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Assessment of Preclinical Students' Knowledge on Formalin as an Occupational Hazard and Precautions Taken to Prevent its Toxicity

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Abstract

Introduction: Formaldehyde is a colorless, flammable gas that is extremely soluble in water and its aqueous solution is called formalin. One of the ways in which occupational exposure of formaldehyde occurs is through formaldehyde emission from aqueous solutions such as embalming fluids. The evaporation of formaldehyde from cadavers in gross anatomy laboratories can produce high exposures to medical students and this exposure can adversely affect their health. Therefore, this study will seek to assess the level of knowledge that preclinical medical students have on formalin and the precaution taken to prevent its toxicity.

Methods: The study was carried out on 145 3rd year medical students at Copper belt university school of medicine. A questionnaire was used to assess the students and the data was analyzed with SPSS software version 21.

Results: 63.9% had poor knowledge on formalin and its effects while 34% had average knowledge and 2.1% were knowledgeable. 75.2% of the students took average precautions while only 2.8% where very cautious.

Conclusion: The majority of the respondents had poor knowledge on formalin and its effects. Furthermore a majority of the respondents took average precautions while handling the cadavers in the dissection room.

Keywords: Preclinical students; Toxicity; Flammable gas; Oxidation of alcohol; Pneumonia; Symptoms

Introduction

Background information

Cadavers are defined as a dead human body used in scientific or medical research. (New Oxford dictionary of English, 1999). Dissection in human anatomy is the opening up of a cadaver in a view to expose their organs and take note of the locations, shapes, sizes thickness, consistency and distribution [1]. In order to preserve these cadavers, formalin is infused in femoral or internal carotid arteries. This prevents denaturation of the cadavers by solidification of tissue proteins, disinfection and maintenance of the integrity of the anatomic relations.

Formaldehyde is a simple aldehyde with a molecular formula CH2O produced by the oxidation of alcohol. At room temperature, it is a colorless, flammable, strong smelling gas. (IARC) Formaldehyde is present as a dissolved gas in water-based solution called formalin. Formalin contains 37% by weight or 40% by volume of formaldehyde gas in water. It is the chemical formalin that is commonly used for embalming [2]. Embalming of a cadaver is done by infusing of chemical substances which include formalin (which contains formaldehyde), alcohol, glycerin, carbonic acid and dye. These substances have specific functions and infusion is usually via the femoral or internal carotid arteries [3].

When exposed to living human beings, formaldehyde is metabolized in the body to form formic acid (formate) which is non-toxic. Formic acid is excreted in the urine or converted to carbon dioxide and excreted via the lungs. Even though it can be metabolized by the body, it can be carcinogenic [4] harmful to some organs such as the liver, pancreas, kidney and brain (Koppel et al, 1990) or cause allergies to handlers [5].

Medical students, staff and technicians are regularly exposed to formaldehyde in gross anatomy dissection by different routes which may include inhalation (Bernstein et al, 1984), skin contact [6] or accidently by splashes to the eye and ingestion (gastro-intestinal tract).

The effects of inhalation of formaldehyde become more as the concentration increases. Symptoms that have been observed from acute exposure include throat, eye, and nose and skin irritation. It may also cause neurophysiologic symptoms such as irritation of the upper respiratory tract which can trigger asthma symptoms and other respiratory symptoms. Chronic exposure can lead to pneumonia and bronchitis. When formaldehyde is swallowed it can lead to sudden death. Formaldehyde has also been thought to be a potential carcinogen [7]. Even though formaldehyde remains a popular choice of tissue fixation, it has toxic effects on users. Therefore, it is high time to switch to a better and much safer preservative [8].

Formaldehyde causes degenerative, inflammatory and hyperplastic changes in the mucosa of the target organ. In the body, it is converted to format by enzymes in erythrocytes. Formalin targets the amine functional groups in proteins and nucleic acids thereby denaturing them and causing cell death. Formalin also affects the RBCs and platelet count by making them significantly lower in individuals exposed to it compared to the unexposed. Furthermore, the MCV, MCH and MCHC was reported to be higher in formalin exposed individuals [9].

