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EVALUATION OF SMART PHONE APPLICATION IN AWARENESS OF TRAUMATIC INJURIES OF PERMANENT TEETH

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Abstract

Aim: This cross-sectional study aimed to compare the effectiveness of a smartphone application, PowerPoint lecture, or their combination in increasing awareness about managing traumatic injuries of permanent teeth among primary school teachers, nurses, and parents. **Subjects and methods:** The study involved 135 participants divided into three groups of 45 each: teachers, nurses, and parents. Each group was further randomized into three subgroups of 15 participants each, using one of the following awareness methods: smartphone application only, 30-minute PowerPoint lecture only, or both methods combined. **Results:** Most participants were female, aged 31-40. Teachers and parents mostly held bachelor's degrees, while nurses had high school or diploma education. All educational methods effectively increased knowledge about traumatic dental injuries (TDIs), with 80%-100% of participants choosing correct answers after intervention. The combined method was the most effective, followed by the smartphone application, and then the lecture, with significant differences between them. **Conclusion:** All educational methods significantly improved knowledge of TDIs. The combined method had the greatest impact, followed by the application and lecture. Teachers showed the highest improvement, then parents, and finally nurses.

Keywords: Smart Phone Application, Awareness, KAP, Traumatic Injuries, Permanent Teeth.

BACKGROUND

Traumatic dental injury (TDI) is a significant public health concern, particularly in childhood, as it is one of the leading causes of tooth loss, especially in cases of tooth avulsion. The lack of awareness among parents, school teachers, sports coaches, and nurses regarding the appropriate management of dental trauma often results in poor treatment outcomes. Untreated dental injuries can have profound psychological, physical, and emotional impacts on children, underscoring the importance of timely and effective intervention to preserve the health of traumatized teeth [1]. The initial management of TDIs is critical, as it significantly influences the long-term prognosis of the injured tooth. Factors such as the timing of the injury, the site of the trauma, the nature of the injury, and the type of trauma all play a role in determining the success of treatment. However, the first aid care required immediately after the injury is often administered by laypeople who are present at the scene. Unfortunately, a general lack of knowledge among these individuals about dental trauma management often leads to suboptimal outcomes [2].

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In recent years, mobile technology has revolutionized various fields, including healthcare. Smartphones, in particular, have become ubiquitous, offering not only enhanced communication capabilities but also innovative solutions for participatory surveillance and health education through the use of mobile applications [3]. In the medical field, smartphones are increasingly being utilized for diagnostic and educational purposes. Dentistry, in particular, has seen a growing demand for mobile applications designed to support dental professionals, students, and assistants in their daily practices [4]. Mobile technology has also had a transformative impact on education, with healthcare applications emerging as powerful tools for effective communication. Numerous mobile health applications, such as Dental Trauma Tracker, Dental Trauma, Tooth SOS, and All Dental Disorders, have been developed to address dental health concerns for both patients and practitioners [5,6].

Given the potential of mobile applications to disseminate critical information in an accessible and user-friendly manner, it is imperative to educate individuals who are frequently in contact with children—such as parents, teachers, and coaches—on the use of dental trauma applications. These applications are designed to present information in simple, easy-to-understand terms, making them suitable for users with limited or no dental background. Moreover, they are readily available on platforms such as the Google Play Store, ensuring widespread accessibility [7]. Despite the growing popularity of mobile health applications, there is a notable gap in research regarding their use in raising awareness about dental trauma, particularly among laypeople in regions such as Egypt. Furthermore, there is a lack of comprehensive studies that explore the integration of various health education methods in the management of TDIs on a global scale.

This study aims to address these gaps by evaluating the effectiveness of smartphone applications in enhancing awareness and knowledge about the management of traumatic injuries to permanent teeth. By focusing on laypeople, this research seeks to provide insights into how mobile technology can be leveraged to improve the outcomes of dental trauma management, ultimately contributing to better oral health for children. The findings of this study could have significant implications for public health strategies, particularly in regions where access to dental care and education is limited.

METHODS

Experimental design, ethical approval and sample size calculations

This cross-sectional study was carried out on 135 participants in the Pediatric Department, Faculty of Dentistry, Suez Canal University in Ismailia Governorate, private primary schools and governmental medical centers in Suez Governorate to compare different awareness methods for management of traumatic injuries of permanent teeth. The current research was conducted after the approval of the Research Ethics Committee (REC) of the Faculty of Dentistry, Suez Canal University (authorization number 295/2020).

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The sample size for this study was calculated according to Hulley *et al.* [8]. The present study included 135 participants (teachers, nurses and parents) from Pediatric Department, Faculty of Dentistry, Suez Canal University, private primary schools, and governmental medical centers in Suez Governorate. 135 participants were selected according to the inclusion criteria [9].

The inclusion criteria include an age participant between 20-60 years old, including both females and males, with the educational level was at least a high school or diploma, participants were familiar with using smartphones and being cooperative. All participants signed informed consent.

The total sample size was 135 participants which were divided into three groups, 45 participants for each group as follows: Group I (Teachers): 45 teachers work in private primary schools in Islamic Language School and Suez Hills School in Suez Governorate. Group II (Nurses): 45 nurses work in Islamic Language School, Suez Hills School and governmental medical centers in Suez Governorate. Group III (Parents): 45 parents who had children at age 6 to 12 years old from those who attended in Pediatric Dental Clinic, Faculty of Dentistry, Suez Canal University in Ismailia Governorate.

Subgroup randomization: Each group was subdivided into three different subgroups by randomization: Each participant was allowed to select one card from a bowl, which contained 45 cards that were equally distributed A, B, and C (15 for each subgroup), (See Figure 1).

They were represented according to the awareness methods as follows: Subgroup A: 15 participants used only the First Aid Dental Trauma Application (FADTA) on a smartphone with an Arabic version during answering the posttest questionnaire.

Subgroup B: 15 participants received 30-minute power point lecture on dental traumatic injuries in permanent teeth in the Arabic language before answering the posttest questionnaire.

Subgroup C: 15 participants received 30- minute power point lecture as in subgroup B, then they used FADTA on a smartphone with an Arabic version during answering the posttest questionnaire.

Study Procedures: The nature and purpose of the study were explained to teachers, nurses, and parents, and strict confidentiality was assured. Participants were given pretest questionnaires and asked to answer them (supplementary data I). The pretest questionnaires were collected within half an hour. The participants in each group were divided randomly into three subgroups according to the awareness methods used. Posttest questionnaires (similar to pretest questionnaires but containing only questions from sections II and III were distributed, and participants were asked to answer them. (Appendix I). The posttest questionnaires were collected within half an hour. Section III at both pretest and posttest questionnaires for each participant was evaluated according to the model answer (Appendix II). The model answer was based on information from the International Association of Dental Traumatology (IADT).

