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Evaluating the knowledge base and current training of paramedics in the southwest United States in assessing and managing toxic alcohol exposures

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Research

Evaluating the knowledge base and current training of paramedics in the southwest United States in assessing and managing toxic alcohol exposures

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Abstract

Introduction
Toxic alcohol overdose poses a problem in patients who are suffering from the toxicological consequences of toxic alcohol exposure and front line emergency care providers, such as paramedics, need to be well versed in assessing patients, identifying specific toxicities, and implementing appropriate therapies.

Objectives
The aim of this research was to identify the current knowledge base of paramedics to recognise key clinical, pathophysiological and treatment features of toxic alcohol poisoning. Additionally, the emphasis in training and education of paramedics in terms of the level of importance assigned to toxic alcohol emergencies was evaluated.

Methods
The study was conducted as an anonymous online survey. Demographic data, timed choice and open-ended questions were collected to evaluate knowledge and identify gaps in toxic alcohol poisoning training by paramedics. The survey link was sent out to emergency medical services (EMS) organisations and individual paramedics in the southwest United States. Bivariate analysis via Pearson correlation coefficient (PCC) was used to compare variables.

Results
Eighty paramedics participated in the survey, with 60 (75%) participants completing all questions. Respondents were able to identify common sources of toxic alcohol exposure to varying degrees with 58% for methanol and 89% for ethylene glycol. Data indicated that a lack of knowledge of the underlying pathophysiology was related to missing education (PCC <0.05) in toxicology. Education appears to have been insufficient in regards to recognising and treating toxic alcohol exposure. A majority of respondents (68.6%) believed that assessment and treatment of toxic alcohol poisoning is an important component of their training.

Conclusion
Although symptom recognition for toxic alcohol poisoning is present in most EMS providers, pharmacological intervention and treatment approaches were often not known. The results indicate that there is a need for educators and curriculum builders to include additional coverage of topics of toxicological importance such as the anion gap and toxic alcohol assessment, pathophysiology and treatment.

Keywords:
Toxic alcohols, paramedics, education, anion gap

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Introduction

Toxic alcohols are examples of hydroxylated hydrocarbons associated with specific toxicological consequences. The three major toxic alcohols are isopropyl alcohol, ethylene glycol and methanol (1).

According to 2012 data involving poison control centre reports in the United States (US) there was a total of 16,458 cases of isopropanol ingestion and 8773 cases of actual toxicity with over 60 reports of complications including one death (2). Many of these cases were the result of ingesting common household products such as rubbing alcohol, hand sanitisers and various cleaning agents (3). Reports of methanol and ethylene glycol exposure were considerably less but not trivial in terms of mortality. According to the same data set there were 5869 cases of ethylene glycol ingestion and 1612 cases of methanol ingestion (3). In spite of these lower exposure numbers, there were expressively higher rates of mortality in methanol and ethylene glycol exposed patients. Of the methanol patients, there were over 200 patients that experienced severe complications and six fatalities (3). Of the ethylene glycol patients, over 200 patients experienced complications requiring extended hospitalisation with 23 deaths. Clearly, toxic alcohol overdoses pose a problem in patients who are suffering from the toxicological consequences of toxic alcohol exposure, and front line emergency care providers such as paramedics need to be well versed in assessing patients, identifying specific toxicities and implementing appropriate therapies.

Sixteen percent of all paramedics in the US work in emergency rooms where they provide initial assessment and management of patients who are admitted with poisoning emergencies in addition to their pivotal role in the pre-hospital setting (4). Because paramedics are often in situations where they encounter patients that are experiencing toxicological emergencies, they are required to assess, identify and properly manage victims of toxic alcohol emergencies.

A review of the current US National Emergency Medical Services Educational Standards, Paramedic Instructional Guidelines found that the term 'alcohols' was present among a list of other specific agents of toxicological significance such as cyanide and carbon monoxide (5). A list of specific antidotal agents such as methylene blue and cyanide antidotes are also presented in this document but fomepizole and ethanol were not included in this list. Because the national educational guidelines appear to be vague regarding the amount of attention that should be focused on toxic alcohol exposure, it is reasonable to suspect that the amount of time spent discussing specific toxicological issues in paramedic educational programs may vary significantly. However, while cyanide poisonings and antidotes are specifically mentioned in this document, only about 202 cases of cyanide exposure were reported to poison control centres in 2012 (3). While some predict that cyanide toxicity may contribute to the morbidity and mortality of perhaps up to 10,000 deaths following smoke inhalation (6), there were still more reported cases of methanol, ethylene glycol and isopropyl alcohol exposures in 2012 making them at least as common as cyanide exposure even when accounting for smoke inhalation.