Most of the effects of formaldehyde toxicity due to high exposure can be avoided by the use of protective equipment and improving laboratory ventilation conditions. According to a study done by [10] students who did not wear protective equipment such as medical masks

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were adversely affected by the exposure to formaldehyde and exhibited some clinical symptoms such as respiratory distress. Pre-clinical students handle these cadavers mostly and so this study will seek to know how much knowledge that pre-clinical students at Copper belt University School of Medicine have on use of fixatives such as formalin in embalming and the effects of high exposure and the precautions taken while in the cadaver room.

Statement of the problem

Studies have shown that formaldehyde can be toxic, allergic and carcinogenic. Furthermore, ingestion of formaldehyde can result in a sudden death. Its evaporation from formalin treated cadavers may lead to high exposure to handlers. Exposure occurs primarily via inhalation or skin absorption of formaldehyde containing fluids [11]. Medical students are among the people at risk of the effects of formaldehyde exposure. Studies have shown that evaporation of formaldehyde from formalin treated cadavers can produce high exposures. The toxicity gets worse as there is a tendency of the exposed individuals to develop tolerance within a few hours of exposure. Therefore, these individuals remain in a raised formaldehyde concentrated environment without been aware of the increased exposure levels and consequent hazards [12-16]. Studies have been done on the effects of formaldehyde toxicity on medical students however no studies have been done on the knowledge medical students have on its toxicity and any precautions they should take to reduce its exposure. Therefore, this study will seek to find out that.

Justification

Formaldehyde can be toxic, allergic and carcinogenic. Medical students are among the people at risk of the effects of formaldehyde exposure. This may be because of poor ventilation in dissecting rooms, poor working practices that may lead to spillage of formaldehyde, leakage of the formaldehyde due to poor conditions of the cadavers, lack of strict guidelines for handling embalmed cadavers and specimens and ignorance of consequences of formalin exposure [17-22]. In order to minimize adverse effects students should be provided with safety instructions to raise awareness of health hazards during gross anatomy sessions.

In Zambia little or no studies have been done on knowledge medical students have on the effects of high exposure to embalming chemicals such as formaldehyde and the precautions they take while in the cadaver room. With the information obtained from this study, policies can be made to reduce exposure and toxicity of formaldehyde. These may include; handlers may be given protective clothing to reduce the exposure to formalin. Furthermore, medical schools can venture into the use of simulators during gross anatomy practical.

Literature review

According to [23-28] the disadvantages of cadaver use include there be a risk to health due to the prolonged exposure to formalin and contact to cadavers. With the new age of technology some people believe that computers can actually replace human body dissection. The reasons were: there may be reduction in the risks of infections that may arise due to exposure to dead bodies and there will be no smell of formalin.

A study done by Lakchayapakorn et al. about formaldehyde exposure of medical students and instructors and the clinical symptoms showed that 82.7-82.8% had experienced general fatigue due to high concentrations of formaldehyde. Other symptoms included burning eyes (66.2-85%) and burning nose (62.5-81%). He further stated that even if concentrations of formaldehyde were low, medical students, instructors and cadaver related workers should wear personal protective devices to reduce the effect of gaseous formaldehyde exposure during gross anatomy laboratory [29-32].

In a sample size of 150 first year MBBS students from Bundelk hand medical college, a study was done on the effects of formalin on these students. The results showed that 67% students had reported irritation and watering of eyes, 17.33% complained of irritation in the throat, 20.67% experienced tingling sensation in the nose, 12% reported skin problems, 16.67% experienced a lack of concentration and 14.67% complained of headaches.

A longitudinal study conducted by Mulu and Tegabu among second year students on attitude surveyed at 3 time points (1 week before the dissection, a week after the initiation of dissection and 8 weeks after the second survey) revealed that some students felt that the dissection was stressful and the smell of the cadaver and eye irritation were major contributors to the stress [33-35].

A questionnaire-based study on the effects of formaldehyde exposure to students in gross anatomy dissection laboratory revealed that out of the 75 students 77% were affected by the unpleasant smell of formaldehyde. Other symptoms were "runny or congested nose" and redness of the eyes. The lease ranked effect was skin related diseases. The author further suggested that formaldehyde was not a suitable chemical for embalmment due to its health effects to the students [35].