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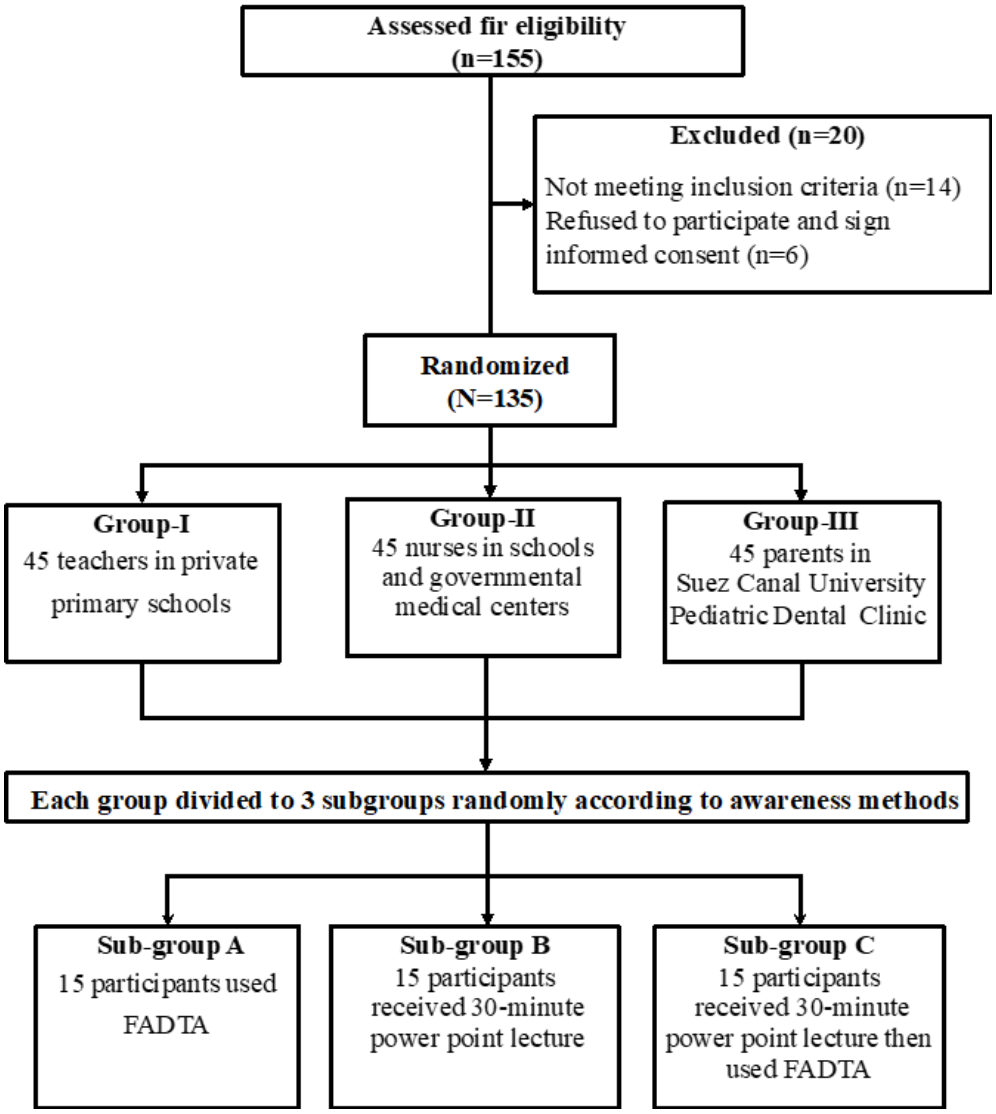

Figure 1: Consort diagram showing the study design

Questionnaire description

In order to address research objectives, pretest and posttest questionnaires were prepared in this study. Both questionnaires had the same questions that were translated into Arabic (Attached Appendix I) modified from Dental Trauma First Aid Application, Marcano-Caldera *et al.* and Niviethitha *et al.* [10, 11, 12].

The questionnaire consisted of three sections: Section I: Five questions for demographic data and dental trauma experience included: participants' age, gender, level of education, receiving first aid training and witnessed any dental trauma accident modified from Marcano- Caldera *et al.*, and Niviethitha *et al.* [11,12]. Section II: Two questions included: dental trauma education.

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Section III: (15) questions on how to manage traumatic dental injuries and were focused on eight questions for avulsion, five questions for fractured tooth and two questions for the displacement of permanent teeth modified from Dental Trauma First Aid application and Marcano-Caldera *et al.*[10,11], for description of the questionnaire see figure (2).

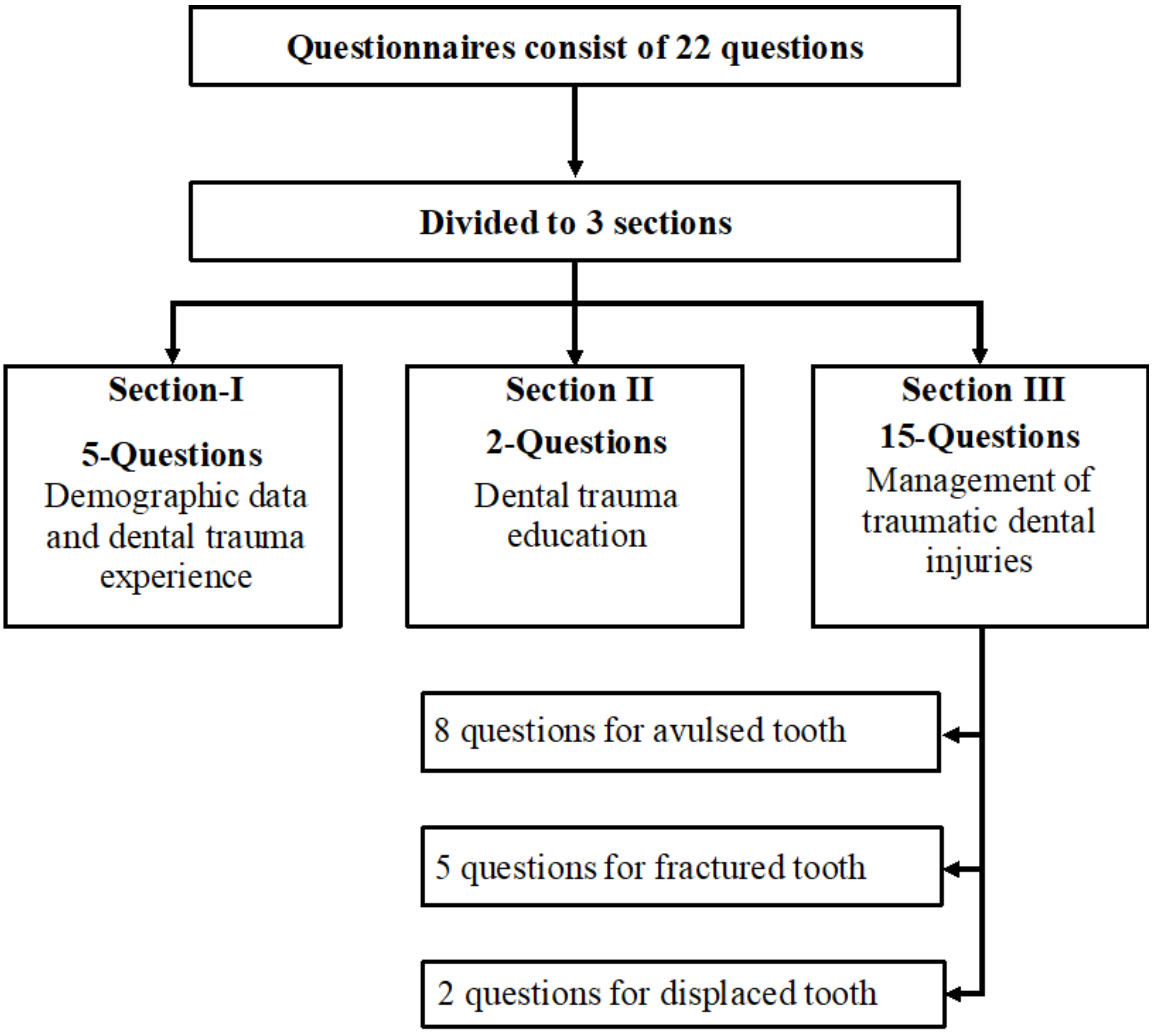

Figure 2: Diagram represents a description of the questionnaire

Description of First Aid Dental Trauma Application: Subgroup A and subgroup C used FATDA by the following steps then chose suitable case of tooth injury to follow instructions of emergency management.

Description of power point lecture: Subgroup B and subgroup C used PowerPoint lecture. It contained the same information and figures found in FADTA. It was consisted of 8 slides. Power point lecture was presented to teachers at the conference room through a projector on a smart board at their schools, while nurses and parents received power point lecture on the laptop.

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Statistical Analysis:

Statistical analyses were carried out using computer software Statistical Package for Social Science SPSS (IBM-SPSS ver. 29.0 for Mac OS) [13]. The questionnaire reliability was checked using Cronbach's alpha to ensure the high internal consistency among questionnaire answers (>0.7). Normality testing to detect whether the data are parametric or nonparametric using Kolmogorov-Smirnov at 0.05 level. Obtained results were found nonparametric especially all questions, gender, witnessed dental trauma, first aid training, and educational level, however, age was normally distributed (parametric data) as revealed by Shapiro-Wilk and Kolmogorov-Smirnov test. Data described statistically both graphical and numerical description. Parametric data (age) was presented in terms of mean and standard deviation. However, nonparametric data were presented as frequency (n %). Inferential statistics for evaluating and comparing intragroup differences (pre/post) were presented in terms of P1 using Wilcoxon's signed rank test within each group. The inter group difference between app, lecture and combined were performed using Kruskal-Wallis test statistic at 0.05 level presented as p2. The inter group difference between teachers, parents, and nurses were performed using Kruskal-Wallis test statistic at 0.05 level presented as p3. All statistical analyses were at 0.05 level. Interaction between variables were performed using Pearson's correlation test, at 0.05 level. Heatmap was performed using PAST statistical software version 4.04. In addition to Canonical Correspondence analysis (CCA) to present interaction between variables.