The aim of this study was to use an anonymous survey that would help determine the knowledge base of paramedics with a focus on the ability to identify key clinical, pathophysiological and treatment features of toxic alcohol poisoning. Additionally, the survey attempted to assess the current training of paramedics in terms of the level of importance assigned to toxic alcohol emergencies and how much initial and recurrent training paramedics feel they received on toxic alcohols. Finally, this study aimed to identify how much time was spent covering toxicology in general among paramedics educated in the US.

Methods

The study protocol was developed and approved by the Institutional Review Board at the University of Florida (IRB 2014-U-1393). This study employed an anonymous online survey using the Qualtrics software program and server available to university faculty and students. The data collection included demographics, timed multiple choice questions and brief text answers of a targeted convenience sample readily available to the investigators. The survey link was sent out to various emergency medical service (EMS) organisations and individual paramedics for further distribution. Bivariate logistic regression analysis and Pearson correlation coefficient (PCC) were used to relate quiz questions with demographic and training variables. Differences were considered significant if $p \leq 0.05$.

Inclusion criteria: To be included in the study, participants had to be at least 18 years of age and also an active paramedic in the US, which had to be acknowledged at the beginning of the survey. Due to the anonymity of the survey, a small risk exists that a person under the age of 18 participated. Additionally, there was a small risk that non-paramedic credentialed providers could take the survey.
Exclusion criteria: Participants were excluded from the survey if they did not meet the inclusion criteria.

Survey sections and variables
Demographic variables: The initial assessment tool of the study gathered demographic information from each participant. This information included: gender, age range, number of years employed as a paramedic and highest level of education.

Toxic alcohol assessment and management variables: Following the demographic assessment, participants were asked 10 questions about the assessment and management of toxic alcohol overdose. The questions focused on identifying key features of toxic alcohol overdose, key pathophysiological processes and pharmacological treatment modalities for three significant toxic alcohols; methanol, isopropyl alcohol and ethylene glycol. Participants were given 30 seconds to answer each question. The time limit was designed to prevent participants from looking answers up as opposed to truthfully answering the question using innate knowledge. The quiz questions are listed in Table 1 with their respective answer choices (Table 1).

Post assessment and training variables: The final section of the survey contained questions that attempted to ascertain what the participant thought about the importance of incorporating toxic alcohol education into initial and recurrent paramedic education and how much time the participant spent on toxic alcohols and general toxicology during initial and recurrent training.

Results

The total response to the online survey was relatively low, with 80 responses even after multiple reminders were sent to various EMS providers and individuals in the field. Of these 80, three-quarters (n=60) completed the full survey, with participants mainly dropping out during the timed multiple-choice responses that evaluated their actual knowledge about toxic alcohols. The demographics (Table 2) indicate a mainly male population response (90% male), which is fairly representative of the overall EMS field in the US. The main age range for this population was 31–45 years (62.9% of all respondents) with equal tails to the younger and older age ranges. A majority of respondents (65.7%) had worked in the EMS field between 6–20 years (Table 2), which indicates experienced professionals likely to have been involved with toxic alcohol exposures in their careers and practical settings.

No respondent answered all 10 quiz questions correctly. Only one respondent was able to identify nine correct answers while a majority of respondents (54%) answered between 4–6 questions correctly. The distribution of incorrect responses was not specific to a toxic alcohol.

One main question of this survey was to seek an association between prior education and knowledge of specific toxic alcohol symptoms and treatments. About half (55%) of respondents had either a non-college degree or an Associate degree in the field of EMS (Figure 1). A comparison of percentage correct responses to education showed that overall there were no significant differences in response rates. However, one question that indicated significant differences was question 2 ('Which of the following findings would you expect to find among patients with significant toxic alcohol overdose?') with lower correct response rates from participants with either an Associate degree or Master degree (Figure 1). This may indicate that there is inconsistent knowledge in initial diagnosis of toxic alcohol exposure. This was further confirmed by the association between percentage correct response rates and training in anion gap, and how it relates to clinical symptoms (Figure 2). Interestingly, the differences here between groups indicates a wide variability in knowledge even if the anion gap was discussed. For question 3 ('Which of the following products would be most likely to contain methanol?') a higher correct response rate was observed by those who did not learn about the anion gap as for those who learned about it or do not remember. The opposite was the case for correct responses to question 8 ('What is the pathophysiological basis of methanol toxicity?'), which also asked about methanol toxicity. For this question a majority of correct responses came from participants who learned about the anion gap during their training compared to those who did not or could not remember (Figure 2). All other correlations between age, length of working in the field and prior exposure to toxicology did not indicate significant differences with the timed multiple choice toxic alcohol questions.