A cross sectional study was done by Noha and Madiha on the toxic effects of formalin-treated cadaver on medical students, staff members and workers in the Alexandria faculty of medicine. The study investigated first, second and third years (454 students) on their first exposure to formalin or within the first 14 days of exposure at the dissection room. Stuff members were also asked to participate as unexposed group (16 were formalin exposed and 19 were unexposed). The results reported that most medical students complained of symptoms of acute exposure to formalin- treated cadavers such as unpleasant smell (91.2%), sore nose (74.2%), running or congested nose (69.5), unusual thirst (53.9), itching eyes (81.3), redness in the eyes (72.4), excessive lacrimation (76.1), disturbance in sight (58.6%) and headache (53.6%) from the formalin exposed staff members (44% males and 56% females), more than 50% had been employed for more than ten years. They reported symptoms of skin disorders such as burning 68.8%, drying 75.5%, cracking 56.25%, scaling 50%, erythema 56.25%, edema 31.25%, eczema 68.85% and allergic contact dermatitis 87.5%. However, these symptoms were not encountered by the unexposed group. Furthermore, formalin exposed females reported menstrual disorders and anemia 33.3% and 44.4% compared to 0.00% and 6.25% of unexposed females respectively. 44.4% formalin exposed female staff reported a history of spontaneous abortion and 22.2% gave birth to a baby with congenital anomalies compared to 12.5% and 6.25% of unexposed female staff respectively. It was also reported that the mean RBCs count, mean platelet count and Ht% was significantly lower among formalin exposed staff compared with those not exposed.

Objectives

General objective

To find out the knowledge that preclinical students at Copper Belt University have on the effects of formaldehyde as an embalming chemical

Specific objectives

- To find out if the preclinical students take safety precautions whilst in the cadaver room
- To assess whether preclinical students are taught or oriented about cadavers' embalming fluids before they begin dissecting
- To assess preclinical students' knowledge on the short- and long-term effects of formaldehyde.

Research questions

1. Do students who are oriented take more precautions while handling cadavers compared to those who were not oriented
2. Does gender have a role to play in the precautions taken in the cadaver room? Are the female students more cautious than the male students
3. Does an increase in age make the student more cautious?
4. Does been knowledgeable about the short and long term effects of formalin toxicity make the students take better precautions when handling the cadavers compared to the less knowledgeable

Measurement

This research had five variables of which some were independent while the some were dependent. The variables were orientation, knowledge, precautions, age and gender.

Orientation in this study is defined as familiarization of the cadaver room.it also includes a discussion on formalin, its effects (both short and long term) and precautions to taken to reduce toxicity. Orientation was an independent variable.

Knowledge of the acute and chronic effects of formalin toxicity was a dependent variable. It was defined as facts and information that could have been acquired through experience or skill. It was measured as follows; those who scored 0-10 were considered to have poor knowledge, 11-16 had average knowledge and finally 17-21 were considered to be knowledgeable. Knowledge of the short and long effects of formalin toxicity was dependent on orientation before beginning cadaver dissections.

Precautions were defined as a measure taken in advance to prevent the effects of formalin toxicity. It was a dependent variable which could be affected by knowledge, age, gender and orientation. Total precautions were scored as follows; 0-5 did not take proper precautions (i.e. poor) while 5-7 took average precautions. Lastly those who scored 8-10 were considered to be cautious.

Gender which is the state of been male or female was an independent variable.

Age of the respondents was an independent variable which was divided into the following ranges; 20-25, 26-30 and > 30 years. (Figure 1)

Methodology

Background on study area

The Copperbelt University is located in the Copperbelt province of Zambia. It is situated in riverside in Kitwe. It constitutes of 7 schools of which the school of medicine is included. The school of medicine is located in Ndola and has 4 programs which include MBChB, dental surgery, biomedical science and clinical medicine. The total number of registered undergraduate students at the school of medicine is 1,037. The students are divided into preclinical and clinical students. The preclinical students are 581 and they are further divided in 2nd years (327) and 3rd years (254).

