

ORIGINAL RESEARCH

Dental Students' Perceptions Regarding Bioterrorism; a Cross-Sectional Study

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Received: March 2023; Accepted: April 2023; Published online: 22 May 2023

Abstract: **Introduction:** During the COVID-19 outbreak, dental professionals have demonstrated their importance in combating mass casualty incidents. This study aimed to understand dental students' perceptions of their potential roles in a bioterrorism attack. **Methods:** This cross-sectional study used a self-administered anonymous questionnaire, which was sent to all dental students and interns at King Abdulaziz University, Saudi Arabia. Bivariate and multiple linear regression analyses were conducted to assess dental students' willingness to provide care during a bioterrorism attack, knowledge regarding bioterrorism and total number of roles a dentist should play during an attack. **Results:** This study included 472 dental students and interns. The mean knowledge score regarding bioterrorism was 3.3 ± 1.9 out of 5. A large majority of the respondents (83.8%) were willing to provide care during a bioterrorism attack. Students with a cumulative grade point average (GPA) of 4.5–5 were more likely to indicate that a dental professional should take on more roles during a bioterrorism attack than those with a GPA of 2.5–2.99. Fourth- and fifth-year dental students had lower knowledge scores regarding bioterrorism than dental interns (B: -0.71; SE: 0.30; 95% CI: -1.3—0.1 and B: -0.68; SE: 0.30; 95% CI: -1.3—-0.1, respectively). **Conclusion:** Despite the fact that dental curricula do not cover topics related to bioterrorism, most students would be willing to provide care under bioterrorism conditions. There is wide agreement among the students regarding the need to add bioterrorism-related educations to dental curricula.

Keywords: COVID-19; Dentistry; Disaster planning; Education, dental

Cite this article as: Bahanan L, Alsharif M, Al Qhtani O, Al Juhani A, Samman M. Dental Students' Perceptions Regarding Bioterrorism; a Cross-Sectional Study. Arch Acad Emerg Med. 2023; 11(1): e40. <https://doi.org/10.22037/aaem.v11i1.2018>.

1. Introduction

Bioterrorism can be defined as a terrorist attack via a biological agent or the intentional use of a harmful biological agent that causes a civil illness, physical dysfunction or death (1, 2). Appropriate interventions must be implemented as soon as a threat is identified to limit the morbidity and mortality caused by the attack (3). With the increased incidence of biological weapon use worldwide, healthcare personnel are an indispensable factor in facing such threats (3). There have been many claims and conspiracy theories that the COVID-19 global pandemic was a result of deliberate bioterrorism. Dentists are considered vital members of the healthcare community as they play a significant role in combating

bioterrorism attacks (4–6). The role of the dental professionals in bioterrorism attacks was defined by the American Dental Association (ADA) in 2002 (7). Dentists may be called upon to fill a range of roles in the event of a bioterrorism attack, including but not limited to education, sample collection, diagnosis, providing first aid and Cardiopulmonary Resuscitation (CPR), starting IV lines, suturing, vaccination, distribution of medications, and decontamination (7,8).

The role of dentists in the COVID-19 outbreak has revealed their importance in combating any mass casualty incident that may arise from natural or human-caused circumstances. Licensed dental professionals were able to perform nasopharyngeal and oropharyngeal swabs for COVID-19 diagnoses (8). Moreover, COVID-19 screening capacity was increased through the use of dental clinics with negative pressure and high-volume excavators (8). It is, therefore, important for dental schools to expand their curricula to include preparedness skills for pandemics and natural catastrophes (8).