RESULTS

This cross-sectional study was performed to compare the effectiveness of smart phone application and/or PowerPoint lecture on increasing awareness about management of traumatic injuries of permanent teeth among primary school teachers, nurses and parents. They were 135 participants who were divided into 3 groups, forty-five (45) for each group. Each group was subdivided into 3 sub- groups (3 methods).

Each subgroup (method) included fifteen (15) participants. Demographic data and dental trauma experience (Q1-Q5 as shown in Table 1): Q1-The age of all participants ranged from 20 to 60 years old. It was found that four (8.9%) teachers had ages ranged from 20 -30 years old, 26 (57.8%) had ages ranged from 31-40 years old, 12 (26.7%) had ages ranged from 41-50 years old and three (6.7%) had ages ranged from 51-60 years old.

Concerning nurses' group; it was found that 16 (35.6%) nurses had ages ranged from 20-30 years old, 18 (40%) had ages ranged from 31-40 years old, 11 (24.4%) had ages ranged from 41-50 years old while there were no nurses in the age category from 51-60 years old.

The parent's group, it was found that 15 (33.3%) parents had ranged from 20-30 years old. 20 (44.4%) had ages ranged from 31-40 years old, eight (17.8%) had ages ranged from 41-50 years old and two (4.4%) parents had ages ranged from 51-60 years old. There was statistically highly significant difference (P= 0.004) in all groups.

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The majority were females in all groups represented by 39 (86.7%) teachers, 45(100%) nurses and 33 (73.3%) parents. There was statistically very highly significant difference (P <0.001) in all groups. Concerning the educational level; It was found that 15 (33.3%) teachers had high school or diplom degree, one (2.2 %) had completed a two-year institute, 28 (62.2%) had a bachelor degree and one (2.2%) held a master degree.

It was found that 25 (55.6%) nurses had high school or diplom degree, 18 (40%) had two years institutes, two (4.4%) had bachelor degree, while there was no nurse had master or doctor degree. It was found that four (8.9%) parents completed high school or diplom degree, two (4.4%) had two years institute, 32 (71.1%) had bachelor degree and seven (15.6%) had master or doctor degree. There was statistically highly very significant difference (P <0.001) in all groups.

According to receiving first aid training: It revealed that 16 (35.6%) teachers, 36 (80%) nurse and 14 (31.1%) parents were received first-aid training. There was statistically very highly significant difference (P<0.001) in all groups. When they were asked if they had witnessed any dental trauma accident; It was found that 28 (62.2 %) teachers, 31 (68.9%) nurses and 21 (46.7%) parents had witnessed a dental trauma accident. There was no statistically significant difference in all groups.

Results highlight the high baseline awareness of the importance of including dental trauma management in first aid training and the value of receiving such training. While improvements were observed across all groups and methods, the combined method showed the most significant difference (P1 ≤ 0.03), particularly for teachers and parents. Nurses consistently demonstrated high baseline knowledge, with minimal changes post-intervention (Table 2).

The third section of our results (Section-III) involving the management of traumatic dental injuries consist of question from Q8-Q22.

Q8-Q15 represents participants responses case 1 (avulsion). Q8 (Looking for the Lost Tooth), there was great improvement in posttest questionnaires with all participants to 100%. There was statistically very highly significant difference (P1 <0.001) in application method with teachers group and in combined method with parents group.

Moreover, there was significant difference (p1≤ 0.03) in lecture methods in teacher group, combined method with nurses group and application and lecture methods in parents group. Intergroup analysis revealed very highly significant differences (P2 < 0.001) among educational methods within the teacher group (represented horizontally by p2 and evaluated by Kruskal – Wallis). There was highly significant difference (P3=0.008) between groups within application method (represented vertically by p3 evaluated by Kruskal – Wallis) (Table 3).

Q9 (Need for Dentist Assistance): Most participants recognized the need for dentist assistance with improving in posttest responses with no statically significant difference were observed within or between groups for this question (Table 3).

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Q10 (Timing of Dental Visit): Teachers improved from 66.7% to 100% in all methods, with statistically significant differences (P1 ≤ 0.04). Nurses and parents also showed improvements, particularly in the application method, though statistical significance was not consistently observed. Intergroup analysis revealed significant differences (P2 = 0.013) among educational methods within the teacher group and between groups within the combined method (P3 = 0.013) (Table 3).

Q11 (Holding the Avulsed Tooth): After the educational interventions, teachers, nurses, and parents all showed marked improvement in correctly identifying the crown as the part to hold on an avulsed tooth. In teachers group, lecture-driven gains being highly significant

(P1 < 0.001) and application/combined methods also showing significant improvement (P1 ≤ 0.023). Nurses had a highly significant change (P1< 0.001) within the combined method only. Parents had statistically significant difference (P1 <0.023) in all methods. Intergroup analysis showed very highly significant differences (P2 < 0.001) among educational methods for teachers and nurses and significant difference (p2 = 0.016) between educational methods within parents group. There was very highly significant difference (P3 ≤0.001) between groups within lecture method and highly significant difference (P3 ≤0.003) between groups within combined methods. (Table 3).

Table 1: Showing demographic data and dental trauma experience

	Teachers (n=45)	Nurses (n=45)	Parents (n=45)	P value
Q1- Age				
20-30	4 (8.9%)	16 (35.6%)	15 (33.3%)	0.004 **
31-40	26 (57.8%)	18 (40%)	20 (44.4%)	
41-50	12 (26.7%)	11 (24.4%)	8 (17.8%)	
51-60	3 (6.7%)	-	2 (4.4%)	
Q2- Gender				
Female	39 (86.7%)	45 (100%)	33 (73.3%)	<0.001 ***
Male	6 (13.3%)	-	12 (26.7%)	
Q3- Education Level				
High school or diploma	15 (33.3%)	25 (55.6%)	4 (8.9%)	<0.001 ***
Two years institute	1 (2.2%)	18 (40.0%)	2 (4.4%)	
Bachelor	28 (62.2%)	2 (4.4%)	32 (71.1%)	
Master or doctor degree	1 (2.2%)	-	7 (15.6%)	
Q4- Did you receive first aid training?				
Yes	16 (35.6%)	36 (80.0%)	14 (31.1%)	<0.001 ***
No	29 (64.4%)	9 (20.0%)	31 (68.9%)	
Q5- Have you ever witnessed any dental trauma accident?				
Yes	28 (62.2%)	31 (68.9%)	21 (46.7%)	0.170 ns
No	17 (37.8%)	14 (31.1%)	24 (53.3%)	

Ns non-significant at p > 0.05, ** highly significant at p ≤0.01, *** very highly significant at p ≤ 0.001.

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Table 2: Showing importance of dental trauma education

Question		App			Lecture			Combined			P2
		Before	After	P1	Before	After	P1	Before	After	P1	
Q6- Is dental traumatic injury should be part of first aid training?											
T	Yes	14 (93.3%)	14 (93.3%)	1.00ns	13 (86.7%)	15 (100%)	0.143ns	11 (73.3%)	15 (100%)	0.03*	0.210ns
	No	1 (6.7%)	1 (6.7%)		2 (13.3%)	-		4 (26.7%)	-		
N	Yes	12 (80%)	13 (86.7%)	0.62ns	13 (86.7%)	15 (100%)	0.14ns	13 (86.7%)	15 (100%)	0.14ns	0.119ns
	No	3 (20%)	2 (13.3%)		2 (13.3%)	-		2 (13.3%)	-		
P	Yes	10 (66.7%)	14 (93.3%)	0.06ns	11 (73.3%)	15 (100%)	0.03*	7 (46.7%)	13 (86.7%)	0.02*	0.056ns
	No	5 (33.3%)	1 (6.7%)		4 (26.7%)	-		8 (53.3%)	2 (13.3%)		
P3		**0.850 ns**			**0.638 ns**			**0.075 ns**			
Q7- Is it important for you to receive training on dental traumatic management?											
T	Yes	11 (73.3%)	12 (80%)	0.66ns	15 (100%)	15 (100%)	1.00ns	12 (80%)	14 (93.3%)	0.282 ns	0.267ns
	No	4 (26.7%)	3 (20%)		-	-		3 (20%)	1 (6.7%)		
N	Yes	15(100%)	15(100%)	1.00ns	15 (100%)	15 (100%)	1.00ns	15 (100%)	15 (100%)	>0.999ns	>0.999ns
	No	-	-		-	-		-	-		
P	Yes	14(93.3%)	15(100%)	0.31ns	13 (86.7%)	15 (100%)	0.14ns	13 (86.75%)	15 (100%)	0.14ns	0.796ns
	No	1(6.7%)	-		2 (13.3%)	-		2 (13.3%)	-		
P3		**0.294 ns**			**0.647 ns**			**0.582 ns**			

NS, non-significant at p >0.05, * Significant at p≤ 0.05. P1-value between before and after in each method using Wilcoxon's signed rank test statistic. P2- value between methods in each group horizontally using Kruskal-Wallis test statistic. P3- value between groups in each method vertically using Kruskal-Wallis test statistic.