Target population

Third year preclinical students as they were the only class performing cadaver dissections at the time of data collection

Study design

This study utilized cross-sectional type of study design and will be conducted for a period of 5 months

Sample size

The following formula was used in comparison to epi.info software to determine the sample size.

$$sample\ size = \frac{n}{1 + \frac{n}{population}}$$

$$n = z^2 \frac{P(1-P)}{e^2}$$

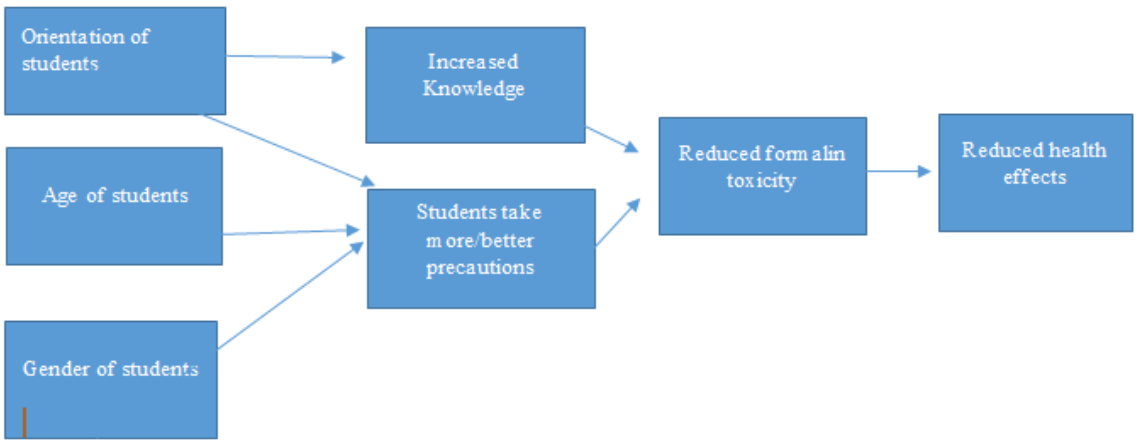

Figure 1: Flowchart of factors that lead to reduced formalin toxicity and reduced health effects.

Information needed for determination of sample size included

Approximation of sample size	
Level of confidence measure (Z)	1.96 (at 95% confidence level)
Margin error (e2)	5%
Prevalence	50% (as no estimates exist)

The sample population of 254 was used to determine the sample size using the stat calc programme of Epi info version 7.0 with the expected frequency being 50% confidence level being 95% or 1.96 and 5% margin of error, a sample of 154 students was calculated (which was the number of students assessed).

Sampling procedure

Systematic random sampling was used in this study as it reduced biasness.

Inclusion criteria

The study will involve collection of data from third years that consent to participate

Exclusion criteria

Clinical students and biomedical students as they do not perform cadaver dissections. Second years as were not performing cadaver dissection at the time of data collection. Third year students who refuse to consent will be excluded from this study.

Data collection

The data was collected by the principle investigator through questionnaires administered to the participants upon receipt of a formal consent. The principal investigator was available while the respondents were answering the questionnaires and this was to explain any questions the respondents did not understand. The questionnaires were in English as all the participants understood English well.

Data analysis

The data was analyzed using SPSS version 21.

Ethical consideration

Results obtained from this study were strictly confidential and only relevant authorities had access to this information. It should also be noted that there was no direct link to participants as the principle of confidentiality was observed. The participants took part in this study voluntarily and before they took part an informed consent was taken. With this autonomy was respected.

Limitations

This study was limited to third preclinical medical students at the Copper belt University School of Medicine, Ndola

Results

Demographics

The total number of students that were accessed was 154 however 9 students didn't return the questionnaires hence making the total number of students assessed 145. All the students assessed were third year students at the Copperbelt university school of medicine. The students were a mixture of MBChB, Bachelor of dental surgery and clinical medicine programs. Out of the students assessed, 66.2% were male while 33.8% were female. The majority of the student ages ranged from 20-25(90.3%) while the rest were 26- 30(7.6%) and > 30(2.1%). Table 1

Safety precautions in the cadaver room

75.2% of the students took average precautions in the dissection room while only 2.8% were very cautious as shown by the bar chart (Figure 2).