Dental personnel, however, may face challenges during

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bioterrorist attacks due to a lack of knowledge and experience (4). A study by Bhoopathi et al. revealed that dentists both exposed and unexposed to a bioterrorism event showed low levels of perceived bioterrorism attack preparedness (9). Another study showed that less than 15% of dentists were able to identify a bioterrorism event, and less than 10% were confident that they could respond effectively in a bioterrorist attack (10). To lower morbidity and improve outcomes during such malicious events, dental schools should incorporate pandemic and disaster preparedness skills into their curricula. Moreover, this would allow dental students to recognise and effectively respond to any catastrophic event and bioterrorist attack (8,11.) Thus, this study aimed to understand dental students' perceptions of their potential roles in a bioterrorism attack, self-perceived knowledge and self-perceived need for education.

2. Methods

2.1. Study design and setting

This cross-sectional study was conducted between September 2021 and May 2022, with participants recruited between November 2021 and January 2022 using a self-administered anonymous questionnaire regarding the students' perceptions about bioterrorism attack, which was sent to all dental students and interns at King Abdulaziz University, Saudi Arabia. The study was reviewed and approved by the Institutional Review Board at King Abdulaziz University Faculty of Dentistry (#364-12-21). All participants provided informed consent. This study was performed in accordance with the principles of the Declaration of Helsinki.

2.2. Study participants

The inclusion criteria for the study included undergraduate dental students (second through sixth year) and dental interns at King Abdulaziz University Faculty of Dentistry. Sample size calculation was performed using Raosoft sample size calculator with a population size of 861 students and interns, response distribution of 50%, confidence level of 95% and error margin of 5% (12). This study required a minimum sample size of 266 participants.

2.3. Data gathering

A self-administered anonymous questionnaire was adapted from previous studies (9,13–15). To ensure the validity and reliability of the questionnaire, it was evaluated by two academic dentists. In addition, a pilot test was conducted on 12 participants from the target population (two students from each year). The pilot test aimed to identify any potential issues with the questionnaire, such as vague or confusing questions, and to assess the clarity and comprehensibility of the questionnaire. Based on the results of the pilot test, the

questionnaire was modified and finalized for use in the main data collection. Moreover, the internal consistency and reliability of the questionnaire were assessed using Cronbach's alpha coefficient, which was > 0.7 indicating an acceptable level of reliability and consistency. It was distributed in English using Question Pro forms. Every student received an email with the survey link and detailed instructions regarding the study. Two reminders were sent, two weeks and one month after the first email.

Participation was completely voluntary and informed consent was obtained from each participant.

The questionnaire consisted of five main sections. The first section comprised personal questions, including on gender (male or female), year of study (second, third, fourth, fifth, sixth, interns), grade point average (GPA) (4.5–5, 4–4.49, 3.5–3.99, 3–3.49, 2.5–2.99 and less than 2.5) and marital status (single or married). The second section included a yes–no question about the students' willingness to provide care during a bioterrorist attack. It also included 5-point Likert scale questions about students' opinions regarding the following topics: "1) bioterrorism is a national security concern, 2) local community at risk of bioterrorism attack, 3) first responder team should include dental professionals". In the third section, respondents were asked to choose from 10 potential roles that a dental professional could play during a bioterrorism attack, as recommended by the ADA. The fourth section consisted of yes–no questions to assess students' self-perceived knowledge regarding whether they "1) would be able to identify signs and symptoms of an attack, 2) know who to contact in case of an attack, 3) know how to get information about an attack, 4) know how to get clinical information about a bioterrorism-related disease, 5) know the current state of bioterrorism and how to manage it".

The level of knowledge was then categorised according to the number of affirmative responses (good: 4–5, fair: 3, poor: 0–2).

The final section comprised five questions about the self-perceived need for education and training on bioterrorism: '1) the need for more education regarding bioterrorism, 2) knowledge of a bioterrorism-related continuing education course, 3) previous training in bioterrorism, 4) incorporating bioterrorism preparedness into dental curricula, 5) willingness to attend a continuing education course on bioterrorism'. The questionnaire is attached as Appendix A.

Omar Al Qhtani and Ahmad Al Juhani were responsible for data gathering.

