Medical Science

pISSN 2321–7359; eISSN 2321–7367

Knowledge and perception about light-curing units among dental students and interns: A cross-sectional study

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To Cite:
Alsenan D, Mudhish H, Alharbi L, Alzahrani M, Aljarallah N, Ageel F. Knowledge and perception about light-curing units among dental students and interns: A cross-sectional study. Medical Science 2022; 26: ms529e2600.
doi: https://doi.org/10.54905/disssi/v26i130/ms529e2600

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Peer-Review History
Received: 15 November 2022
Reviewed & Revised: 19/November/2022 to 06/December/2022
Accepted: 10 December 2022
Published: 14 December 2022

Peer-review Method
External peer-review was done through double-blind method.

URL: https://www.discoveryjournals.org/medicalscience

ABSTRACT

Objective: This study aimed to evaluate the knowledge and perception of dental students and interns about Light-Curing Units (LCUs), at Princess Nourah Bint Abdulrahman University (PNU), Riyadh, KSA. *Materials and Methods:* The online questionnaire entailed 14 questions that were grouped under three sections: (1) Demographics, (2) LCUs and light-activated materials and (3) LCUs' maintenance, safety and disinfection. Chi-Square and ANOVA tests were used to compare the groups with a significance fixed at $p \leq 0.05$. *Results:* A total of 108 dental students and interns participated in the survey. Regarding the overall knowledge among the groups, an insignificant statistical difference was found between the groups' knowledge of LCUs based on the level of education (P-value=0.231). As for the appropriate infection control methods, many have answered correctly (69.4%). Regarding the use of radiometers (50.9%) of the participants do not use radiometers in their daily practice, moreover (36.1%) were not familiar with the device. *Conclusion:* Our findings suggest that dental students and interns have very low overall knowledge regarding the light-curing units while demonstrating relatively high awareness toward maintenance and infection control protocols.

Keywords: Light-Curing Units, Interns, Dental students, Saudi Arabia.

1. INTRODUCTION

The use of resin-based restorations and materials has remarkably increased in the recent years and consequently so has the use of light-curing units (LCUs) (Kramer et al., 2008). The polymerization of light-cured materials is a clinically significant process to ensure that these materials obtain their intended properties to serve for a long period of time (Bayne, 2012). Therefore, if resin-based materials are not sufficiently light-cured, various types of clinical failures may occur as repercussions; including, but not limited to, recurrent caries, restoration fracture, marginal breakdown and adhesive failure (Bernardo et al., 2007). The efficiency of light-polymerization of a resin is greatly influenced by several factors, like, the wavelength, irradiance of the LCU, material composition, shade translucency, increment thickness and

curing time (Jadhav et al., 2011). Moreover, the cured materials are directly affected by the light source and intensity (David et al., 2007). Meticulous attention should be practiced when selecting the appropriate LCUs, especially parameters like their energy, irradiance and beam uniformity, which have a direct impact on the final restoration (Jadhav et al., 2011).

The four currently available Light-curing unit systems are Light-Emitting Diode (LED), Quartz-Tungsten-Halogen (QTH), Argon-laser and Plasma Arc Curing (PAC) (Singh et al., 2011). The LED poly-wave system is by far the most widely utilized type due to its many advantages overcoming the shortcomings of other LCU's, such as minor heat generation and dissipation, re-chargeable, wireless, less bulky, durable device with a long shelf (Corciolani et al., 2008). Additionally, the curing unit tip position over and distance from, the restoration surface during the polymerization process is an essential factor to guarantee the complete curing of all the surfaces, thereby obtaining an optimum restoration (Leprince et al., 2010; Jandt and Mills, 2013). Moreover, as the light-curing units age, the poorer the intensity of the emitted light becomes (Martin, 1998). The decline in the light intensity can be linked to several reasons such as bulb frosting, improper disinfection or autoclaving of the light guide, damage to internal fibers and reflectors and adhesion of cured restorative material remnants (Martin, 1998; El-Mowafy et al., 2005).