On further analysis, as shown in Table 2 below, 97.9% of the participants agreed to have taken general precautions in the dissection room. Some of the precautions taken where wearing laboratory coats (94.5%) gloves (99.3%) face masks (25.5%) washing hands after handling cadavers (89%). Furthermore 86.9% agreed to opening windows during dissections and 33.8% agreed to opening only the part to be dissected during dissections. The least percentages where participants who wore face goggles (0.7%), aprons (2.1%) during dissections and periodically removed fluid dripping in the body trays (7.6%) (Table 2).

Orientation of respondents

The bar chart in figure 3 shows the frequency and percentage of respondents responding to the whether they were oriented or not before beginning cadaver dissections. 33.1% agreed to have been oriented before they started cadaver dissections while 69.9% responded that they were not oriented (Figure 3).

Knowledge of formalin and its effects

The bar chart in figure 4 shows the frequency and percentage on how respondents scored on the knowledge of formalin and it effects (acute and chronic). 63.4% had poor knowledge while 34.5% of the respondents had average knowledge. Those who were knowledge were only 2.1% (Figure 4) (Table 3).

From the table above 82.1% know the chemical used in embalming/ fixation, 40.7% had knowledge of the short and long term effects of formalin. 84.8% knew unpleasant smell as an effect of formalin while 72.4% reported to know itching eyes as an effect. The other effects were which the respondents knew were headaches (39.3%), asthma trigger (16.6%) potential carcinogen (15.2) decreased red cell count (12.4) and lastly sudden death if swallowed (10.3%) (Table 4).

From the table above, cross tabulation of precautions and different variables showed different p values. Cross tabulation with gender gave a p value of 0.350, knowledge 0.792, orientation, 0.041 and age 0.356.

		Frequency	Percentage
Gender	male	96	66.2
	female	49	33.8
Age	20-25	131	90.3
	26-30	11	7.6
	>30	3	2.1

Table 1: Gender and Age distribution of the respondents.

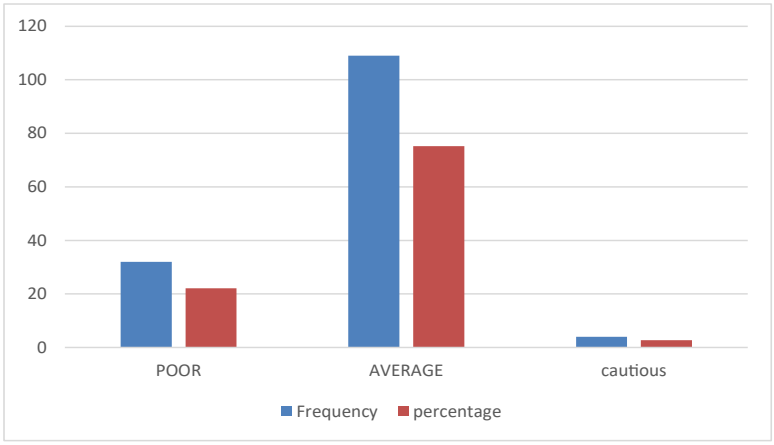

Figure 2: Frequency and percentage of the total precautions taken to reduce formalin toxicity.

	Frequency out of 145	Percentage
Participants who took precautions in the cadaver room	142	97.9
Participants who wore gloves when handling cadavers	144	99.3
Participants who wore face masks when handling cadavers	37	25.5
Participants who wore aprons when handling cadavers	3	2.1
Participants who wore laboratory coats when handling cadavers	137	94.5
Participants who wore face goggles when handling cadavers	1	0.7
Participants who washed their hands after handling cadavers	129	89
Participants who opened windows/doors during dissections	126	86.9
Participants who opened only the part to be dissected	49	33.8
Participants who periodically removed the fluid dripping in the body trays	11	7.6

Table 2: Distribution of specific precautions respondents took.

