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Exploring the Health Outcomes of Formaldehyde Exposure During Cadavers Handling Among Medical University Students: A Cross-Sectional Survey

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Abstract

Background

Formaldehyde is widely used as an embalming agent for cadaver preservation in medical education. The exposure during dissection is associated with a range of adverse health effects. Despite established exposure limits, symptoms are frequently reported even at low concentrations, particularly among medical students. This study aimed to assess the prevalence of FA-related symptoms and evaluate their association with exposure among preclinical medical students.

Methods

An institutional based cross-sectional study was conducted among 153 first- and second-year medical students at a medical college from April to June 2025. Data were collected using a structured, pre-validated questionnaire assessing demographic characteristics, exposure duration, frequency of dissection sessions, and FA-related symptoms. A pilot environmental assessment of FA concentration was performed using passive diffusive samplers placed at breathing zone height. Descriptive statistics were calculated, and associations between exposure duration and symptoms were analyzed using the chi-square test. Spearman's correlation analysis was performed to evaluate the relationship between FA exposure and total symptom score. A p-value < 0.05 was considered statistically significant.

Results

Overall, 93.5% of participants experienced at least one symptom, with a mean symptom score of 7.29 ± 5.61. The most frequently reported symptoms were unpleasant smell (81.0%), nasal irritation/sneezing (60.1%), and ocular irritation. Significant associations were observed between increased duration of exposure and several symptoms, including nasal irritation ($p = 0.007$), sleep disturbance ($p = 0.034$), dizziness ($p = 0.007$), shortness of breath ($p < 0.001$), skin irritation ($p = 0.001$), and throat irritation ($p < 0.001$). However, no significant correlation was found between cumulative weekly exposure and overall symptom score ($p = 0.504$).

Conclusions

Formaldehyde exposure during cadaveric dissection is associated with a high frequency of irritative and nonspecific symptoms among medical students. These findings highlight the need for improved ventilation systems, consistent use of effective personal protective equipment, and implementation of safer preservation alternatives to reduce exposure risks in anatomy dissection hall.

1. Introduction

In medical education, the department of anatomy plays a crucial role in understanding morphology of human body. Cadaveric dissection is a vital method for learning human anatomy. Through hands-on dissection, medical students can develop a comprehensive and three-dimensional understanding by involving both visual and tactile senses (Aung et al., 2021). Formaldehyde (FA), a cost-effective and durable chemical, is utilized as an embalming agent for the preservation of cadavers in medical colleges and hospitals (Handady et al., 2024). FA is a flammable, colorless noxious gas which was discovered by English chemist August Wilhelm Von Hofmann in 1867 with the chemical formula CH2O (Tiruneh, 2021b). Despite its diverse utilization in medical field, its adverse effects are often overlooked. It is still the world's most widely used protocol for the fixation of cadavers (Waschke et al., 2019), although some alternating procedures have emerged such as Thiel's embalming method (Thiel, 1992), ethanol–glycerin embalming (Hammer et al., 2012) and nitrite pickling salt embalming. These solutions are usually infused through the femoral arteries or internal carotid arteries (Janczyk et al., 2011).

Exposure to FA causes wide range of health problems extends from allergic reactions to genetic damages. The most common acute adverse effects are headache, upper respiratory tract, skin, and irritation of eyes which are related to high concentration exposure. As a strong irritant, this chemical affects the mucous membrane of nose, throat and eyes. Several organizations have established permissible formaldehyde exposure limits. The National Institute for Occupational Safety and Health (NIOSH) recommends a short-term exposure limit (REL) of 1 ppm (1.2 mg/m³) over 30 minutes (*Current Intelligence Bulletin 34 – Formaldehyde: Evidence of Carcinogenicity (with Reference Package)*, 1981). The Occupational Safety and Health Administration (OSHA) advises a permissible exposure limit (PEL) of 2 ppm for a maximum of 15 minutes (Lee & Garg, 2023). In contrast, the World Health Organization (WHO) sets a much lower short-term exposure limit of 0.1 mg/m³ over 30 minutes (Wu & Yu, 2022). Importantly, even when measured FA concentrations comply with OSHA or NIOSH limits, students and faculty frequently report persistent symptoms including underreported ones like sleep and concentration difficulties. This discrepancy highlights current regulatory limits may not be sufficiently protective for sensitive populations or chronic intermittent exposure. Therefore, relying solely on compliance with formal standards is inadequate; practical exposure control measures, such as enhanced ventilation, fume extraction, and routine monitoring of low-level symptoms, are essential to safeguard student and staff health.