About two-thirds of respondents (68.6%) either agreed or strongly agreed that knowledge of toxic alcohol symptoms and treatment approaches was important knowledge to them (Table 3). All bivariate analysis responses associating quiz questions with demographic variables and corresponding significance levels are listed in Table 4.

Discussion

Toxic alcohol exposure has a significant impact on the healthcare system and the individual patient. As first responders, EMS providers and paramedics are in a position to diagnose and treat initial symptoms when confronted with them. The results of this small sample size survey indicate that there is a need for further education on toxic alcohol exposures that can translate into life-saving measures and potentially reduce the burden on the healthcare system by decreasing morbidity and mortality in the general population. Knowledge of toxic alcohol symptoms, pathophysiology, and treatment approaches by EMS providers appears to be variable and inconsistently taught during formal and recertification training.

Although small in scale, the results of this survey may serve the larger EMS community, especially educational providers and educators at colleges and universities, to dedicate more hours to toxic alcohol training. Initial symptom recognition may provide pre-hospital treatment approaches that prevent progression of organ damage.

Table 1. Online timed multiple-choice questions to evaluate current knowledge of toxic alcohol exposure by survey participants

Question #	Question	Answer choices (correct answer is in bold)
1	Which of the following electrocardiogram (ECG) findings would be concerning with a severe ethylene glycol overdose?	**Hypocalcaemia with prolonged QT interval**
		Hyperkalaemia with the development of atrial dysrhythmias
		Hypernatremia with significant AV blocks
		Hypomagnesemia with the development of atrial fibrillation and flutter
2	Which of the following findings would you expect to find among patients with significant toxic alcohol overdose?	**Elevated anion gap metabolic acidosis**
		Hyperchloraemic metabolic acidosis
		Partially compensated respiratory alkalosis
		Uncompensated respiratory alkalosis
3	Which of the following products would be most likely to contain methanol?	**Adulterated home brewed ethanol containing spirits**
		Brake fluids
		Household insect killing sprays
		Household plant fertilisers
4	Which of the following products would be most likely to contain ethylene glycol?	**Radiator fluid**
		Brake fluid
		Household insect killing sprays
		Household toilet bowl cleaners
5	Which of the following findings is unique in the setting of isopropyl alcohol overdose?	**Ketosis without the presence of acidosis on the arterial blood gas**
		Ketoacidosis with partial compensation on the arterial blood gas
		Marked uremic syndrome with alkalosis on the arterial blood gas
		Marked leukocytosis with a left shift and uncompensated respiratory acidosis on the arterial blood gas
6	Which complaint would be most suggestive of methanol toxicity?	**Visual changes**
		Flank pain
		Generalised myalgia
		Peripheral neuropathy
7	What is the pathophysiological basis of ethylene glycol toxicity?	**Oxalic acid formation and nephrotoxicity**
		Acetone formation and ketosis
		Acetaldehyde formation and inebriation
		Formic acid formation and optic nerve toxicity
8	What is the pathophysiological basis of methanol toxicity?	**Formic acid formation and optic nerve toxicity**
		Acetone formation and ketosis
		Oxalic acid formation and nephrotoxicity
		Acetaldehyde formation and inebriation
9	What is the 'front line' pharmacological therapy for treating methanol and ethylene glycol toxicity?	**Fomepizole**
		Hypertonic saline solution
		Lipid emulsion therapy
		Metronidazole
10	If supportive care and front line pharmacological therapies fail to treat a severe toxic alcohol overdose, which of the following is considered definitive treatment?	**Haemodialysis**
		Activated charcoal lavage
		Potassium therapy
		Sodium bicarbonate therapy

Table 2. Demographic data of survey participants

Question	Frequency	Percent
How long have you worked in the EMS field?		
0-5 years	8	11.4
6-12 years	24	34.3
13-20 years	22	31.4
21-25 years	11	15.7
26 or more years	5	7.1
What is your age in years?		
18-21	1	1.4
22-30	13	18.6
31-36	23	32.9
37-45	21	30
46-55	10	14.3
56-65	2	2.9
What is your gender?		
Female	7	10
Male	63	90