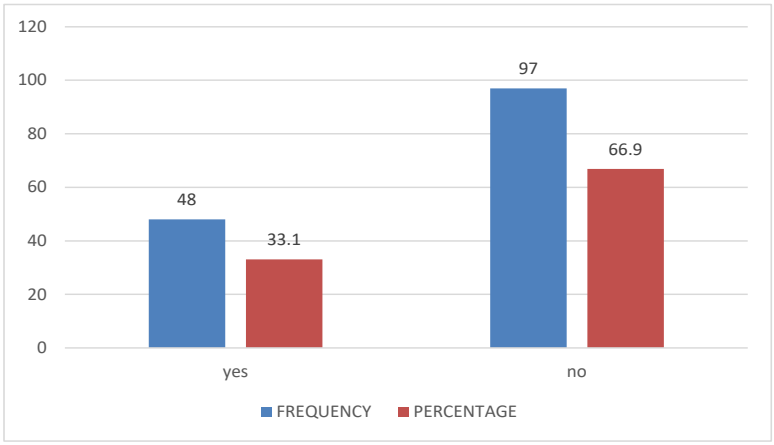

Figure 3: Orientation of students before cadaver dissections.

	Frequency	Percentage
Knowledge of chemical used in embalming/fixation	119	82.1
Knowledge of the short and long term effects of formalin	59	40.7
Unpleasant smell as an effect of formalin	123	84.8
Itching eyes	105	72.4
Headaches	57	39.3
Asthma trigger	24	16.6
Potential carcinogen	22	15.2
Decreased red cell count	18	12.4
Sudden death if swallowed	15	10.3

Table 3: Distribution of specific effects that the respondents knew.

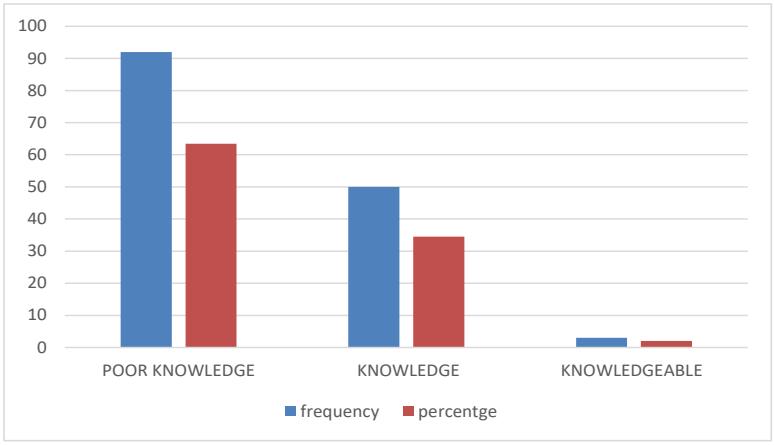

Figure 4: Knowledge on long term and short term effects of formalin.

Table 4: Cross tabulation of dependent independent variables and their p values.

Cross tabulations							
			Precautions			N	P values
			Poor	Average	Cautious		
Gender	Male	Count	21	71	4	96	0.35
		Percentage	21.88	73.96	4.17		
	Female	Count	11	38	0	49	
		Percentage	22.45	77.55	0		
Total		Count	32	109	4	145	
		Percentage	22.07	75.17	2.76		
Knowledge	Poor	Count	19	70	3	92	0.792
		Percentage	20.65	76.09	9.78		
	Average	Count	13	36	1	50	
		Percentage	26	72	2		
	Knowledgeable	Count	0	3	0	3	
		Percentage	0	100	0		
Orientation	Yes	Count	6	42	0	48	0.041
		Percentage	12.5	87.5	0		
	No	Count	26	67	4	97	
		Percentage	26.8	69.07	4.12		
Age	20-25	Count	28	100	3	131	0.356
		Percentage	21.37	76.34	2.29		
	26-30	Count	4	6	1	11	
		Percentage	36.37	54.55	1		
	>30	Count	0	3	0	3	
		Percentage	0	100	0		

