfield N, Terry G. Thematic analysis. In: Liamputtong P, editors. Handbook of Research Methods in Health

Social Sciences. Singapore: Springer; 2018. p. 1-18. [CrossRef]
15. Brenner E. Human body preservation - old and new techniques. J Anat 2014;224(3):316-44. [CrossRef]
16. Waschke J, Bergmann M, Bräuer L, Brenner E, Buchhorn A, Deutsch A, et al. Recommendations of the working group of the Anatomische Gesellschaft on reduction of formaldehyde exposure in anatomical curricula and institutes. Ann Anat 2019;221:179-85. [CrossRef]
17. Nielsen GD, Larsen ST, Wolkoff P. Re-evaluation of the WHO (2010) formaldehyde indoor air quality guideline for cancer risk assessment. Arch Toxicol 2017;91(1):35-61. [CrossRef]
18. Udhayakumar S, Anaqath AMS. Methods of cadaver preservation used in Sri Lankan medical faculties: merits and demerits. Jaffna Med J 2023;35(2):36-8. [CrossRef]
19. Tıpta Uzmanlık Kurulu (TUKMOS). Anatomi çekirdek müfredatı v.2.2 [Core Curriculum of Anatomy v.2.2]. 2017. Available at: https://tuk.saglik.gov.tr/TR-82498/mufredatlar.html Accessed Sep 17, 2025.
20. McDougall S, Soames R, Felts P. Thiel embalming: Quantifying histological changes in skeletal muscle and tendon and investigating the role of boric acid. Clin Anat 2020;33(5):696-704. [CrossRef]
21. Gupta S, Ashrith G, Chandra D, Gupta AK, Finkel KW, Guntupalli JS. Acute phenol poisoning: a life-threatening hazard of chronic pain relief. Clin Toxicol (Phila) 2008;46(3):250-3. [CrossRef]
22. Gahukar S, Ramteke U, Majumdar D, Malviya R, Patil D, Trivedi J, et al. Prevalence of formaldehyde in indoor air of gross anatomy laboratory and cadaver storage room of a medical college. J Environ Occup Sci 2014;3(4):181-5. [CrossRef]
23. European Parliament; Council of the European Union. Directive (EU) 2019/983 of 5 June 2019 amending Directive 2004/37/EC on the protection of workers from carcinogens or mutagens at work. Off J Eur Union 2019; L164:23-9. Available at: https://www.legislation.gov.uk/eudr/2019/983 Accessed Sep 17, 2025.
24. Aung WY, Sakamoto H, Sato A, Yi EE, Thein ZL, Nwe MS, et al. Indoor formaldehyde concentration, personal formaldehyde exposure and clinical symptoms during anatomy dissection sessions, university of medicine 1, Yangon. Int J Environ Res Public Health 2021;18(2):712. [CrossRef]
25. Vazquez-Ferreiro P, Carrera Hueso FJ, Alvarez Lopez B, Diaz-Rey M, Martinez-Casal X, Ramón Barrios MA. Evaluation of formaldehyde as an ocular irritant: a systematic review and Meta-analysis. Cutan Ocul Toxicol 2019;38(2):169-75. [CrossRef]
26. Bhat D, Chittoor H, Murugesh P, Basavanna PN, Doddaiah S. Estimation of occupational formaldehyde exposure in cadaver dissection laboratory and its implications. Anat Cell Biol 2019;52(4):419-25. [CrossRef]
27. Lucena JD de, Silveira HF da, Paula LS de, Ribeiro HL, Sobrinho OOP da C, Leal KMB, et al. The irritating effects of exposure to formaldehyde in user students of the human anatomy laboratory. Int Arch Med 2017;10(220):1-6. [CrossRef]
28. Tiruneh C. Acute adverse effects of formaldehyde treated cadaver on new ınnovative medical students and anatomy staff members in the dissection hall at Wollo University, Northeast Ethiopia. Adv Med Educ Pract 2021;12:41-7. [CrossRef]
29. Dhar DK. Effect of exposure to formalin on peripheral and smaller airways of 1st-year medical students. CHRISMED J Health Res 2020;7(1):8-11. [CrossRef]
30. Scheepers PTJ, Graumans MHF, Beckmann G, van Dael M, Anzion RBM, Melissen M, et al. Changes in Work Practices for Safe Use of Formaldehyde in a University-Based Anatomy Teaching and Research Facility. Int J Environ Res Public Health 2018;15(9):2049. [CrossRef]



Appendix 1.



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Appendix 3.