Table 3: Participants responses to Question Q8-11 presented as frequency n, %

Question		App			Lecture			Combined			P2 value
		Before	After	P1	Before	After	P1	Before	After	P1	
Q8) If the tooth falls down, do you look for the lost tooth?											
T	Yes	7(46.7%)	15(100%)	<0.001 ***	11(73.3%)	15(100%)	0.03*	13(86.7%)	15(100%)	0.14ns	<0.001 ***
	No	8(53.3%)	-		4(26.7%)	-		2(13.3%)	-		
N	Yes	12(80%)	15(100%)	0.067 ns	15(100%)	15(100%)	1.00ns	10(66.7%)	15(100%)	0.014*	0.078 ns
	No	3(20%)	-		-	-		5(33.3%)	-		
P	Yes	11(73.3%)	15(100%)	0.03*	10(66.7%)	15(100%)	0.01**	9(60%)	15(100%)	<0.001 ***	0.056 ns
	No	4(26.7%)	-		5(33.3%)	-		6(40%)	-		
P3 value		**0.008****			**0.085 ns**			**0.078 ns**			
Q9) Do you need assistant of a dentist?											
T	Yes	13(86.7%)	15(100%)	0.14 ns	12(80%)	15(100%)	0.067ns	15(100%)	15(100%)	1.00ns	**0.124 ns**
	No	2(13.3%)	-		3(20%)	-		-	-		
N	Yes	10(66.7%)	12(80%)	0.41 ns	15(100%)	15(100%)	1.0ns	13(86.7%)	15(100%)	0.14ns	0.265 ns
	No	5(33.3%)	3(20%)		-	-		2(13.3%)	-		
P	Yes	14(93.3%)	15(100%)	0.3 ns	15(100%)	15(100%)	1.00ns	15(100%)	15(100%)	1.00ns	0.544 ns
	No	1(6.7%)	-		-	-		-	-		
P3 value		**0.502 ns**			**0.184 ns**			**0.112 ns**			

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Q10) When do you visit dentist?											
T	**Immed.**	10(66.7%)	15(100)	0.025*	10(66.7%)	15(100%)	0.014*	10(66.7%)	15(100%)	0.04*	0.013*
	week	1(6.7%)	-		-	-		1(6.7%)	-		
	month	-	-		-	-		4(26.7%)	-		
	Any time	4(26.7%)	-		5(33.3%)	-		-	-		
N	**Immed.**	12(80%)	15(100%)	0.06 ns	13(86.7%)	13(86.7%)	1.00ns	15(100%)	15(100%)	>0.99 ns	0.484 ns
	Week	-	-		2(13.3%)	2(13.3%)		-	-		
	Month	-	-		-	-		-	-		
	Any time	3(20%)	-		-	-		-	-		
P	**Immed.**	12(80%)	15(100)	0.067ns	12(80%)	15(100%)	0.18ns	15(100%)	15(100%)	>0.99 ns	**0.209 ns**
	Week	3(20%)	-		2(13.3%)	-		-	-		
	Month	-	-		-	-		-	-		
	Any time	-	-		1(6.7%)	-		-	-		
P3		**0.182 ns**			**0.186 ns**			**0.013***			
Q11) Which part you will hold avulsed tooth?											
T	Crown	8(53.3%)	13(86.7%)	0.023*	6(40%)	15(100%)	<0.001 ***	8(53.3%)	15(100%)	0.01**	<0.001 ***
	Root	1(6.7%)	2(13.3%)		8(53.3%)	-		3(20%)	-		
	Any place	6(40%)	-		1(6.7%)	-		4(26.7%)	-		
N	Crown	12(80%)	15(100%)	0.067 ns	14(93.3%)	15(100%)	0.300 ns	5(33.3%)	15(100%)	<0.001 ***	0.002 **
	Root	-	-		1(6.7%)	-		6(40%)	-		
	Any place	3(20%)	-		-	-		4(26.7%)	-		
P	Crown	9(60%)	15(100%)	0.023*	13(86.7%)	15(100%)	0.019*	8(53.3%)	15(100%)	0.010 **	0.016*
	Root	1(6.7%)	-		-	-		4(26.7%)	-		
	Any place	5(33.3%)	-		2(13.3%)	-		3(20%)	-		
P3		**0.062 ns**			**0.001*** **			**0.003****			

NS, non-significant at p >0.05, * Significant at p≤ 0.05. P1-value between before and after in each method using Wilcoxon's signed rank test statistic. P2- value between methods in each group horizontally using Kruskal-Wallis test statistic. P3- value between groups in each method vertically using Kruskal-Wallis test statistic.

(Rinsing the Avulsed Tooth): Correct knowledge of rinsing with tap water without rubbing improved dramatically. Teachers improved with very highly significant differences (P1 < 0.001) in all methods. Nurses and parents also showed substantial improvements, particularly in the combined method (P1<0.001). Intergroup analysis revealed very highly significant differences (P2<0.0001) among educational methods within allgroups and between groups within all methods (P3<0.001) (Table 4).

Q13 (Avoiding Storage in Water): Awareness of avoiding water storage improved significantly. Teachers improved in post-intervention, with very highly significant differences (P1 < 0.001) in all methods. Nurses and parents also showed improvements, particularly in the application method (P1 < 0.001). Intergroup analysis revealed very highly significant differences (P2 < 0.001) between educational methods within all groups and between groups within application and combined methods (P3 < 0.001) (Table 4).

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Q14 (Replanting the Tooth): Knowledge of self-replantation improved from near-zero baseline to 80%-100% post-intervention across all groups, with very highly significant differences (P1 ≤ 0.001). Intergroup analysis showed very highly significant differences (P2<0.001) among educational methods and between groups (P3 < 0.001) (Table 4).

Q15 (Follow-Up with Dentist): Most participants recognized the need for follow-up, There was only statistically significant difference (P1 = 0.014) in application method with teachers group. Parents showed statistically highly significant difference (P1 ≤ 0.006) in lecture and combined method while Nurses showed high baseline knowledge with minimal improvements.

Inter groups analysis showed very highly significant difference (P2≤0.001) between educational methods within parents groups and highly significant difference (P2≤0.008) between educational methods within teachers. Moreover, there was significant difference (P3≤0.017) between groups within combined method (Table 4).