2.4. Statistical analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), Version 20. We used Cronbach's alpha to determine the internal consistency of the opinion domain. Descriptive statistics, such as frequencies

Table 1: Characteristics of studied dental students (n=472)

Characteristic	Value
Gender	
Male	248 (53.0)
Female	220 (47.0)
Age (year)	
Mean \pm SD	21.6 \pm 1.7
Year of study	
2nd	64 (13.6)
3rd	81 (17.3)
4th	80 (17.1)
5th	85 (18.1)
6th	73 (15.6)
Dental intern	86 (18.3)
Cumulative GPA	
4.5-5	188 (40.1)
4-4.49	207 (44.1)
3.5-3.99	58 (12.4)
3-3.49	12 (2.6)
2.5-2.99	4 (0.9)
Marital status	
Single	457 (98.9)
Married	5 (1.1)
Willing to provide care	
Yes	393 (83.8)
No	76 (16.2)
Total score of self-perceived knowledge (out of 5)	
Mean \pm SD	3.3 \pm 1.9
Total number of roles during a bioterrorism attack (out of 10)	
Mean \pm SD	8.3 \pm 2.4

Data are presented as mean \pm standard deviation (SD) or frequency (%). Some variables do not add up to the total, as not all participants answered every question.

GPA: grade point average.

and percentages, were used to report the sample characteristics. Bivariate analysis was used to assess students' opinions and self-perceived need for education against the sample characteristics. Using a multivariate linear regression analysis, the dependent variable dental students' need for bioterrorism education and training was determined based on the following predictors: gender, year of study, GPA, and marital status. We chose to handle the missing data using the pairwise deletion method, which involves excluding cases with missing data on a particular variable from the analysis for that variable only. The significance level was set at $p < 0.05$.

3. Results

A total of 472 participants with the mean age of 21.6 ± 1.7 (range: 19 - 24) years were included in the study, which corresponds to a response rate of 54.8%. The response rate may indicate that students were overburdened with requirements and exams or that awareness of the topic was partially underdeveloped. More than half of the respondents were male

(53.0%). The majority of participants were single (98.9%), had a cumulative GPA ≥ 4 (84.2%) and were willing to provide care during a bioterrorist attack (83.8%) (Figure 1). The mean total score of self-perceived knowledge regarding bioterrorism was 3.3 ± 1.9 out of 5. Moreover, the mean total number of roles that participants perceived that a dentist should play during a bioterrorism attack was 8.3 ± 2.4 out of 10 (Table 1). Table 2 shows students' perceptions regarding bioterrorism preparedness and management. Most of the respondents (78.2%) believed that bioterrorism is a national concern, and a substantial majority (71.7%) believed that the local community is at risk of bioterrorism. Additionally, 68.6% of the participants believed that one of the first responder teams should be dental professionals. Most of the responders agreed with the roles given by the ADA regarding bioterrorism, with the majority believing they should provide first aid and CPR (90.5%) and a smaller majority considering that they should diagnose a possible bioterrorist attack (76.4%).

According to 75.2% of the respondents, the dental curriculum should include bioterrorism, and 76.3% were willing to attend a continuing education course on the topic (Figure 1). Overall, participants showed willingness to provide care during a bioterrorism event, though none of the results were statistically significant. Females (85.9%) showed slightly more willingness than males (82.1%). Dental interns were the most willing to provide care (88.1%), and students in the fifth year were the least willing to provide it (81.2%). Respondents with a GPA of 3–3.49 were the most willing to provide care (91.7%). Single dental students (84%) were slightly more likely to provide care than married dental students (80%) (Table 3).

Most participants from both genders (males 71.4% and females 75.8%) had excellent knowledge of bioterrorism. There was also an almost equal gender distribution of poor knowledge (males 8.2% and females 9.0%). Dental interns had the highest proportion of excellent knowledge regarding bioterrorism (83.9%), whereas second- and fourth-year dental students had the highest proportion of poor knowledge regarding bioterrorism (13.1% and 13.3%, respectively) (Table 4).