Discussion

According to Abdullahi et al. there are many ways in which the exposure to formaldehyde can be reduced in the anatomy lab, however, the most cost effective step in minimizing formalin exposure involves a discussion with medical students before starting dissections with the aim of achieving a balance attitude towards the health hazard of formaldehyde in the anatomy lab. Furthermore Abdullahi et al. found that the lack of discussion with the students contributed to the undue exposure to formaldehyde as evidence by 95% of his respondents having no knowledge of health hazards and precautions against formaldehyde. In this study, 63.9% had poor knowledge on formalin and its effects. However, even though they had poor knowledge, they performed average precautions in the anatomy labs. Most of the respondents knew the chemical used and the common side effects that were known were unpleasant smell (84.8%) and itching eyes (72.4%). 10.3% did not know that ingestion of formaldehyde would lead to a sudden death. The p value of the chi square test was found to be

0.72 showing that knowledge and precautions were independent of each other. It was further found that 76.09% who had poor knowledge and those who were knowledgeable (3%) took average precautions. This meant that having knowledge on formalin, the short and long term effects of formalin did not make the respondent take proper precautions.

On the other hand, it was found that only 33.1% were oriented before starting cadaver dissections and it was proven that orientation and precautions taken in the dissection room are not independent of each other (p value of 0.041). Furthermore 87.5% of the oriented

respondents took average precautions compared to 69.07% who were not. This means that orientation of the students before beginning cadaver dissections would make them more cautious and therefore reducing the exposure and effects of formalin.

During their medical practice, medical students are exposed to formaldehyde via the specimens they dissect. (Neginhal et al,) Formaldehyde which is present in formalin has toxic effects which can affect the health of medical students. To prevent such effects, proper precautions should be taken to prevent toxicity (Patil et al,). In this study, 75.2% scored average on the precautions they took in the dissection room. 99.3% reported wearing gloves and 94.5% reported to have worn laboratory coats during the dissections in comparison with students from Alexandria faculty of medicine where 73.1% wore gloves and 78.1 wore laboratory coats (Elshaer and Mahmoud). This is also in agreement with Nigerian medical students were 78% wore gloves and 86% wore laboratory coats to reduce toxic effects of formalin(Dixit et al,) On the other hand 0.7% of the students in the current study reported wearing eye goggles in contrast to 9.7% by the Alexandria medical students and 67% by the Nigerian medical students. According to a study done by (Fahima et al,) students who did not wear protective equipment were adversely affected by the exposure to formaldehyde and exhibited some clinical symptoms. According Balmes, factors like work environments that facilitate formalin spillage, leaking of embalming fluid due to poor condition of the cadavers, high concentration of formaldehyde in the air, poor ventilation in the dissection room, lack of strict guideline when handling embalmed cadavers and ignorance of consequences of formalin exposure all lead to an excessive increase in formaldehyde vapor in the dissection room. This study showed 86.9% of the respondents opened the windows during dissections while 7.6% periodically removed the embalming fluid that was dripping and collected in the body trays. This means that there was an increased exposure to formalin due to failure to remove the formalin that was dripping and collected in the body trays.

It was found gender and precautions are independent of each other; however a slightly higher percentage of the female students (77.55%) took average precautions compared to the males (73.96%). Age had no relationship with the precautions taken by the respondents in the cadaver room. However 76.34% students who took average precautions were aged between 20 and 25.

Conclusion

Most students had poor knowledge on formalin and its effects and furthermore most were not oriented on formalin before they begun cadaver dissections. The consequences of this were manifested by the failure to take proper precautions in the cadaver room. This lead to exposure to formalin and experience of formalin induced health effects. Therefore it should be advised that the preclinical students are oriented before they start dissections. They should also be advised to take proper precautions always such as wearing gloves, face masks, goggles etc. All this lead to reduced exposure to formalin and reduced health effects.

Acknowledgement

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Recommendations

- Personal protective clothing must always be provided and worn by preclinical medical students to reduce exposure to formalin
- Orienting the students on cadaver dissection, formalin and its toxicity is one of the cost effective methods to reduce formalin toxicity and there should always be done before students start dissections.
- This study should be repeated in one or two other medical schools so that a proper conclusion can be made and policies such as replacement of cadavers with simulators. Use of simulators does not utilize formalin and therefore its health effects will not be experienced.

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