Table 4: Participants responses to Question Q12-15 presented as frequency n, %

Questions		App			Lecture			Combined			P2 value
		Before	After	P1 value	Before	After	P1 value	Before	After	P1 value	
Q12) If you decide to rinse avulsed tooth, how do you do?											
T	Tap water without rubbing	3(20%)	14(93.3%)	<0.001***	2(13.3%)	11(73.3%)	<0.001***	3(20%)	15(100%)	<0.001***	<0.0001***
	Soap and brush	6(40%)	-		8(53.3%)	2(13.3%)		11(73.3%)	-		
	Anti septic	6(40%)	1(6.7%)		5(33.3%)	2(13.3%)		1(6.7%)	-		
N	Tap water without rubbing	9(60%)	15(100%)	0.02*	14(93.3%)	14(93.3%)	1.00ns	2(13.3%)	14(93.3%)	<0.001***	<0.0001***
	Soap and brush	3(20%)	-		1(6.7%)	1(6.7%)		6(40%)	1(6.7%)		
	Anti septic	3(20%)	-		-	-		7(46.7%)	-		
P	Tap water without rubbing	5(33.3%)	12(80%)	0.022*	6(40%)	13(86.7%)	0.019*	-	13(86.7%)	<0.001***	<0.0001***
	Soap and brush	7(46.7%)	1(6.7%)		4(26.7%)	-		7(46.7%)	-		
	Anti septic	3(20%)	2(13.3%)		5(33.3%)	2(13.3%)		8(53.3%)	2(13.3%)		
P3 value		<0.001***			<0.001***			<0.001***			
Q13) Avoid keep avulsed tooth in?											
T	Water	1(6.7%)	12(80%)	<0.001***	1(6.7%)	9(60%)	<0.001**	1(6.7%)	10(66.7%)	<0.001***	0.002 **
	Milk	6(40%)	-		5(33.3%)	-		3(20%)	4(26.7%)		
	Saline	6(40%)	-		8(53.3%)	3(20%)		9(60%)	-		
	Saliva	2(13.3%)	3(20%)		1(6.7%)	3(20%)		2(13.3%)	1(6.7%)		
N	Water	3(20%)	15(100%)	<0.001***	4(26.7%)	8(53.3%)	0.09ns	6(40%)	13(86.7%)	0.016*	<0.001***
	Milk	4(26.7%)	-		9(60%)	5(33.3%)		5(33.3%)	-		
	Saline	4(26.7%)	-		2(13.3%)	-		4(26.7%)	2(13.3%)		
	Saliva	4(26.7%)	-		-	2(13.3%)		-	-		
P	Water	9(60%)	12(80%)	<0.001***	5(33.3%)	12(80%)	0.05*	8(53.3%)	14(93.3%)	0.04*	0.001***
	Milk	-	2(13.3%)		6(40.0%)	1(6.7%)		2(13.3%)	-		
	Saline	3(20%)	1(6.7%)		3(20%)	2(13.3%)		5(33.3%)	1(6.7%)		
	Saliva	3(20%)	-		1(6.7%)	-		-	-		
P3 value		<0.001***			0.062 ns			<0.001***			
Q14- Is avulsed tooth return to its place by yourself?											
T	Yes	1(6.7%)	15(100%)	<0.001***	-	13(86.7%)	<0.001***	-	13(86.7%)	<0.001***	<0.001***
	No	14(93.3%)	-		15(100%)	2(13.3%)		15(100%)	2(13.3%)		
N	Yes	-	15(100%)	<0.001***	1(6.7)	15(100)	<0.001***	1(6.7%)	14(93.3%)	<0.001***	<0.001***
	No	15(100%)	-		14(93.3)	-		14(93.3%)	1(6.7%)		
P	Yes	-	15(100%)	<0.001***	-	15(100%)	<0.001***	-	12(80%)	<0.001***	<0.001***
	No	15(100%)	-		15(100%)	-		15(100%)	3(20%)		
P3 value		<0.001***			<0.001***			<0.001***			

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Q15) Does avulsed tooth need follow up with dentist after treatment?											
T	Yes	10(66.7%)	15(100%)	0.014*	12(80%)	15(100%)	0.067 ns	15(100%)	15(100%)	1.00ns	0.008 ***
	No	5(33.3%)	-		3(20%)	-		-	-		
N	Yes	15(100%)	15(100%)	1.00 ns	13(86.7%)	15(100%)	0.140 ns	12(80%)	15(100%)	0.06ns	0.208 ns
	No	-	-		2(13.3%)	-		3(20%)	-		
P	Yes	12(80%)	15(100%)	<0.067 ns	8(53.3%)	15(100%)	0.002**	9(60%)	15(100%)	0.006**	0.001 ***
	No	3(20%)	-		7(46.7%)	-		6(40%)	-		
P3		0.060 ns			0.123 ns			0.017 *			

NS, non-significant at p >0.05, * Significant at p≤ 0.05. P1-value between before and after in each method using Wilcoxon's signed rank test statistic. P2- value between methods in each group horizontally using Kruskal-Wallis test statistic. P3- value between groups in each method vertically using Kruskal-Wallis test statistic.

The questions 16-20 presents the third section (Section III: Management of Traumatic Dental Injuries – Case 2: Fractured Tooth) The results demonstrated significant improvements in knowledge and practices across all groups following the educational interventions.

Q16 (Looking for the Fractured Fragment): there was great imptovement in post intervention with all participants. Teachers group showed very highly significant difference(P1<0.001) in application and combined methods and significant difference (P1 =0.03) in lecture method. Whereas nurses group showed very highly significant difference (P1< 0.001) in application and combined methods. Parents group revealed very highly significant difference (P1 ≤ 0.001) in lecture and combined methods and highly significant difference (P1 ≤ 0.006) in application method. Inter group analysis showed very highly significant difference (P2<0.001) between educational methods within teachers and parents groups and significant difference (p2=0.033) between educational methods within nurses group. Moreover, There was very highly significant difference (P3≤0.001) between groups within application method and highly significant difference (P3≤0.002), (P3≤0.008) between groups within lecture and combined methods. (Table 5).

Q17 (Using the Fragment to Restore the Tooth): Knowledge of using the fractured fragment for restoration improved significantly across all groups. Teachers improved from 13.3% (application), 40% (lecture), and 53.3% (combined) to 93.3%-100% post-intervention, with very highly significant differences (P1 ≤ 0.001) in all methods. Nurses and parents also achieved high post-intervention scores, with nurses showing very highly significant improvements in the combined method (P1 < 0.001) and significant improvements in the application method (P = 0.02). Parents achieved 100% correct responses post-intervention, with very highly significant differences (P1 < 0.001) in all methods. Intergroup analysis showed very highly significant difference (P2<0.001) between educational methods within teachers and parents groups and significant difference (p=0.025) between educational methods within nurses group. Moreover, there was very highly significant difference (P3≤0.001) between groups within all methods (Table 5).

Q18 (Storing the Fractured Fragment): Awareness of storing the fragment in cold water improved dramatically. Teachers improved post intervention with very highly significant difference (P1 ≤ 0.001) in application and lecture methods and highly significant

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difference (P1 ≤ 0.006) in combined method. Nurses and parents also showed substantial improvements, particularly in the application method (P1 < 0.001 for nurses, P1 ≤ 0.008 for parents). Intergroup analysis revealed very highly significant differences (P2 < 0.001) among educational methods and between groups (P3 < 0.001) (Table 5). Q19 (Timing of Dental Visit for Bleeding): Most participants recognized the need to visit a dentist within 24 hours for bleeding. Teachers improved with all methods post intervention with only significant differences (P1 = 0.03) in the application method. Nurses and parents also showed improvements, with parents achieving 100% correct responses in the application and combined methods post-intervention. Statistically, very highly significant differences (P1 < 0.001) were noted in the lecture and combined methods for parents. No significant intergroup differences were observed (Table 5). Q20 (Follow-Up with Dentist): Most participants recognized the need for follow-up after treatment. Teachers improved from 73.3% (application), 93.3% (lecture), and 66.7% (combined) to 100% post-intervention, with significant differences (P1 ≤ 0.03) in the application and combined methods. Nurses and parents also showed high baseline knowledge, with minimal improvements. Only the combined method for parents showed statistically significant improvement (P1 = 0.03). Intergroup analysis revealed significant differences (P2 = 0.018) among educational methods within the teacher group (Table 5).

Q21-22 represents the Section III: Management of Traumatic Dental Injuries – Case 3: Displaced Tooth) (Table 6). Q21 (Visiting a Dentist for Slight Displacement): results showed high baseline knowledge among all participants with improvement in posttest interventions. There was no significant difference within intra group and inter groups analysis. (Table 6). Q22 (Follow-Up with Dentist After Treatment): Teachers improved with significant difference only in the combined method (P1 = 0.031). Nurses demonstrated 100% correct responses in both pretest and posttest questionnaires. Parents improved with no significant differences. Intergroup analysis revealed no significant differences between educational methods or groups (Table 6).

The average percentage of correct answers between pretest and posttest questionnaires across all groups and methods was analyzed using the Kruskal-Wallis test. The results revealed that the average percentage change in correct answers within each group was 37.91% for teachers, 25.36% for nurses, and 33.16% for parents. A highly significant difference (p2 = 0.004) was observed between educational methods within the nurses group, while no significant differences were found within the teachers and parents groups. When comparing groups within each method, the average percentage change in correct answers was 35.03% for the application method, 28.5% for the lecture method, and 35.95% for the combined method. A significant difference (p3 = 0.042) was noted between groups within the lecture method, but no significant differences were observed within the application and combined methods. Overall, there was a significant difference (P = 0.037) in the total percentage average of correct answers across all groups and methods. These findings highlight the varying effectiveness of educational interventions, with the lecture method showing notable differences between groups and the nurses group demonstrating highly significant improvements across methods (Table 7; Figure 3).