A linear regression model to predict the score of knowledge regarding bioterrorism and the number of roles that a dentist should play during a bioterrorism attack included the following: gender, year of study, cumulative GPA, and marital status (Table 5).

According to our findings, fourth- and fifth-year dental students had significantly less knowledge of bioterrorism than dental interns. Furthermore, dental interns reported a significantly higher number of roles that a dental professional should play during a bioterrorism attack than dental students from the second to fifth years. Moreover, participants with a cumulative GPA of 4.5–5 and 4–4.49 were significantly more likely to indicate that a dental professional should take on more roles during a bioterrorism attack than those with a

Table 2: Students' perception regarding bioterrorism preparedness and management

Variable of interest	Number (%)
Students' opinion regarding bioterrorism (affirmative response)	
Bioterrorism is a national security concern	366 (78.2)
Local community at risk of bioterrorism attack	324 (71.7)
First responder team should include dental professionals	310 (68.6)
Students' perception regarding the roles during a bioterrorism event (affirmative response)	
Report a possible bioterrorism infection	394 (85.7)
Identify and triage victims	373 (81.8)
Provide information and guidance to the public during an attack	384 (82.9)
Diagnose a possible bioterrorism infection	350 (76.4)
Keep dental records for forensic identification	402 (87.2)
Provide first aid and cardiopulmonary resuscitation	420 (90.5)
Perform forensic dentistry	380 (82.1)
Provide assistance to medical personnel (e.g., physician, nurse)	388 (84.2)
Create an alternative medical site by providing clinic space	403 (86.7)
Give vaccines and medications under supervision	405 (87.7)

Table 3: Bivariate analysis of demographic characteristics and willing to provide care during a bioterrorism attack

Characteristic	Willing to provide care during a bioterrorism attack		P-value
	Yes n (%)	No n (%)	
Gender			
Male	202 (82.1)	44 (17.9)	0.3
Female	189 (85.9)	31 (14.1)	
Year of study			
2nd	53 (82.8)	11 (17.2)	0.8
3rd	66 (81.5)	15 (18.5)	
4th	68 (85.0)	12 (15.0)	
5th	69 (81.2)	16 (18.8)	
6th	61 (83.6)	12 (16.4)	
Dental intern	74 (88.1)	10 (11.9)	
Cumulative GPA			
4.5-5	156 (83.0)	32 (17.0)	0.8
4-4.49	176 (85.0)	31 (15.0)	
3.5-3.99	46 (82.1)	10 (17.9)	
3-3.49	11 (91.7)	1 (8.3)	
2.5-2.99	3 (75.0)	1 (25.0)	
Marital status			
Single	382 (84.0)	73 (16.0)	0.6
Married	4 (80.0)	1 (20.0)	

Data are presented as frequency (%). GPA: grade point average.

GPA of 2.5–2.99 (Table 5).

4. Discussion

The purpose of this cross-sectional study was to examine dental students' perceptions of their potential roles in a bioterrorism attack, self-perceived knowledge and self-perceived need for education. This study found that dental interns had a higher level of knowledge about bioterrorism than fourth- and fifth-year dental students. The majority of dental students believed that dental professionals should be part of the first responder team. Furthermore, most dental students were willing to assist during a bioterrorist attack.

They also recommended including bioterrorism preparedness in dental curricula.