Especially low correct response rates were observed for question 9 ('What is the "front line" pharmacological therapy for treating methanol and ethylene glycol toxicity?') which is troublesome given the significant exposures to methanol and ethylene glycol toxicity – a combined 7481 cases which is close to the roughly 10,000 cases reported for smoke inhalation exposures in 2012. An even more significant finding of the survey is that two-thirds of respondents agree that further education and training on toxic alcohol exposure should be part of either their initial or recertification training (Table 3). These findings clearly indicate that there is a need for education that can directly translate into clinical practice and better health outcomes.

Limitations

One obvious limitation of the findings is the small sample size. This limits interpretation of the results to the larger EMS community. This targeted convenience sample may not have been heterogeneous enough to reach the larger EMS community because recruitment was limited to personal contacts and reliance on 'word of mouth'. Another limitation was the relatively brief time period for collection of data due to time restrictions imposed by the institutional review board. The attrition rate over the course of the survey was highest in the section evaluating paramedics' knowledge of toxic alcohols pointing to a potential skewed sample representing the best informed paramedics. The survey focused on cognitive rather than applied skills and may therefore not account for treatment approaches learnt in the field other than current best practice guidelines tested in the knowledge section. Further limitations are a lack of stratification by location (urban versus rural) or employment (private versus public). This survey also does not account for alcohol as a co-ingestant with other toxicants such as opioids or stimulants, which is commonly occurring and may change the course of treatment.

Conclusion

These survey results provide a base for further discussion on the educational needs and current knowledge on toxic alcohol exposures by EMS providers and paramedics. Although the study sample size was small, the findings clearly indicate that providing further education in this area will improve provider knowledge, diagnosis and early treatment intervention that is linked to better health outcomes for patients. Further research is required to extend the findings of this study to the larger EMS community – be it on the national or international level. We hope that our findings will stimulate further discussion and research to improve best practices on integrating knowledge on toxic alcohol symptoms, diagnosis and treatment, and consideration by educational providers and institutions to revise their curriculum for initial EMS training and recertification alike.

Conflict of interest
The authors declare they have no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

Table 3. Survey questions related to toxic alcohol training evaluated after completion of the timed multiple-choice questions

Question	Frequency	Percent
How much time did you spent discussing toxic alcohol poisoning during your paramedic training?		
0 hours	9	12.9
Less than one hour but more than 0 hours	23	32.9
1-3 hours	18	25.7
4-8 hours	3	4.3
Do not remember	7	10
Not answered	10	14.3
How much time did you spent discussing toxicology in general during your paramedic training?		
0 hours	1	1.4
Less than one hour but more than 0 hours	4	5.7
1-3 hours	29	41.4
4-8 hours	17	24.3
9-16 hours	8	11.4
17-24 hours	1	1.4
Not answered	10	14.3
Did you discuss toxic alcohol poisoning as part of your recurrent or refresher training for relicensure?		
Yes	6	8.6
No	53	75.7
Do not remember	1	1.4
Not answered	10	14.3
Do you believe that understanding how to assess and treat toxic alcohol poisoning is an important part of being a paramedic?		
Strongly agree	18	25.7
Agree	30	42.9
Slightly agree	10	14.3
Disagree	1	1.4
Strongly disagree	1	1.4
Not answered	10	14.3

Table 4. Principle component comparison and bivariate analysis (binned by correct vs. incorrect responses) for each quiz question. Bivariate analysis by education, work experience, and age for N=70 responses. Bivariate analysis by training and toxic alcohol refresher for N=60 responses

Quiz-question	Education	Work experience	Age	N correct response (%)	Toxic alcohol training	General toxicology training	Anion gap training	Toxic alcohol refresher	N correct response (%)
1	0.81	0.87	0.78	26 (37)	0.84	0.39	0.17	0.30	23 (38)
2	0.05*	0.13	0.30	29 (41)	0.23	0.41	0.80	0.19	26 (43)
3	0.34	0.22	0.13	35 (50)	0.84	0.45	0.01*	0.39	34 (57)
4	0.18	0.06	0.41	56 (80)	0.93	0.48	0.12	0.05*	53 (88)
5	0.71	0.60	0.87	15 (21)	0.24	0.52	0.53	0.20	15 (25)
6	0.23	0.83	0.69	34 (49)	0.84	0.20	0.98	0.28	34 (57)
7	0.10	0.06	0.67	18 (26)	0.60	0.70	0.28	0.10	18 (30)
8	0.26	0.46	0.06	23 (33)	0.99	0.65	0.05*	0.11	23 (38)
9	0.09	0.29	0.87	10 (14)	0.67	0.07	0.15	0.48	10 (17)
10	0.25	0.86	0.55	46 (66)	0.73	0.63	0.55	0.69	46 (77)