In Pakistan, limited research has systematically evaluated FA exposure among medical students, especially in settings with modern infrastructure. This study is one of the first to assess formaldehyde exposure in a Pakistani medical college, taking into account updated conditions including mechanical ventilation systems and the availability and use of personal protective equipment (PPE). By providing local data with global implications, this research addresses a critical gap in occupational health within medical education in low- and middle-income countries.

2. Objectives

a. To evaluate the association between formaldehyde-related exposure and the occurrence of relevant health symptoms among students
b. To determine the prevalence of health symptoms related to formaldehyde exposure among medical students

3. Material and Methods

3.1 Study Area and Design

The institutional-based quantitative cross-sectional survey was conducted on preclinical medical students in the dissection hall of Foundation University Medical College from April 2025 to June 2025. This air-conditioned dissection hall is located on the 1st floor with direct sunlight exposure, contains 2 windows with 5 fans with multiple containers containing preserved anatomical specimens immersed in dilute formaldehyde solution and no devices for monitoring indoor formaldehyde levels. To address this limitation, a pilot environmental measurement of formaldehyde concentrations was conducted during routine dissection sessions using passive diffusive samplers placed at breathing zone height at three locations within the hall, and levels were correlated with symptom prevalence.

3.2 Sample Size and Sampling Technique

The sample size of 170 was calculated by online software Raosoft with a 95% confidence level and 5% error of margin. Data were collected by using non-probability convenience sampling. Out of total sample, 4 participants did not give us consent & 13 of them did not meet the inclusion criterion. As a result, 153 students were included in this study.

3.3 Data Collection Procedures and Tool

Data were collected using a structured questionnaire previously developed by Tiruneh et al. in their study (12). Permission to use the questionnaire was obtained from the corresponding author prior to data collection. The questionnaire consists of 3 parts: First part acquired the consent of participants by ensuring the confidentiality of data. The second part consists of demographics such as age, gender and year of medical education. The final section contains questions related to the duration of exposure to formaldehyde, number of sessions of dissection hall, acute adverse symptoms of formaldehyde in the dissection hall such as watering & redness of eyes, running nose with a tingling sensation, irritation of the throat, cough, difficulty in breathing, tiredness/dizziness, skin problems (itching, sore skin on hands, burning sensation), lack of concentration, unpleasant smell, headache, disturbance of sleep, nausea, vomiting, abdominal pain, and reproductive disorder (menstrual disorder). Moreover, it also acquired detailed assessment of personal-protective equipment use including type of mask (N95 vs surgical), frequency of use (always/sometimes/rarely/never), and correct usage practices, which was then linked to symptom severity. Additionally, cumulative exposure index was calculated for each participant using the formula: (estimated formaldehyde concentration from pilot measurement × average hours per

session × sessions per week × total weeks of exposure), and this continuous variable was used in regression analysis to assess dose-response relationships.

3.4 Eligibility Criterion

Our study included those individuals who are enrolled in 1st and 2nd year of MBBS and gave consent to participate in the study and excluded those who are allergic to chemicals, smokers, having known past chronic respiratory diseases like asthma.

3.5 Data Analysis

The statistical analysis of 153 participants was done on IBM SPSS 26. Descriptive statistics, such as frequencies and percentages, along with variances and standard deviations has been reported and inferential statistical tests has been applied. The p-value less than 0.05 was considered statistically significant.

3.6 Ethical Consideration

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Foundation University Medical College (Ref No: FF/FUMC/215–630 Phy/25). All participants were informed about the procedures of the study, and written informed consent was obtained from each participant before the data collection. Participation was entirely voluntary, and participants were assured of their right to withdraw from the study at any stage without any consequences. Confidentiality and anonymity of the participants were strictly maintained throughout the study. All collected data were securely stored and used solely for research purposes. No identifying information was disclosed in any reports or publications resulting from this study.

4. Results

4.1 Baseline Characteristics

Table 1 describes the population characteristics: most of the 153 participants were aged between 18-22, and there were more than twice male respondents than females. Also, there were more 1st year students than 2nd year students. Most students had less than 1 hour exposure to formaldehyde per session. The number of dissections per week averaged around 2 hours, although this was highly right skewed due to non-normal distribution, non-parametric tests were applied with a subset of participants having disproportionately higher number of dissection sessions.