Our findings regarding high willingness of dental students and interns to provide care during a bioterrorism attack were in line with those of previous studies. Bhatt et al., who evaluated Indian students' knowledge and willingness to assist in a bioterrorist attack, found that 96.6% of undergraduate dental students were willing to provide care during an attack (13). In Boston in 2005, the majority (92.0%) of the dental students, assistants and hygienists attending the Yankee dental conference expressed willingness to assist during an attack (14). Similarly, Katz et al. revealed that 73.8% of Hawai-

Table 4: Bivariate analysis of demographic characteristics and level of knowledge regarding bioterrorism

Characteristic	Level of knowledge regarding bioterrorism			P-value
	Excellent	Fair	Poor	
Gender				
Male	105 (71.4)	30 (20.4)	12 (8.2)	0.5†
Female	100 (75.8)	20 (15.2)	12 (9.0)	
Year of study				
2nd	24 (63.2)	9 (23.7)	5 (13.1)	0.4‡
3rd	35 (72.9)	10 (20.8)	3 (6.3)	
4th	30 (66.7)	9 (20.0)	6 (13.3)	
5th	32 (69.6)	10 (21.7)	4 (8.7)	
6th	36 (78.2)	5 (10.9)	5 (10.9)	
Dental intern	47 (83.9)	7 (12.5)	2 (3.6)	
Cumulative GPA				
4.5-5	80 (70.8)	24 (21.2)	9 (8.0)	0.3‡
4-4.49	95 (76.0)	16 (12.8)	14 (11.0)	
3.5-3.99	22 (66.7)	9 (27.3)	2 (6.0)	
3-3.49	8 (100.0)	0 (0.0)	0 (0.0)	
2.5-2.99	1 (50.0)	1 (50.0)	0 (0.0)	
Marital status				
Single	201 (73.9)	48 (17.7)	23 (8.4)	0.2¥
Married	0 (0.0)	1 (100.0)	0 (0.0)	

Data are presented as frequency (%). GPA: grade point average, †Chi-square test, ‡Fisher exact test with Monte Carlo simulation, ¥fisher exact test.

Table 5: Linear regression model predicting students' total knowledge score regarding bioterrorism and total number of roles a dentist should play during a bioterrorism attack

Variables	Total knowledge score			Total number of roles		
	Estimate	SE	95% CI	Estimate	SE	95% CI
Gender						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	-0.04	0.19	-0.4 – 0.3	0.09	0.22	-0.4 – 0.5
Year of study						
2nd	-0.51	0.34	-1.2 – 0.2	-1.9	0.40	-2.7 – -1.1*
3rd	-0.56	0.30	-1.1 – 0.03	-1.9	0.36	-2.6 – -1.2*
4th	0.71	0.30	-1.3 – -0.1*	-1.1	0.36	-1.8 – -0.3*
5th	-0.68	0.30	-1.3 – -0.1*	-0.9	0.36	-1.6 – -0.2*
6th	-0.18	0.31	-0.8 – 0.4	-0.6	0.37	-1.3 – 0.1
Dental intern	Ref	Ref	Ref	Ref	Ref	Ref
Cumulative GPA						
4.5-5	1.18	1.16	-1.1 – 3.5	3.2	1.38	0.5 – 5.9*
4-4.49	0.97	1.15	-1.3 – 3.2	2.9	1.38	0.2 – 5.6*
3.5-3.99	0.66	1.17	-1.6 – 3.0	2.2	1.40	-0.5 – 5.0
3-3.49	1.19	1.28	-1.3 – 3.7	2.7	1.50	-0.3 – 5.7
2.5-2.99	Ref	Ref	Ref	Ref	Ref	Ref
Marital status						
Single	-2.4	0.89	-1.1 – 1.5	0.4	1.06	-1.7 – 2.5
Married	Ref	Ref	Ref	Ref	Ref	Ref

* Statistically significant; p < 0.05. ER: Standard error; CI: confidence interval; GPA: grade point average; Ref: reference.

ian dentists were willing to assist during a bioterrorism event (10). Our findings were also consistent with a cross-sectional study conducted among healthcare professionals in three emergency departments and poison control centres/clinical laboratories in Riyadh, Saudi Arabia, which found that 68.7% of respondents were willing to provide care during an attack

(15). Among the respondents, only 23.1% had received bioterrorism training. Similarly, a study of physicians and nurses in Riyadh found that 20.6% were trained in bioterrorism (15). In comparison, two previous studies showed that only 4.5% of dental students in India and 5.5% of dental professionals in