* = associations that reached statistical significance

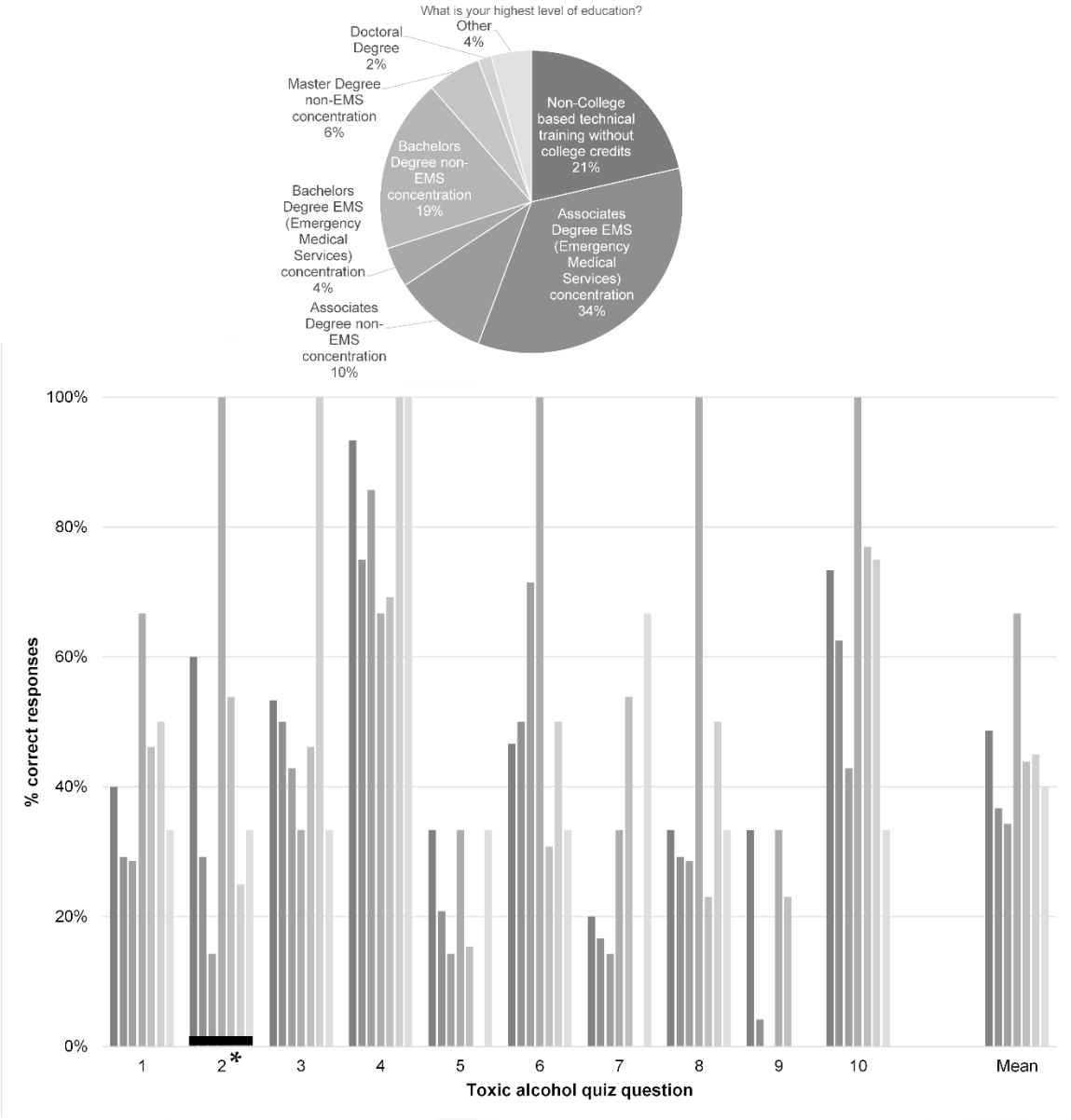

Figure 1. Distribution of survey participants by education (pie chart insert). Percent correct responses to each timed multiple-choice question by education (bar chart)