Table1: Descriptive Statistics of Study Variables (N=153)

Variable	Category/Statistic	N (%)	Mean ± SD/Range
Age	18–22years	150(98.0)	
	23–26years	3(2.0)	
Gender	Male	109(71.2)	
	Female	44(28.8)	
Year of Study	1styear	108(70.6)	
	2ndyear	45(29.4)	
Duration of Exposure per Session	<1hour	97(63.4)	
	1–2hours	53(34.6)	
	>2hours	3(2.0)	
Number of Dissections per week			1.99±1.13(0–6)
Symptom Score (Sum score)			7.29±5.61(0–37)

4.2 Symptoms and Association

A large majority of 143 (93.5) participants reported at least one symptom, and the mean symptom score was 7.29, although this variable was also right skewed. The most prevalent symptom found was unpleasant odour (n = 124), followed irritation/sneezing (n= 92). The least prevalent symptom was reproductive disorders. The differences in the symptoms scores between gender, and year of study were assessed using Mann Whitney's U test, and were found to be statistically insignificant. The frequencies of reported symptoms are shown in **Figure 1**.

Chi-square test was performed to assess the association between number of dissection hours and associated symptoms. Significant associations were observed for several symptoms, including nasal irritation, sleep disturbance, dizziness, shortness of breath, skin irritation, and throat irritation ($p < 0.05$), while others were not statistically significant See table 2. This shows that the duration of exposure is positively related to the severity of symptoms.

Table 2: Association between Duration of Exposure and Physical Symptoms (N =153)

Symptom	Category	<1h	1–2h	>2h	p-value
Eye redness / watering	Not experienced	51	26 11	1	0.366
	Mild	26	12	0	
	Moderate	15		1	
	Severe	5	4	1	
Reproductive disorder[a]	Not experienced	90	51	2	0.119
	Mild	7	2	1	
Nose irritation / sneezing	Not experienced	43	18	0	0.007
	Mild	37	21	2	
	Moderate	17	10	0	
	Severe	0	4	1	
Disturbance of sleeping	Not experienced	84	42	2	0.034
	Mild	9 2	7	0 0	
	Moderate		3		
	Severe	2	1	1	
Nausea or vomiting	Not experienced	69	34	1	0.060
	Mild	19	11	1 0	
	Moderate	8	5		
	Severe	1	3	1	
Dizziness / fatigue	Not experienced	76	35	1 1	0.007
	Mild	13	8 9	0	
	Moderate	6			
	Severe	2	1	1	
Difficulty breathing	Not experienced	70	35	1	0.184
	Mild	16	12	1 0	
	Moderate	8	4		
	Severe	3	2	1	

Cough	Not experienced	61	34	2	0.296
	Mild	28	13	0 0	
	Moderate	5	2		
	Severe	3	4	1	
Shortness of breath	Not experienced	80	44	2 0	<0.001
	Mild	14	6 3	0	
	Moderate	3			
	Severe	0	0	1	
Skin irritation (hands/face)	Not experienced	78	33	1	0.001
	Mild	12	12	1 0	
	Moderate	7	6		
	Severe	0	2	1	
Throat irritation / soreness	Not experienced	69	31	1	<0.001
	Mild	20	13	1 0	
	Moderate	8	8		
	Severe	0	1	1	
Unpleasant smell	Not experienced	18	10	1	0.082
	Mild	32 35	15 11	0	
	Moderate			1	
	Severe	12	17	1	
Headache	Not experienced	50	18	0	0.075
	Mild 1	28	20	2	
	Moderate Severe	12	12	0 1	
		7	3		

[a]Only applicable to females; moderate and severe categories were not reported.

Spearman's correlation test was performed between the non-normally distributed variables of number of dissection hours per week and the symptom score. No significant association was observed ($p = 0.504$). The scatterplot in **figure 2** corroborates these findings, no visible linearity suggests a non-association of dissection hours per week with the symptom score.