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Table 5: Participants responses to Question Q16-20 presented as frequency n, %

Questions		App			Lecture			Combined			P2 Value
		Before	After	P1	Before	After	P1	Before	After	P1	
Q 16- If the tooth fractured, will you Look for the fragment that is broken?											
T	Yes	5(33.3%)	14(93.3%)	<0.001 ***	11(73.3%)	15(100%)	0.031*	8(53.3%)	15(100%)	0.002 **	<0.001 ***
	No	10(66.7%)	1(6.7%)		4(26.7%)	-		7(46.7%)	-		
N	Yes	9(60%)	15(100%)	<0.001 ***	12(80%)	15(100%)	0.067ns	9(60%)	15(100%)	<0.001 ***	0.033*
	No	6(40%)	-		3(20%)	-		6(40%)	-		
P	Yes	6(40%)	15(100%)	0.006 **	4(26.7%)	15(100%)	<0.001***	7(46.7%)	15(100%)	<0.001 ***	<0.001 ***
	No	9(60%)	-		11(73.3%)	-		8(53.3%)	-		
P3		**<0.001*** **			**0.002** **			**0.008** **			
Q17) Do you think that this fragment can be used to restore the tooth?											
T	Yes	2(13.3%)	14(93.3%)	<0.001 ***	6(40%)	15(100%)	<0.001 ***	8(53.3%)	15(100%)	0.002 **	<0.001 ***
	No	13(86.7%)	1(6.7%)		9(60%)	-		7(46.7%)	-		
N	Yes	7(46.7%)	13(86.7%)	0.02*	10(66.7%)	13(86.7%)	0.19ns	6(40%)	15(100%)	<0.001 ***	0.025*
	No	8(53.3%)	2(13.3%)		5(33.3%)	2(13.3%)		9(60%)	-		
P	Yes	4(26.7%)	15(100%)	<0.001 ***	6(40%)	15(100%)	<0.001 ***	7(46.7%)	15(100%)	<0.001 ***	<0.001 ***
	No	11(73.3%)	-		9(60%)	-		8(53.3%)	-		
P3 value		**<0.001*** **			**0.002** **			**<0.001*** **			
Q18) Where can you store the fragment that broken?											
T	NaOCl	-	-	<0.001 ***	-	-	<0.001 ***	-	-	0.006 **	0.452 ns
	Napkin	5(33.3%)	1(6.7%)		10(66.7%)	-		6(40%)	-		
	Cold water	3(20%)	14(93.3%)		-	13(86.7%)		6(40%)	15(100%)		
	Alcohol	7(46.7%)	-		5(33.3%)	2(13.3%)		3(20%)	-		
N	NaOCl	1(6.7%)	-	0.012*	-	-	0.02*	-	-	<0.001 ***	0.950 ns
	Napkin	5(33.3%)	-		6(40%)	2(13.3%)		10(66.7%)	4(26.7%)		
	Cold water	7(46.7%)	15(100%)		6(40%)	13(86.7%)		-	9(60%)		
	Alcohol	2(13.3%)	-		3(20%)	-		5(33.3%)	2(13.3%)		
P	Na hypo chloride	1(6.7%)	-	0.008**	-	-	0.002**	-	-	0.019*	0.078 ns
	Napkin	8(53.3%)	1(6.7%)		8(53.3%)	-		7(46.7%)	1(6.7%)		
	Cold water	5(33.3%)	14(93.3%)		7(46.7%)	15(100%)		7(46.7%)	14(93.3%)		
	Alcohol	1(6.7%)	-		-	-		1(6.7%)	-		
P3 value		**0.340 ns**			**0.193 ns**			**0.811 ns**			

Q19) If there is bleeding from site of fracture, when to visit dentist?											
T	Any time	5(33.3%)	-	0.030*	2(13.3%)	-	0.14ns	3(20%)	1(6.7%)	0.51ns	0.631 ns
	within 24hrs	8(53.3%)	14(93.3%)		13(86.7%)	15(100%)		11(73.3%)	14(93.3%)		
	After 48hrs	2(13.3%)	1(6.7%)		-	-		1(6.7%)	-		
N	Any time	5(33.3%)	1(6.7%)	0.12ns	-	-	0.79ns	-	-	1.0ns	0.187 ns
	within 24hrs	8(53.3%)	13(86.7%)		13(86.7%)	15(100%)		13(86.7%)	13(86.7%)		
	After 48hrs	2(13.3%)	1(6.7%)		2(13.3%)	-		2(13.3%)	2(13.3%)		
P	Any time	3(20%)	-	0.09ns	7(46.7%)	-	<0.001 ***	5(33.3%)	-	<0.001 ***	0.612 ns
	within 24hrs	11(73.3%)	15(100%)		6(40%)	14(93.3%)		8(53.3%)	15(100%)		
	After 48hrs	1(6.7%)	-		2(13.3%)	1(6.7%)		2(13.3%)	-		
P3 value		**0.120 ns**			**0.226 ns**			**0.191 ns**			
Q20) Is fractured tooth need follow up with dentist after treatment?											
T	Yes	11(73.3%)	15(100%)	0.03*	14(93.3%)	15(100%)	0.30ns	10(66.7%)	15(100%)	0.014*	0.018*
	No	4(26.7%)	-		1(6.7%)	-		5(33.3%)	-		
N	Yes	13(86.7%)	15(100%)	0.14ns	15(100%)	15(100%)	1.0ns	12(80%)	15(100%)	0.14ns	0.299 ns
	No	2(13.3%)	-		-	-		3(20%)	-		
P	Yes	13(86.7%)	15(100%)	0.14ns	13(86.7%)	15(100%)	0.14ns	9(60%)	14(93.3%)	0.03*	0.080 ns
	No	2(13.35)	-		2(13.3%)	-		6(40%)	1(6.7%)		
P3		**0.305 ns**			**0.867 ns**			**0.128 ns**			

NaOCl, Sodium hypochlorite; NS, non-significant at p >0.05, * Significant at p≤ 0.05. P1- value between before and after in each method using Wilcoxon's signed rank test statistic. P2- value between methods in each group horizontally using Kruskal-Wallis test statistic. P3- value between groups in each method vertically using Kruskal-Wallis test statistic.

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Table 6: Participants responses to Question Q21-22 presented as frequency n, %

Questions		App			Lecture			Combined			P2 value
		Before	After	P1	Before	After	P1	Before	After	P1-value	
Q21) In case of little displacement of tooth from its place, should you go to dentist?											
T	Yes	12(80%)	15(100%)	0.067ns	13(86.7%)	15(100%)	0.14ns	12(80.0)	15(100%)	0.067ns	0.237 ns
	No	3(20%)	-		2(13.3%)	-		3(20.0)	-		
N	Yes	13(86.7%)	15(100%)	0.14ns	15(100%)	15(100%)	1.00ns	14(93.3%)	15(100%)	0.300ns	0.544 ns
	No	2(13.3%)	-		-	-		1(6.7)	-		
P	Yes	13(86.7%)	15(100%	0.14ns	13(86.7%)	13(86.7%)	1.00ns	12(80%)	15(100%)	0.060ns	0.399 ns
	No	2(13.3%)	-		2(13.3%)	2(13.3%)		3(20%)	-		
P3		0.427 ns			0.626 ns			0.298 ns			
Q22) Does displaced tooth need follow up with dentist after treatment?											
T	Yes	11(73.3%)	13(86.7%)	0.36ns	14(93.3%)	15(100%)	0.31ns	9(60%)	14(93.3%)	0.031*	0.052 ns
	No	4(26.7%)	2(13.3%)		1(6.7%)	-		6(40%)	1(6.7%)		
N	Yes	15(100%)	15(100%)	1.00ns	15(100%)	15(100%)	1.00ns	15(100%)	15(100%)	1.00ns	>0.999ns
	No	-	-		-	-		-	-		
P	Yes	13(86.7%)	14(93.3%)	0.54ns	13(86.7%)	15(100%)	0.14ns	10(66.7%)	14(93.3%)	0.067ns	0.542 ns
	No	2(13.3%)	1(6.7%)		2(13.3%)	-		5(33.35)	1(6.7%)		
P3		0.114 ns			0.223 ns			0.421 ns			

NS, non-significant at p >0.05, * Significant at p≤ 0.05. P1-value between before and after in each method using Wilcoxon's signed rank test statistic. P2- value between methods in each group horizontally using Kruskal-Wallis test statistic. P3- value between groups in each method vertically using Kruskal-Wallis test statistic.