The light intensity of the LCUs can be measured by handheld dental radiometers, which are adjunct devices to the LCU, that also control the light output (Price et al., 2012; Rueggeberg et al., 2017). Many dentists are unaware of radiometers or do not have access to radiometers in their practice (Afshar et al., 2021). Additionally, 'Blue Light Hazards', occurring from prolonged exposure to blue light sources without protection, can lead to corneal apoptosis, retinal injuries, ocular dryness and inflammation (Alasiri et al., 2019). Consequently, dentists and dental assistants are at risk and more prone to developing these injuries, thereby mandating that the precautionary guidelines developed by the Occupational Safety and Health Administration must be followed (Shortall et al., 2016; Price, 2017). Periodic maintenance, proper disinfection and following safety protocols of LCU devices are crucial aspects of practice; overlooking them limits the performance and diminishes the quality of the LCUs and consequently, the resultant restoration (Hegde et al., 2009; Milly and Banerjee, 2018). The literature, thus far has mostly concentrated on the knowledge or lack thereof, among general dentists pertaining to the awareness about the proper use and maintenance of LCUs (Santini and Turner, 2011; Tuloglu et al., 2016; Alqabbaa et al., 2018; Alsuliman et al., 2018; Afshar et al., 2021; Al-Senan et al., 2021). There is a dearth of evidence regarding the knowledge of LCUs among undergraduate dental students and interns. Therefore, the goal of this cross-sectional study was to evaluate the knowledge and perception about the various aspects of light-curing units utilized in dentistry, among the dental students and interns attending Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia.

2. MATERIALS AND METHODS

This cross-sectional study was approved by Princess Nourah Bint Abdulrahman University's (PNU) Institutional Review Board with the reference number 21-0455. The survey tool used was a validated questionnaire that comprised of fourteen questions divided into three main sections; the first section collected demographic data (level of education, gender and college name); the second section consisted of seven questions related to the type of light-curing units being used during practice and about light-activated material science; and the last section included four questions pertaining to the maintenance, safety precautions and disinfection of the LCUs.

The target population were the clinical dental students (n=146) at PNU attending from third-year to internship. Pre-clinical dental students were excluded from the study. It is worthy of mention that no male students could be included in the current study as the university is a female only establishment. The questionnaire was uploaded onto Google Forms, and the survey was distributed among the target population electronically through various network channels (Email addresses and personal contacts).

All the statistical analysis was performed using SPSS software version 28. The descriptive data, such as Mean (SD) and Percentage, was estimated. The categorical data was compared between the groups using Chi-Square test. The continuous data was compared between the groups using ANOVA test. The statistical significance was fixed at $p \leq 0.05$.

3. RESULTS

Demographics

A total of 108 dental students and interns participated in the questionnaire, which accounted for a response rate of 74% (total population 146). Of the 108 respondents, third-year students were 28 (25.9%), fourth-year students were 23 (21.3%), fifth-year students were 26 (24.1%) and interns were 31 (28.7%) (Table 1).

Knowledge of Light Curing Units (LCUs)

All the participants utilize light-curing units and light-activated materials. With regards to the type of LCUs being used, the correct response was LED, where 45.2% of the interns and 46.2% of the fifth-year students answered correctly. However, only 21.7% of fourth-year and 21.4% of third-year students answered this question correctly. No statistically significant difference was seen between all the groups. The percentages of correct responses to the question inquiring about the definition of "Irradiance", were 12.9%, 11.5% and 8.7% for interns, fifth-year and fourth-year students, respectively. Whereas, exactly half (50%) of the third-year students answered correctly. Third-year students showed a statistically significant superior knowledge in regards to this question, then did the other groups (p-value <0.001).

Most of the participants answered the question about the association between insufficient radiant exposure and resin-based composite (RBC) properties correctly, with Interns at 74.2%, fifth-year at 65.4%, fourth-year at 91.3%, and third-year at 82.1%. There was no statistically significant difference between the groups. The majority of the respondents answered the question about the effect of tooth location and morphology on the position between the LCU's tip and the resin material surface correctly, with fourth-year students demonstrating the highest percentage of correct responses (91.3%|), followed by third-year students at 85.7%, then the fifth-year students at 84.6% and lastly the interns at 54.8%. A statistically significant difference was found in favor of fourth-year students with a P-value=0.004. Regarding the new advancements in LED units, correct responses were presented by 82.1% of the third-year students, 73.9% of the fourth year, 42.3% of the fifth-year and lastly, 38.7% of the dental interns. A statistically significant difference was observed between the groups demonstrating more knowledge among the third-year dental students (P-value=0.001).