5. Discussion

This cross-sectional study explored the associated health outcomes with formaldehyde (FA) exposure among medical students during cadaveric dissection sessions. The results showed high prevalence of self-reported symptoms (93.5% reporting at least one symptom; mean symptom score 7.29). Symptoms like unpleasant odor, irritation, and sneezing were reported most frequently. These findings are consistent with previous studies conducted in similar educational set-ups, which have reported that exposure to FA, can cause mucosal irritation and discomfort among students and instructors (Elshaer & Mahmoud, 2017; *Formaldehyde Exposure of Medical Students and Instructors and Clinical Symptoms during Gross Anatomy Laboratory in Thammasat University - PubMed*, n.d.; Tiruneh, 2021a), even at concentrations at occupational limits.

The high frequency of odor detection and associated discomfort could be explained by the findings that the olfactory threshold for FA ranges from 0.05 to 1 ppm, which is typically lower than recommended occupational exposure limit (Organization, 2010). The absence of statistically significant differences in symptom scores between genders and year of study indicates similar levels of environmental exposure and comparable vulnerability among subgroups.

The Chi-square analysis revealed a significant association between the number of dissection hours and most individual symptoms, suggesting a dose–response relationship between FA exposure duration and symptom manifestation. Similar findings have been documented in other cross-sectional investigations among medical students and laboratory workers (*Acute Effects of Formalin on Pulmonary Functions in Gross Anatomy Laboratory - PubMed*, n.d.; Bhat et al., 2019). The Spearman's correlation was not significant ($p = 0.504$) between cumulative symptom score and total weekly dissection hours. This value can be explained by uneven distribution of exposure time, individual variability in sensitivity towards FA or a non-linear progression of symptoms, possibly influenced by adaptive tolerance or reporting bias that changes the observed relationship (Salthammer et al., 2010).

The exposure in academic settings was below thresholds associated with acute toxicity despite nonspecific and irritative symptoms being common, because severe systemic effects were rarely observed. However, these findings indicate that individuals can still encounter discomfort even if the exposure is within the recommended limits (*Environmental and Occupational Health Practice*, 2024). However, improving preventive strategies, for example, better ventilation, formaldehyde scavengers and substituting FA with less toxic alternatives could reduce exposure-related health effects (Zdilla, 2020).

The use of low rates of effective personal protective equipment (PPE) observed in this study also demands attention. Most students use disposable masks, which provide the least protection against gaseous FA as compared to other alternatives available. Similar patterns have been documented in previous investigations where simple masks failed to prevent exposure-related symptoms (Ozdemir, 2014). Studies have reported that use of masks with activated carbon filters or half-face respirators can significantly decrease inhaled FA concentrations, whereas local exhaust ventilation systems further reduce airborne levels in dissection halls (Kang et al., 2022; Sato et al., 2016).

6. Limitations

Some limitations should be considered. This cross-sectional design only reveals correlations between FA exposure and health outcomes, but not causality. Self-reported data may be affected by recall bias or heightened symptom awareness due to knowledge of FA's toxicity. Furthermore, symptom prevalence could be influenced by failure to continuously measure environmental FA concentrations and unmeasured factors such as seasonal allergies or exposure to other laboratory chemicals. Despite these limitations, this study adds to the increasing cumulative evidence that medical students are routinely exposed to FA concentrations capable of causing discomfort, emphasizing the need for continued monitoring and preventive measures.

Future research should include objective exposure assessments, for example, real-time FA monitoring, to examine better quality exposure-response relationship and long-term follow-up. Some studies of great importance would be interventional studies assessing the effectiveness of ventilation upgrades, PPE use and use of other non-toxic preservative agents.

7. Conclusion

In conclusion, FA exposure during cadaver handling in anatomy courses was associated with a greater frequency of reports of ocular, nasal, and nonspecific irritative symptoms among medical students. This study highlights the importance of improving safety practices, using PPE and enhancing laboratory ventilation systems to ensure student health during anatomy education.

Abbreviations

FA — Formaldehyde

PPE — Personal Protective Equipment

WHO — World Health Organization

NIOSH — National Institute for Occupational Safety and Health

OSHA — Occupational Safety and Health Administration

REL — Recommended Exposure Limit

PEL — Permissible Exposure Limit

SPSS — Statistical Package for the Social Sciences

LMICs — Low- and Middle-Income Countries

Declarations

Human Ethics and Approval: Ethical approval for this study was obtained from the Ethical Review Board of Foundation University Medical College (Ref: FF/FUMC/215-630 Phy/25).