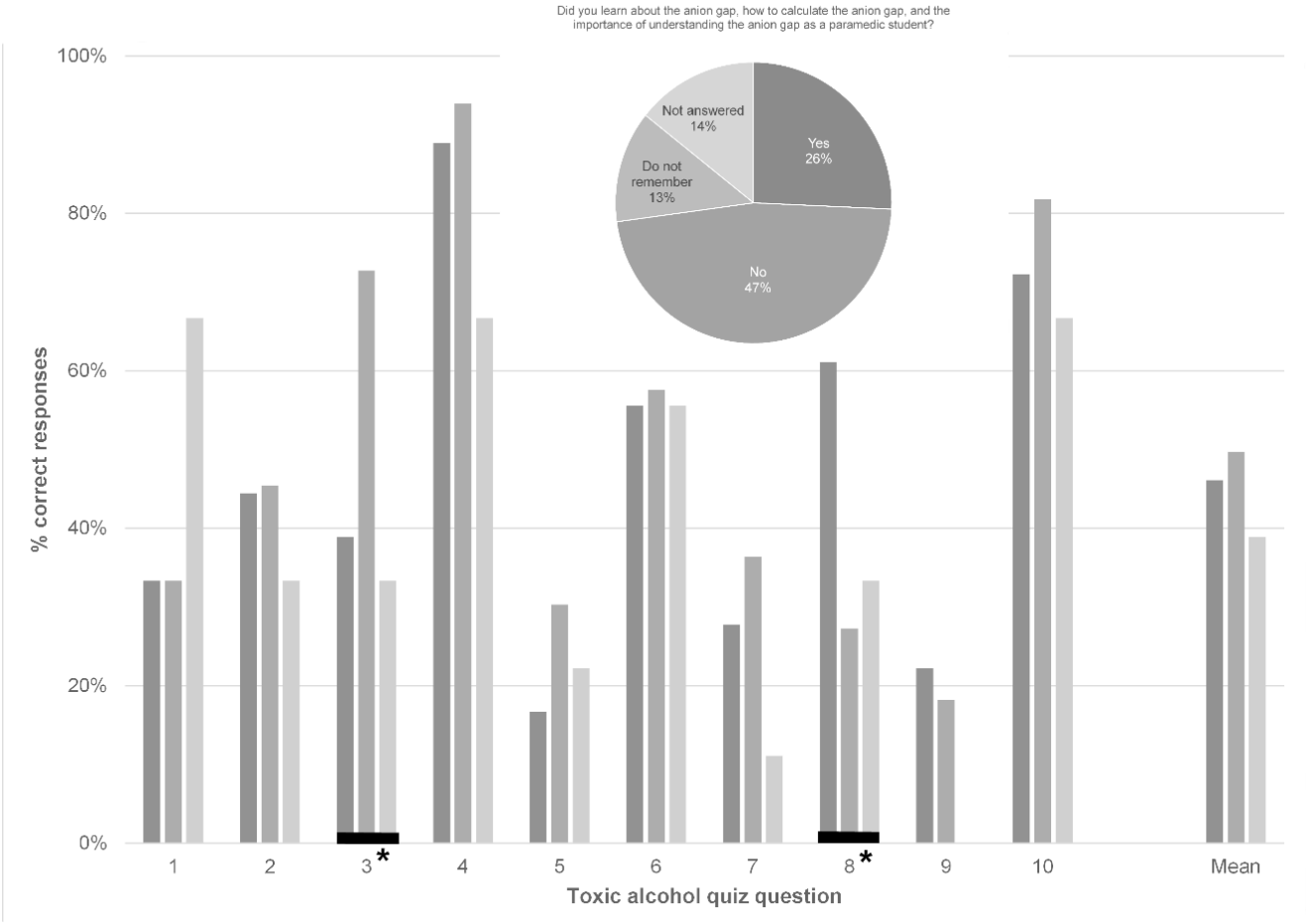

Figure 2. Distribution of survey participants by training and knowledge regarding the anion gap (pie chart insert). Percent correct responses to each timed multiple-choice question by training or knowledge about the anion gap (bar chart)

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