Table 1 The distribution of participants based on level of education

	Frequency	Percentage
Dental interns	31	28.7 %
5th year dental students	26	24.1 %
4th year dental students	23	21.3 %
3rd year dental students	28	25.9 %
Total	108	100 %

Lastly, the percentages of the participants who increased the curing time, longer than the manufacturer's recommendation, to overcome reduced LCUs' power output were 67.7%,46.2%, 30.4%, 50% for dental interns, fifth-year, fourth-year and third-year respectively. No statistically significant difference was found between the groups (Table 2).

Table 2 Comparison between dental students and interns regarding the knowledge towards light-curing unit (ICU) and light-activating materials, maintenance and infection control

Item	3rd year dental students (n=28) No. (%)	4th year dental students (n=23) No. (%)	5th year dental students (n=26) No. (%)	Dental interns (n=31) No. (%)	Total (n=108) No. (%)	X²-value	*P* value
Light cure units and material science:							
Do you use LCUs and light-Activated materials?						-	-
Yes	28 (100%)	23 (100%)	26 (100%)	31 (100%)	108 (100%)		
No	0	0	0	0	0		
What type of LCU are you using?						6.917	.410
Correct (Light-emitting diodes LED)	6 (21.4%)	5 (21.7%)	12 (46.2%)	14 (45.2%)	37 (34.3%)		
Incorrect (Quartz-tungsten-halogen (QTH), Plasma-arc lights (PAC), Argon-ion lasers, Unsure)	22 (78.6%)	18 (78.3%)	14 (53.8%)	17 (54.8%)	71 (65.7%)		
What is the proper term to describe the amount of power output of the LCU received over a defined area of resin based dental material?						18.722	<.001
Correct (irradiance)	14 (50.0%)	2 (8.7%)	3 (11.5%)	4 (12.9%)	23 (21.3%)		
Incorrect (radiant energy, radiant	14 (50.0%)	21 (91.3%)	23 (88.5%)	27 (87.1%)	85 (78.7%)		

power, radiant exposure)							
Insufficient radiant exposure was found to be associated with which of the following's properties of resin-based composite (RBC):							
Correct (Low mechanical and physical properties)	23 (82.1%)	21 (91.3%)	17 (65.4%)	23 (74.2%)	84 (77.8%)	5.284	.125
Incorrect (less bacterial colonization, high bond strength, good color stability)	5 (17.9%)	2 (8.7%)	9 (34.6%)	8 (25.8%)	24 (22.2%)		
Location and morphology of the tooth can affect the position between the LCU tip and the resin material surface, the dentist should always aim to:							
Correct (hold the light curing tip is as close as possible to the restoration surface at 90^0 angle)	24 (85.7%)	21 (91.3%)	22 (84.6%)	17 (54.8%)	84 (77.8%)	13.596	.004
Incorrect (hold the light curing tip up to 10 mm away from the restoration surface, position the light curing tip at 45^0angle at 6 mm away from the restoration surface)	4 (14.3%)	2 (8.7%)	4 (15.4%)	14 (45.2%)	24 (22.2%)		
What is the new advancement technology in the latest LED which makes it different than other types of LCUs?							
Correct (It generates poly-wavelengths)	23 (82.1%)	17 (73.9%)	11 (42.3%)	12 (38.7%)	63 (58.3%)	16.486	.001
Incorrect (it generates mono-wavelengths, it has an advance filter and ventilation fan)	5 (17.9%)	6 (26.1%)	15 (57.7%)	19 (61.3%)	45 (41.7%)		
To overcome any clinical factor that might affect the reduction in power output, you might need to:							
Correct (increase the curing time more than manufacturer's recommendation)	14 (50.0%)	7 (30.4%)	12 (46.2%)	21 (67.7%)	54 (50%)	7.579	.056
Incorrect (store RBC material in a refrigerator before clinical application, choose darker shade of RBC)	14 (50.0%)	16 (69.9%)	14 (53.8%)	10 (32.3%)	54 (50%)		
Maintenance, safety, and disinfection of LCUs:							
Do you inspect and clean the LCU before use to ensure it is on the correct setting, in good working order, and free of defects and debris?							
Yes	16 (57.1%)	16 (69.6%)	21 (80.8%)	22 (71.0%)	75 (69.4%)	3.602	.308
No	12 (42.9%)	7 (30.4%)	5 (19.2%)	9 (29.0%)	33 (30.6%)		
Do you use Radiometer to monitor your LCU output before any clinical session?							
Yes	2 (7.1%)	3 (13.0%)	7 (26.9%)	2 (6.5%)	14 (13%)	19.920	.003
No	21 (75.0%)	13 (56.5%)	11 (42.3%)	10 (32.3%)	55 (50.9%)		
Not familiar with this device	5 (17.9%)	7 (30.8%)	8 (30.8%)	19 (61.3%)	39 (36.1%)		
Infection-control technique was found to affect the light curing tips and reduce its irradiance value, what is the technique that has the least negative effect?							
Correct (disinfectant with a clear barrier)	16 (57.1%)	17 (73.9%)	19 (73.1%)	23 (74.2%)	75 (69.4%)	2.705	.439
Incorrect (autoclaving, use of disinfectant solution)	12 (42.9%)	6 (26.1%)	7 (26.9%)	8 (25.8%)	33 (30.6%)		