Table 7: Showing average percentage of right answers changes between groups and methods

	Average % of right answers change			Total	P2-value
	App	Lecture	Combined		
Teacher	42.75%	34.51	36.47%	37.91%	0.142ns
Nurses	29.02%	14.90	32.16%	25.36%	0.004**
Parents	33.33%	36.08	39.22%	36.21%	0.545ns
Total	**35.03%**	**28.50%**	**35.95%**	**33.16%**	**0.037***
P3-value	**0.346ns**	**0.042***	**0.733ns**		

NS non-significant at p >0.05, * Significant at p≤ 0.05, ** Highly significant at P ≤ 0.01.

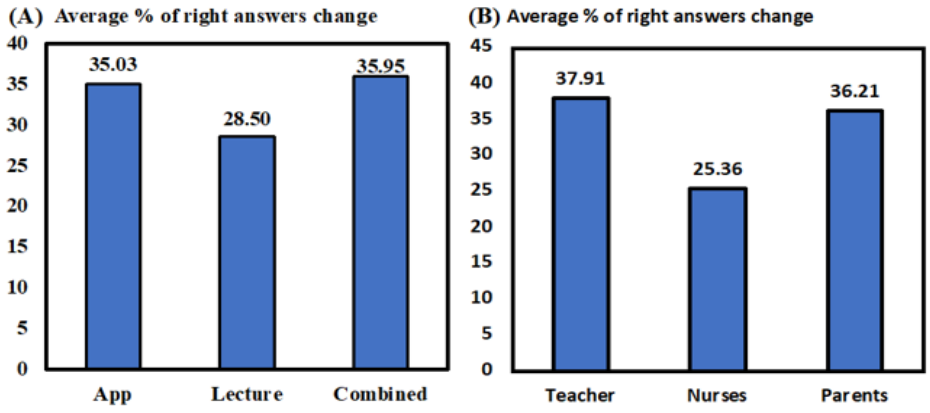

Figure 3: Bar chart representing average percentage of correct answers changes between pretest and posttest questionnaires in three methods (Apps, lectures, combined) and three groups (Teachers, Nurses, and Parents)

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Figure (4) presents the interaction between study variables through a red-blue correlation heatmap, where red indicates a negative correlation, white signifies no correlation, and blue represents a positive correlation. The intensity of the color reflects the strength of the correlation, with darker shades indicating stronger relationships. The diagonal cells, representing the correlation of each variable with itself, are perfectly correlated. Time (before and after the intervention) exhibited a strong negative and significant correlation with questions Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q20, Q21, and Q22, reflecting changes in responses from the pretest to the posttest questionnaire. Educational level showed a positive correlation with first aid training, witnessed dental trauma, Q6, and Q20, indicating that participants with higher education levels were more likely to have received first aid training, witnessed dental trauma incidents, and recognized the importance of including dental trauma management in first aid training. First aid training was positively correlated with educational level, witnessed dental trauma, Q7, Q8, and Q12, suggesting that individuals with first aid training were more knowledgeable about managing dental trauma. Witnessed dental trauma also showed a positive correlation with educational level and first aid training, further emphasizing the link between higher education, practical experience, and preparedness in handling dental injuries. These findings highlight the interconnectedness of education, training, and experience in improving awareness and management of traumatic dental injuries.

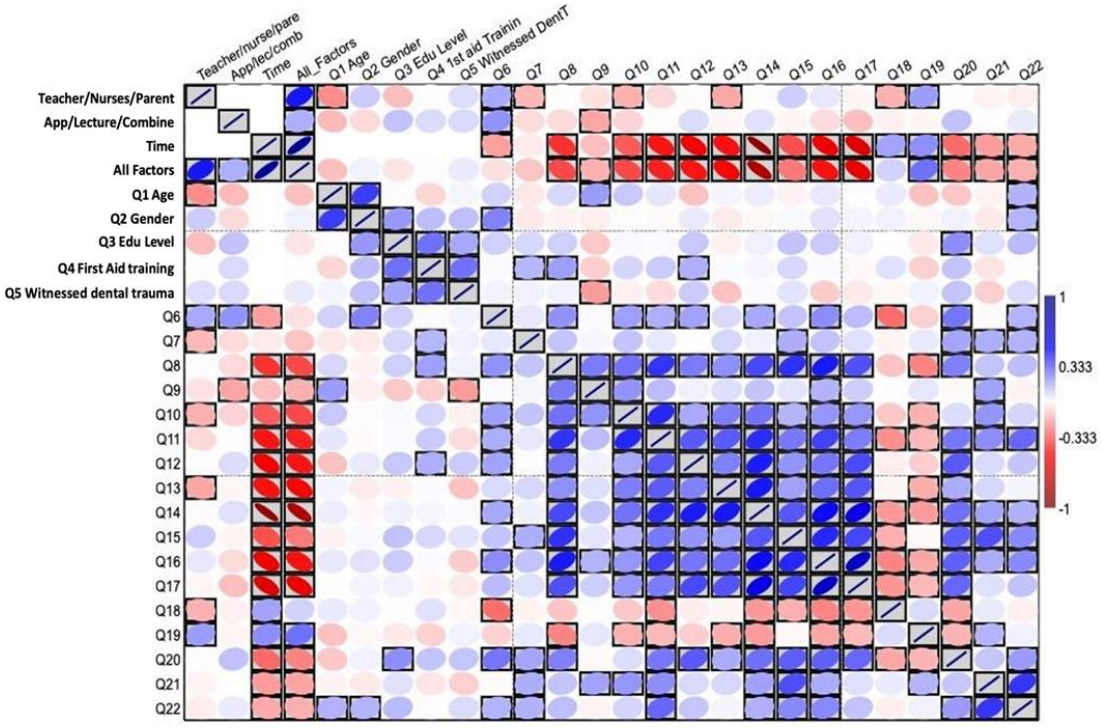

Figure 4: Heatmap presenting the interaction between study variables and questions

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DISCUSSION

The discussion section of this study underscores the critical importance of emergency management in improving the prognosis of traumatic dental injuries (TDIs) and highlights the role of education in equipping key stakeholders-such as teachers, nurses, and parents-with the knowledge and skills necessary to respond effectively to such incidents. The study aimed to evaluate and compare the effectiveness of three educational methods-First Aid Dental Trauma Application (FADTA), a PowerPoint lecture, and a combined method-in enhancing knowledge about the management of TDIs among primary school teachers, nurses, and parents. The findings revealed that all three methods significantly improved participants' understanding of TDI management, with the combined method emerging as the most effective due to its multi-modal approach to delivering information. This discussion elaborates on the study's key findings, their implications, and their alignment with existing literature, while also providing recommendations for future research and practice.

Emergency management of TDIs is a critical factor in determining the long-term survival and success of treatment for injured teeth. Prompt and appropriate action at the scene of an accident, followed by timely dental care, significantly increases the chances of saving the affected tooth. This study emphasizes the need for laypeople, including teachers, nurses, and parents, to be trained in basic dental trauma management, as they are often the first responders in such situations. The high prevalence of TDIs among children, particularly in school and home environments, further underscores the importance of this training. The study builds on previous research as Duruk and Gümüşboğa [14], which highlights the positive impact of delivering traumatized patients to dentists after initial emergency intervention. By equipping non-dental professionals with the knowledge to manage TDIs effectively, the study aims to reduce the long-term physical, emotional, and financial burden associated with these injuries.

The broader impact of TDIs on the oral health-related quality of life (OHRQoL) of injured children and their families was also a key focus of this study. Participation in dental trauma care programs has been shown to improve OHRQoL by providing families with the knowledge and skills needed to manage such injuries effectively. This aligns with findings from Milani *et al.*[15], who emphasized the importance of training laypeople in dental trauma management to reduce the negative consequences of TDIs. The study's focus on teachers, nurses, and parents as primary targets for education is particularly relevant, as these groups are often the first to encounter dental injuries in children. By improving their knowledge and preparedness, the study aims to enhance the overall quality of care provided to children with TDIs, thereby improving their long-term oral health outcomes.