All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee of Foundation University Medical College and with the 1964 Declaration of Helsinki and its later amendments.

Consent to Participate: Informed written consent was obtained from all individual participants included in the study.

Consent for publication: Consent for publication was taken from all authors.

Data Availability: None

Data Deposition: None

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Authors' Contribution Statement:

- SM came up with the concept and contributed to proposal writing, data collection, data analysis, writing manuscript, edited and reviewed the manuscript
- UM came up with the concept and contributed to writing, data collection
- TF contributed to data analysis and writing, formatting
- AR contributed to data collection
- AAT contributed to data collection
- NZ contributed to writing and formatting
- UA contributed to data collection and writing
- SW reviewed the manuscript
- SI contributed to editing and formatting
- MTR contributed to formatting

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Figures

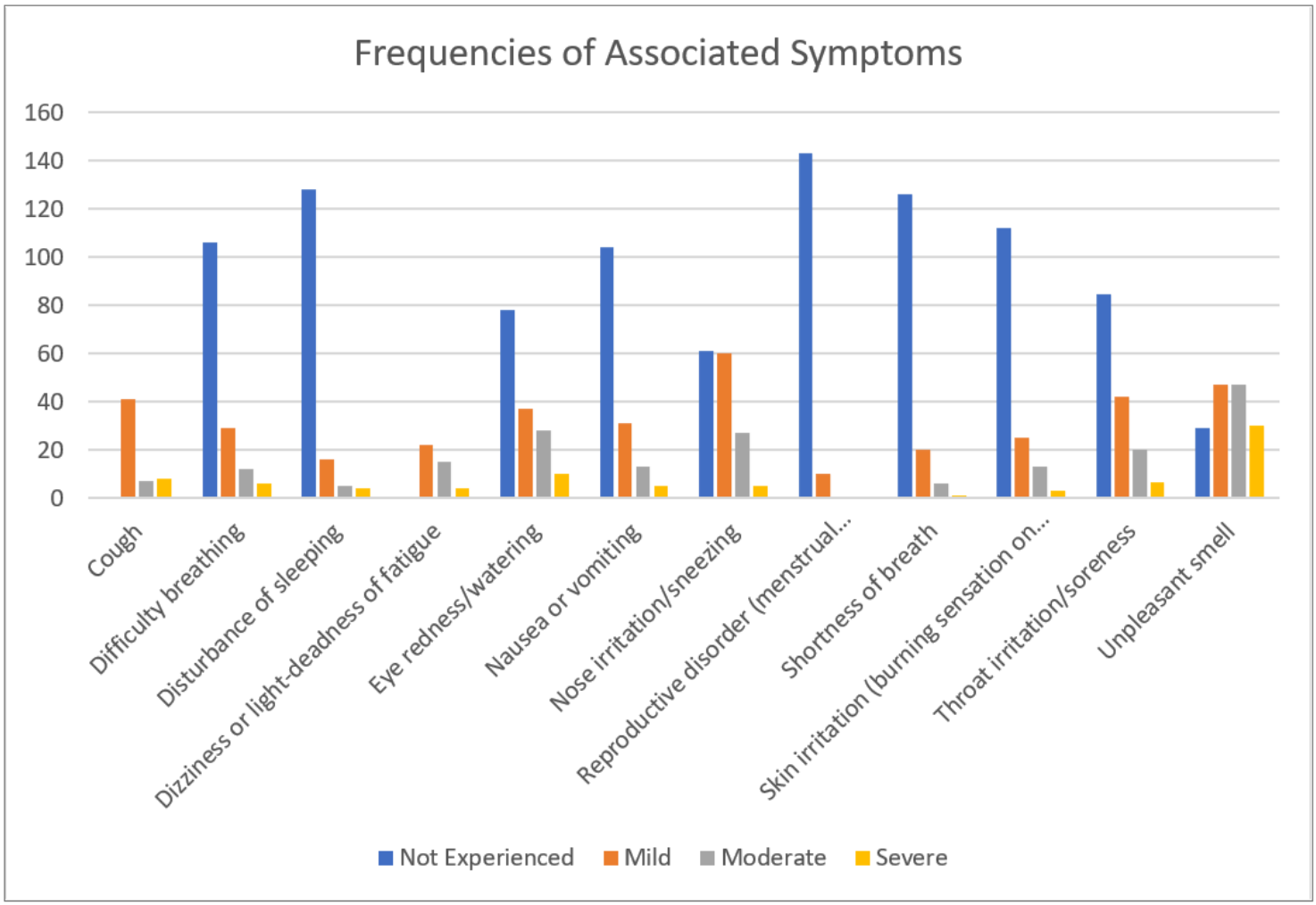


Figure 1

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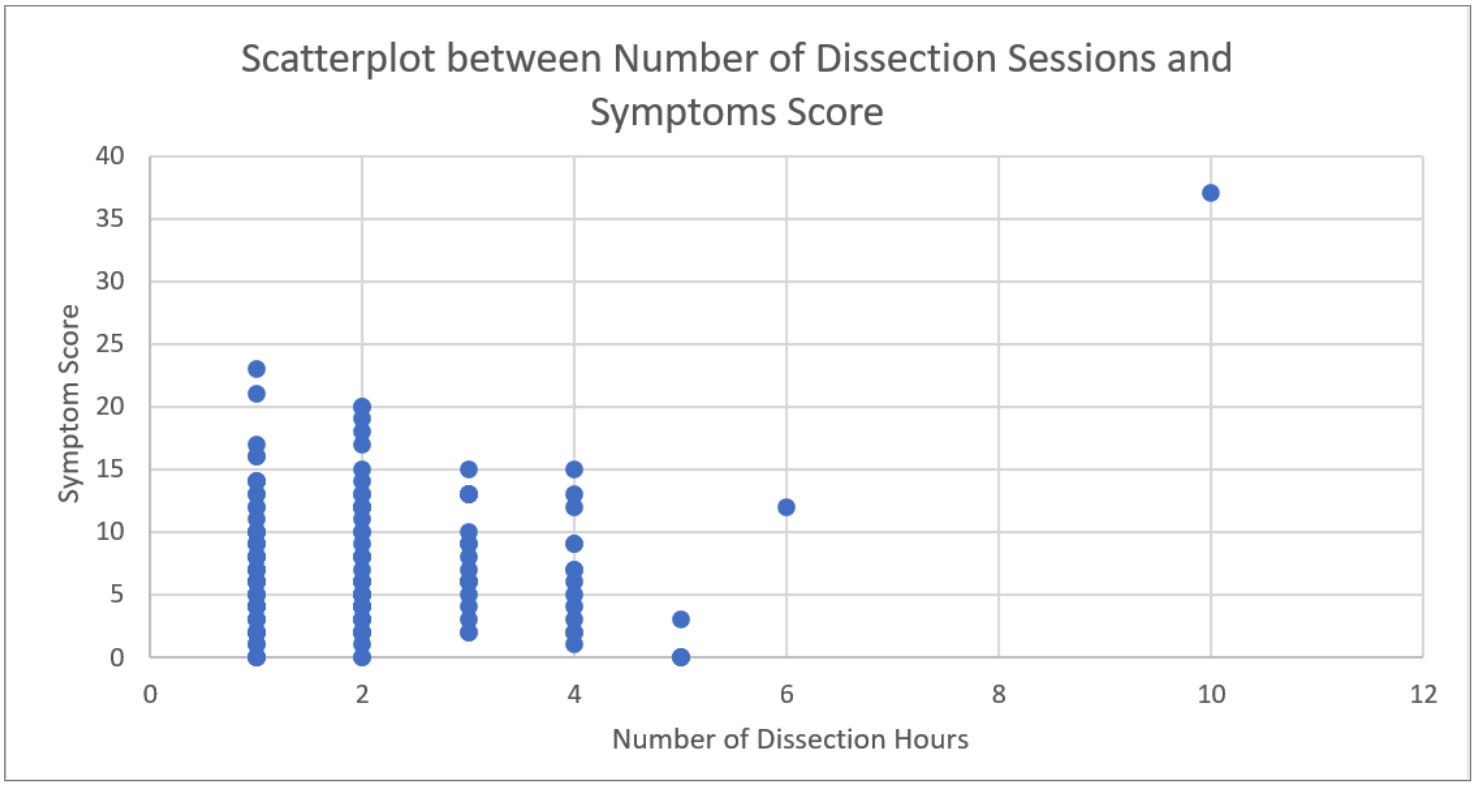


Figure 2

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