Regarding the new advancements in LED units, correct responses were presented by 82.1% of the third-year students, 73.9% of the fourth year, 42.3% of the fifth-year and lastly, 38.7% of the dental interns (Table 3). The mean knowledge scores were compared between the different levels of education categories using one way ANOVA test. It was observed that the mean knowledge scores decreased gradually with the increase in level of the education. The highest mean knowledge score was 4.64 among 3rd year students and lowest score of 3.96 was recorded among the interns. This difference was statistically non-significant (p=0.231) (Table 3).

Table 3 Comparison of mean knowledge scores between the different levels of education

Marks	N	Mean	SD	95% CI		Minimum	Maximum	P value
				Lower	Upper			
Intern	31	3.96	1.58	3.38	4.54	1.00	7.00	0.231*
5th year	26	3.96	1.56	3.33	4.59	1.00	6.00	
4th Year	23	4.43	1.12	3.95	4.91	2.00	6.00	
3rd year	28	4.64	1.59	4.02	5.26	1.00	7.00	

*ANOVA Test, *Statistically Non-significant at p ≤0.05*

The categorical knowledge scores (Marks) distributed among the different levels of education were compared using Chi-square test. The maximum marks of 7 was scored by 14.3% (n=4) among 3rd year students, 3.2% (n=1) among interns and none of the 4th and 5th year students. The frequency of participants who correctly answering more than 50% (≥4) of the knowledge questions was 67.8%, 53.8%, 78.3% and 75% of Interns, 5th year, 4th year and 3rd year students, respectively. The distribution of knowledge scores (Marks) among the different levels of education was statistically non-significant (p=0.144) (Table 4).

Table 4 Comparison of knowledge scores (Frequency) between different levels of education

		Level of education								
		Intern		5th Year		4th Year		3rd Year		P value
		N (31)	%	N (26)	%	N (23)	%	N (28)	%	
Marks	1.00	2	6.5%	2	7.7%	0	0.0%	1	3.6%	0.144*
	2.00	6	19.4%	2	7.7%	1	4.3%	1	3.6%	
	3.00	2	6.5%	8	30.8%	4	17.4%	5	17.9%	
	4.00	7	22.6%	2	7.7%	6	26.1%	6	21.4%	
	5.00	10	32.3%	7	26.9%	8	34.8%	6	21.4%	
	6.00	3	9.7%	5	19.2%	4	17.4%	5	17.9%	
	7.00	1	3.2%	0	0.0%	0	0.0%	4	14.3%	

*Chi square test, *Statistically Non-significant at p ≤0.05*

Infection Control, Safety and Maintenance of LCUs

The majority of the participants answered that they inspected and cleaned the LCU, with no statistically significant difference between the groups. Seventy-one percent of dental interns, 80.8% of fifth-year, 69.6% of fourth-year and 57.1% of third-year students reported that they inspected their LCUs prior to the clinical session. Only 6.5% of dental interns, 26.9% of fifth-year, 13% of fourth-year and 7.1% of third-year students utilized radiometers. There were also some students who were unfamiliar with the device, amounting to 61.3% of interns, 30.8% of fourth and fifth-year students and 17.9% of third-year students. A statistically significant difference was noticed with a P-value=0.003 (Table 2). Regarding the method of "Blue light hazard" protection, all answers provided were correct and multiple answers were enabled. Most of the participants mainly looked away from the blue light (Figure 1). Finally, with regards to the infection control approach resulting in the least negative effect (disinfectant with a clear barrier) on the LCUs, most responses were correct, with 74.2% of dental interns, 73.1% of fifth-year, 73.9% of fourth-year and lastly 57.1% of the third-year students (Figure 1).