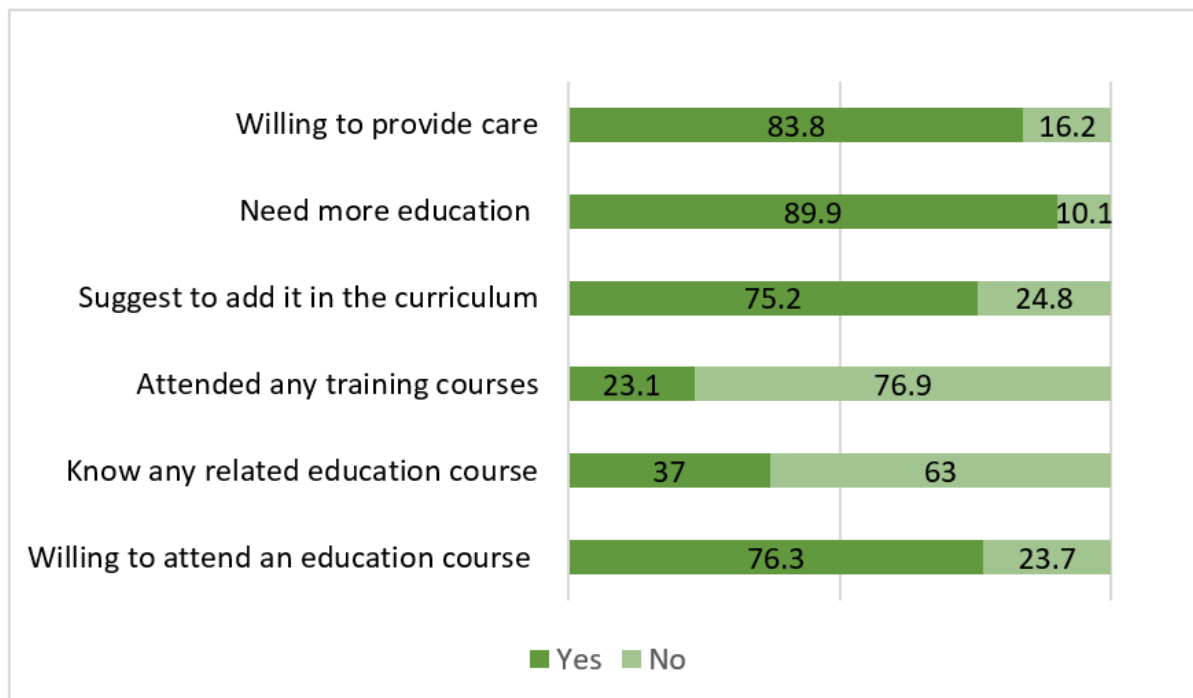


Figure 1: Dental students' perceived need for education and willingness to provide care during bioterrorism attacks.

New England had attended a course on bioterrorism (13,14). In light of the increase in bioterrorism incidents worldwide, these percentages are considered low, especially because the literature has demonstrated that dentists have been effective in handling catastrophic events (7).

In a study by Nofal et al., the percentage of respondents who reported knowing where to take a bioterrorism course was higher than in our study (55.5% vs. 37.0%, respectively) (15). Another study of a sample of family physicians with an active membership in the American Academy of Family Physicians revealed that 56% of the respondents knew where to obtain bioterrorism training (16). This may be due to the fact that the study included physicians, nurses and other members of the emergency department team, whereas our study included undergraduate dental students and interns.