The study's methodology was designed to evaluate the effectiveness of three educational methods included the FADTA application, a PowerPoint lecture, and a combined method in enhancing knowledge about TDI management. The FADTA app was chosen because it provides step-by-step instructions for managing TDIs based on the International Association of Dental Traumatology (IADT) guidelines, making it a reliable and user-friendly tool for individuals with limited dental knowledge. The app’s availability in Arabic

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further increased its accessibility for the study population. The PowerPoint lecture served as a traditional educational method, providing a baseline for comparison with the more innovative smartphone application. Moreover, it contained same content of application to ensure justice among the methods of awareness in agreement. The combined method, which included verbal explanations, written materials, and visual aids, was designed to enhance information retention by engaging multiple senses, as supported by Lee and Nathan-Roberts [16].

The target populations—primary school teachers, nurses, and parents—were chosen due to their frequent exposure to TDIs in school and home settings. Teachers and parents are often the first to witness dental injuries in children, while nurses are typically the first healthcare professionals to encounter injured patients in hospitals and medical centers. The study was conducted in primary schools, where children aged 6 to 12 years are at a higher risk of TDIs due to falls, collisions, and other accidents. This age group also experiences a high frequency of maxillofacial trauma, particularly during the mixed dentition stage, as reported by El-Kenany *et al.* and Patidar *et al.*[17,18] The selection of these populations and settings was further supported by studies such as Awad and Hegazy [19], who reported that 46% of TDIs occur in schools, particularly among primary school children.

Regarding to witnessed dental injuries accident, about (62.2%) teachers, (68.9%) nurses and (46.7%) parents said yes, whereas other researches in UAE and reported that (28%), (47%) and (30%) teachers respectively had witnessed dental injuries accident [20,21,22]. This is indicated that dental trauma is a major problem in Egypt as schools might be un safe playground. In addition, homes contained a lot of furniture which did not give space to children to play safely.

There was improvement in posttest questionnaire about importance of including management of TDIs in first aid training program in agreement with Tewari *et al.* [23] who reported in their systematic review that all the teachers displayed positive attitudes towards the inclusion of dental trauma first-aid as part of training for school teachers. Moreover, first aid training courses did not give information about management of TDIs as mentioned by Alsadhan *et al.* [24].

There was significant improvement about dealing with avulsed tooth after receiving training such as importance of looking for avulsed tooth to reimplant it immediately as any delay exceed 30 minute will lead to root resorption and decrease prognosis [25]. Proper handling of avulsed tooth from crown and rinsing by tap water without rubbing conserve integrity of periodontal ligament (PDL) on root so increase success of replantation. The combined method was particularly effective in teaching participants about the correct storage media (e.g., milk) and the importance of avoiding water, which can damage the periodontal ligament as its hypertonic media which lead to necrosis of PDL and ankylosis of root. There was huge transformation from 0 to 100 % in posttest questionnaire regarding self -reimplantation in contrast to Baginska and Wilczynska-Borawska [26]in Poland who revealed that 44% nurses could not do self-reimplantation after receiving lecture.

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Regarding to dealing with fractured tooth, there was significant improvement after training particularly with searching for fractured fragment and conserve it in cold water as keep fragment hydrated prevent collapsing of collagen fibers of dentin thus good bonding capacity and natural appearance [27].

Most of participant assured on importance of follow up after tooth avulsion, fracture and displacement after receiving training to detect any inflammatory reaction, change in tooth colour or develop any periapical pathosis [28].

The effectiveness of the educational methods varied across the different target populations. The smartphone application was particularly effective for teachers, likely due to its convenience and interactive nature. Teachers t,who are often the first to respond to dental injuries in schools. benefited from the app's step-by-step instructions, which could be easily accessed during emergencies. Nurses, who already had a higher baseline knowledge of TDIs, showed the most improvement with the combined method, which reinforced their existing knowledge through multiple learning modalities. Parents, who are typically the closest to children and responsible for their care, also benefited significantly from the combined method, which provided clear and comprehensive information. These findings align with previous studies [5,7,14,29] which demonstrated that audio-visual (AV) methods and smartphone applications are effective tools for educating non-dental professionals about TDI management. In additions, lecture is less effective than other methods as it is exclusive and difficult in time of accident to remember what they had learned from lectures and other manual instructions like brochures which may not valid in the place of the accident.

The study's findings have important implications for practice and policy. First, they highlight the need for widespread education on TDI management among non-dental professionals, particularly those who work closely with children. By equipping teachers, nurses, and parents with the knowledge and skills to manage dental trauma effectively, the prognosis for injured teeth can be significantly improved. Second, the findings suggest that smartphone applications, such as FADTA, can serve as valuable tools for disseminating information about TDI management, especially in regions where access to dental care is limited. Third, the study underscores the importance of using multi-modal educational methods, such as the combined approach, to enhance information retention and improve learning outcomes.

Based on these findings, several recommendations can be made. First, schools, hospitals, and community centers should implement regular training programs on TDI management for teachers, nurses, and parents. These programs should utilize a combination of methods, including smartphone applications, lectures, and hands-on demonstrations, to maximize learning outcomes. Second, educational curricula for teachers and nurses should include modules on dental trauma management to ensure that they are prepared to handle such incidents effectively. Third, governments and healthcare organizations should launch public awareness campaigns to educate the general public about the importance of immediate action in cases of dental trauma. Finally, further research should explore the long-term retention of knowledge gained

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through these educational methods and assess their impact on actual clinical outcomes for patients with TDIs.

Regarding to heat map and CCA, in this study the time (pretest and posttest questionnaires) had great effect on all questions. Furthermore, choosing different groups (teachers, nurses and parent) in this study gave valuable results as there was difference in response toward most of questions. Most of questions had significant correlation with each other's.

In conclusion, this study demonstrates that education plays a vital role in improving the management of TDIs among non-dental professionals. By training teachers, nurses, and parents, the chances of saving injured teeth and improving oral health outcomes for children can be significantly enhanced. The combined method, which integrates verbal, written, and visual information, was found to be the most effective in retaining knowledge, making it a valuable approach for future educational initiatives. The findings underscore the importance of equipping laypeople with the skills and knowledge needed to respond effectively to dental emergencies, ultimately reducing the burden of TDIs on individuals, families, and healthcare systems. Future research should build on these findings to further refine educational strategies and improve outcomes for patients with TDIs.

Limitations of the study include that the research was carried out during the Covid-19 pandemic when there were numerous on and off restrictions in schools and pediatric dental clinic in Suez Canal University. In addition, the sample size was small which was convenient sample with active places at this time. Difficulty to obtain permission to visit schools.

CONCLUSION

This cross-sectional study demonstrated that all three educational methods—smartphone application, PowerPoint lecture, and the combined approach—were effective in increasing awareness and knowledge about the management of traumatic dental injuries (TDIs) among primary school teachers, nurses, and parents. The combined method, which integrated both the smartphone application and PowerPoint lecture, proved to be the most effective, followed by the smartphone application alone and then the PowerPoint lecture. Significant improvements were observed across all groups, with correct response rates increasing to 80%-100% in the posttest questionnaires. Teachers showed the highest improvement in knowledge, followed by parents and then nurses, suggesting that the impact of educational interventions varied based on the participants' background and prior exposure to dental trauma management. These findings underscore the importance of targeted educational programs in enhancing preparedness for managing TDIs, particularly in school and community settings. The study highlights the potential of digital tools, such as smartphone applications, as accessible and effective resources for disseminating critical dental trauma management information. Future efforts should focus on integrating such educational methods into training programs for teachers, nurses, and parents to improve outcomes for children experiencing dental injuries.

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Abbreviations:

Abbreviations	Explanation
AV	Audio-visual
FADTA	First Aid Dental Trauma Application
IADT	International Association of Dental Traumatology
PDL	Periodontal ligament
REC	Research Ethics Committee
TDI	Traumatic dental injury

Declarations:

Approval: The current research was conducted after the approval of the Research Ethics Committee (REC) of the Faculty of Dentistry, Suez Canal University (authorization number 295/2020). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki

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Authors' contributions

Conceptualization, MM, AA, and MS; methodology, MM; formal analysis, MM, AA, and MS; investigation, MM; data processing, MM, AA, and MS; writing-original draft preparation, and writing-review and editing, MM; visualization. All authors reviewed the final manuscript and gave their approval.

Consent to Participate declaration: Not applicable

Data availability

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

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