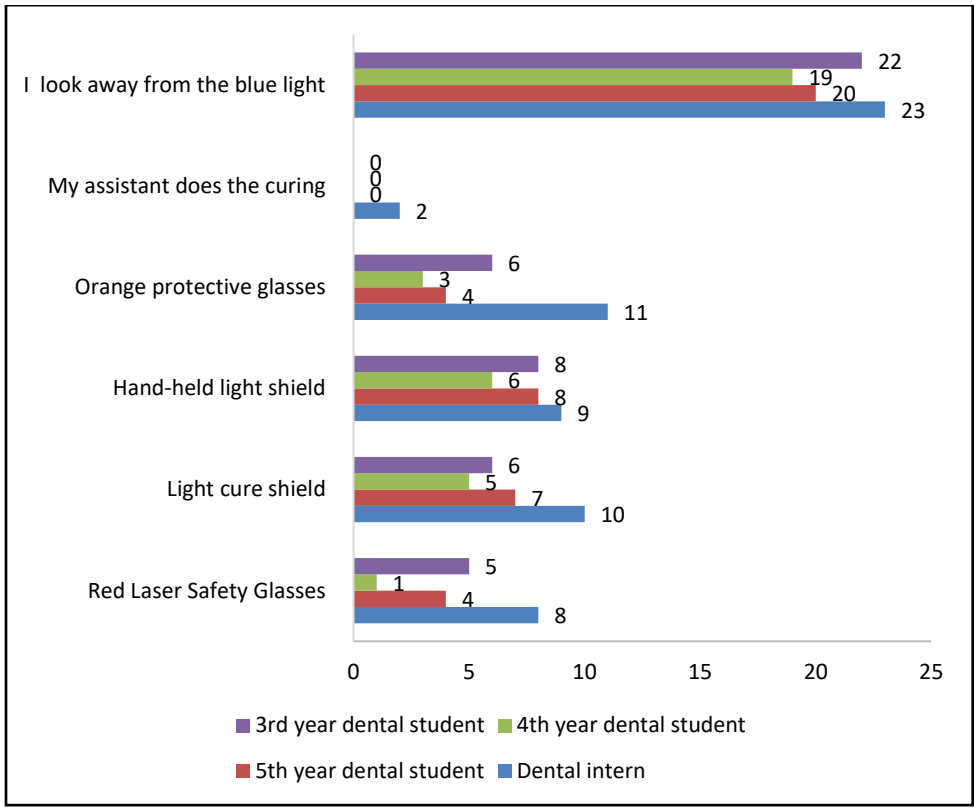

Figure 1 Responses to "Tools used to protect participants' eyes from blue light hazards" (More than one answer allowed)

4. DISCUSSION

This cross-sectional study aimed to compare the knowledge and perception of dental students and dental interns studying at Princess Nourah Bint Abdulrahman University (PNU) in Riyadh, Saudi Arabia, regarding the type of LCU they use in the clinics. The questionnaire comprised of knowledge questions related to the materials and curing of Resin-based composites, maintenance, safety and infection control of the LCUs. The target population was chosen based on the inadequacy of available information in the literature. A validated questionnaire was electronically distributed among the clinical year dental students (third, fourth and fifth-year) and interns (n=146), with an obtained sample size of 108 participants (completed responses). Although the University dental clinics only house LED type LCUs, around two-thirds (65.7%) of the participants were unaware of this fact. A similar result was found in a study conducted among general practitioners and specialists working in the government sector who were unsure about the type of LCUs available to them (Al-Senan et al., 2021). Additionally, the majority (78.8%) of the participants lacked knowledge regarding the definition of irradiance. The current data is in accordance with a previous study established among dentists in Norway's public clinics (Kopperud et al., 2017). Thorough knowledge regarding the properties of resin-based composite (RBC), the proper curing technique and duration is crucial for the long-term success of these restorations (Jadhav et al., 2011). The radiant exposure of uncured resin materials significantly impacts their mechanical and physical properties. The present data showed that most of the respondents (77.8%) are well conscious of the detrimental effect of insufficient radiant exposure on the final restoration. A study illustrated a contrary result, with clinicians in Turkey expressing inadequate recognition of the consequences of substandard polymerization (Tuloglu et al., 2016).