Our study showed that the mean total number of roles that students perceived that a dentist should play during a bioterrorism event was 8.3 ± 2.4 out of 10. This was consistent with a study of Indian undergraduate dental students, which reported the mean number of roles as 8.73 ± 2.1 (13). However, a study conducted on New England dental professionals showed a slightly lower mean total number of roles at 5.9 ± 2.7 (14). The higher mean total number of roles among the Indian undergraduate students and in our findings might be attributed to the fact that these studies were conducted after the COVID-19 pandemic, when students had become more aware of the importance of dental professionals' involvement

and assistance during a catastrophic disaster. In agreement with previous studies, we found that more education about bioterrorism is needed (7,11,13–15,17).

Dental interns had significantly higher scores on self-perceived knowledge of bioterrorism than undergraduate students. Dental interns also reported a higher number of roles for dentists in a bioterrorist attack than undergraduates, which is consistent with a previous study, which found that postgraduate dental students scored higher than undergraduate dental students on this topic (13). This may be due to the postgraduate students' and interns' clinical experience and greater community awareness than the undergraduates. However, we could not compare the overall score in our study with those of previous studies because the method of calculation was different.

Our sample of dental students indicated that CPR, vaccinations, and record-keeping were some of the most commonly mentioned roles they could perform during a bioterrorism event. The survey sample of New England dental professionals showed that 46.3% believed that dentists could help administer vaccines (14), compared to 87.7% of our respondents. The difference may be explained by our study being conducted after the COVID-19 pandemic, during which some dental professionals were involved in administering vaccines through the Ministry of Health (18).

In 2003, at a workshop on bioterrorism preparedness, the ADA and the American Dental Education Association con-

cluded that dental professionals should be knowledgeable about bioterrorism agents, trained to respond appropriately during an attack and capable of communicating surveillance data effectively (7,11). The role of dental schools in this process is crucial. However, adding bioterrorism training to the dental school curriculum can be challenging due to regional differences, core curriculum management, and financial restrictions (11). Chmar et al. proposed three scenarios to improve students' knowledge of bioterrorism: first, to create a new course that would provide bioterrorism training to students; second, to seamlessly integrate terrorism education into existing courses; and third, to combine the two previous scenarios by incorporating training into the existing curriculum as well as a culminating course (11).

5. Limitations

To our knowledge, this is the first study to assess dental students' preparedness to deal with a bioterrorism event in Saudi Arabia. This study has several limitations. First, the study design is cross-sectional, which precludes making causal inferences. Second, the sample consisted of students from one university, limiting the generalisability of the results. Third, the study is limited to undergraduate dental students and does not include postgraduate dental students, hygienists, or dental assistants. Since cross-sectional studies are subject to selection bias, we attempted to minimize non-response bias by following up with non-responders. Although this study has limitations, its significance lies in identifying the need for dental students to receive additional training and education in bioterrorism. There are many ways in which dental professionals can receive bioterrorism training, including undergraduate courses, continuing education programmes, and online courses (15). Hence, future research should focus on training programmes aimed at improving dental professionals' readiness for bioterrorism events.

6. Conclusion

The increasing threat of bioterrorism worldwide necessitates the education and training of all healthcare professionals in bioterrorism. Regardless of whether dental students intend to participate in addressing bioterrorism attacks, they should be familiar with the necessary knowledge and control measures to counter such attacks. This preparation could be achieved by incorporating bioterrorism education into dental curricula.

7. Declarations

7.1. Acknowledgments

We acknowledge dental students and interns at King Abdulaziz University who participated in this study.

7.2. Conflict of interest

The authors declare that they have no competing interests.

7.3. Fundings and supports

This study did not receive any funding.

7.4. Authors' contribution

LB conceived the project idea with MS. OA and AA collected the data and drafted the manuscript. LB analysed the data. LB, MS, and MA critically reviewed the manuscript. All authors read and approved the final manuscript.

7.5. Ethics approval

This study was reviewed and approved by the Institutional Review Board at King Abdulaziz University Faculty of Dentistry, Jeddah, Saudi Arabia (#364-12-21).

All methods were performed in accordance with the principles of the Declaration of Helsinki.

7.6. Consent for publication

All participants provided written informed consent.

7.7. Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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