Moreover, the tip position and distance in relation to the composite resin are essential measures to enhance the energy received by the resin-based restoration (Ueda et al., 2010). Predominantly, 77.8% of dental interns and students answered correctly regarding the distance and angulations, which was to place the tip the closest they possibly could and at a right angle. The newly developed LED type generation produces a broad-spectrum output integrating multiple wavelengths and colors (Afshar et al., 2021). In the current study, over half of the participants (58.3%) were up to date regarding the newly emerging LED curing units that generate poly-wavelength. Furthermore, half of the respondents were aware that increasing the curing time above the manufacturer's recommendation, would compensate for the reduction in the power output. As documented in previous literature, increasing the curing duration will ensure the exposure of all restoration surfaces and ultimately, result in a complete polymerization (Rasetto et al., 2001; Obici et al., 2004).

Concerning the maintenance of LCUs, a great number of participants (69.4%) reported that they inspect and clean the LCU before the dental procedure. These results are in accordance with another study assessing the dental student's maintenance behaviors toward LCUs (Bezerra et al., 2021). However, another study contradicted this result, wherein they revealed an improper inspection and handling of LCUs among general dentists (Kopperud et al., 2017). This could be attributed to the fact that in most universities, PNU included, dental students are the ones responsible for the maintenance and disinfection of LCU in their clinic. Radiometers are used to identify the declining light output of LCUs, thereby informing the practitioner of the need to increase the exposure time in order to overcome this issue (Shortall et al., 2016). This study found that 50.9% of the participants did not use a radiometer, while up to 36.1% of them were unfamiliar with the device. Similarly, it was reported that many primary dental care dentists in Britain were not aware that radiometers were a part of their LCUs, whereas a few of them had access to the device, but did not utilize it (Santini and Turner, 2011). The mean knowledge score was relatively higher among third-year students, although not statistically significant, which could be attributed to the fact that they were more recently exposed to the theoretical aspects of LCUs during their restorative course that is given in the third year.

LCUs produce high-intensity light which could result in diverse adverse effects, particularly on the eyes. Therefore, it is imperative for the clinician to follow the precautionary regulations (Price, 2017; Rueggeberg et al., 2017; Fluent et al., 2019). The data of this study has shown that most of the students and interns practice numerous protection methods, with the majority looking away from the blue light with or without using red laser protection goggles or hand-held light shields. A considerably large number of dentists worldwide protect their eyes while curing. Additionally, the most protective measure practiced among the dental clinicians for Light-hazard is to avoid direct eye-contact, while using a protective eyewear being the second used safety approach (Kopperud et al., 2017; Alsuliman et al., 2018; Afshar et al., 2021; Al-Senan et al., 2021). Nonetheless, using protective goggles whenever there is a blue light hazard is essential according to the Occupational Safety and Health Administration (Fluent et al., 2019). The Light curing units are required to be disinfected regularly for cross-contamination prevention, which could deteriorate the light-curing tip. In the current study it was shown that 69.4% of the participants were aware of the least destructive method to disinfect the LCU, which is via disinfectant and clear barrier placement. However, current research reported that 75% of dentists did not disinfect the LCUs and only used clear barriers (Afshar et al., 2021).

5. CONCLUSION

Within the limitations of the current study, it was found that dental students from third-year to dental interns at Princess Nourah Bint Abdulrahman University had below-average overall knowledge regarding the light-curing units. Nevertheless, the participants demonstrated relatively high awareness levels towards proper maintenance and infection control protocols. This indicates an inadequacy in the emphasis given to provide students with information regarding LCUs and their properties, while only concentrating on the protective and cross-infection control measures to be followed by clinicians. Therefore, light-curing unit focused programs for dental students and intern is crucial to overcoming this knowledge deficit. Moreover, more studies are required with a larger and more diversified sample size to evaluate and determine the knowledge levels in order to obtain representative research results.

Acknowledgments

The authors would like to thank Professor Mamata Iranna Hebbal, from the Preventive Dental Science Department, College of Dentistry, Princess Nourah Bint Abdulrahman University, for her valuable assistance and guidance in the statistical analysis section of this paper.

Authors' Contribution

HM, LA, MA and NA have contributed to the data collection, the analysis of the results and the writing of the manuscript. FA has contributed to the editing and reviewing of the manuscript and approved the final draft. DA has contributed to the conceptualization of the study, study design, editing and reviewing of the manuscript and approval of the final draft. All authors have critically read and agreed to the content of the final manuscript.

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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