

Original Article

Knowledge, Attitude and Self-Reported Practice of Final Year Dental Students on Non-Invasive Management of Caries: A Collaborative Study

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Abstract

Background: Dental caries, one of the most common non-communicable diseases, can be managed non-invasively when lesions are non-cavitated. The aim of the present study was to investigate dental students' knowledge, attitudes, and self-reported practices regarding caries risk assessment and minimally invasive dentistry (MID) in Iran and Ghana.

Methods: A cross-sectional study was conducted in 2022 using a convenience sample of final-year dental students. Following ethical approval, a validated online questionnaire assessing knowledge, attitudes toward caries risk assessment, and self-reported practices based on two case scenarios was administered. Data were analyzed using SPSS software (version 24.0), with statistical significance set at $p < 0.05$.

Results: A total of 185 students responded: 153 from Tehran University of Medical Sciences (TUMS) and 32 from the University of Ghana (response rates: 59% and 67%, respectively). The mean knowledge score was 13.21 (95% CI: 12.96–13.35), attitude score 2.9 (95% CI: 2.84–2.96), and self-reported practice score 2.2 (95% CI: 2.12–2.28), with an effect size of 0.185 for the knowledge domain. In multiple regression analysis, attitude was significantly associated with gender ($p = 0.028$) and school ($p = 0.001$); female students and those from Ghana demonstrated more favorable attitudes toward caries risk assessment and non-invasive management methods. No significant associations were found between background factors and knowledge or self-reported practice. A weak correlation was observed between knowledge and attitude, as well as between knowledge and self-reported practice (Pearson's $r = 0.08$, $p > 0.2$).

Conclusion: Participants demonstrated good knowledge but moderate attitudes and self-reported practice. Integrating this concept into the undergraduate dental curriculum is recommended.

Key Words: Dental Caries, Risk Assessment, Disease Management

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Introduction

Despite significant advances in controlling dental caries, the disease remains prevalent. As a common non-communicable disease, dental caries threatens human health and well-being throughout life. Over 2.4 billion people worldwide have untreated dental caries [1]. Caries becomes apparent when an imbalance exists between risk factors and protective elements, leading to demineralization of tooth

structure. Caries risk is defined as the probability that carious lesions will develop or progress over a given period [2]. Successful management of dental caries relies on assessing the individual's caries risk and implementing appropriate strategies based on relevant risk factors and indicators. Periodic risk assessment is recommended to monitor oral health changes over time [3–9]. Therefore, dentists should be able to identify high-risk individuals and deliver

evidence-based care.

According to the concept of "Minimally Invasive Dentistry," supported by the updated guideline and policy document published by the FDI World Dental Federation in 2016, the dental profession is expected to recognize the value of biologically original healthy tissue [10]. Accordingly, the goal is to preserve tissue, prevent disease occurrence, and intercept disease progression. This concept is based on maximizing preservation of healthy dental structures and includes early detection, caries risk assessment, and risk-based management to minimize unnecessary removal of tooth structure. Caries risk assessment is therefore an essential component of this approach, encompassing the identification of individuals at risk, delivery of risk-based prevention, and support for minimal intervention in caries management [11].

Studies evaluating dentists' attitudes and practices regarding risk-based management of tooth decay have predominantly reported low adherence to the principle of "Minimally Invasive Dentistry" for non-invasive management of the disease [12]. In developing countries, where resources are limited and dental service capacity is constrained, it is important to avoid expensive treatments and preserve tooth structure whenever possible. A recent study reported that the DMFT score of Iranian adults was 8.6 (95% CI: 6.1–9.6) [13]. Similarly, in Ghana, a high number of missing teeth and retained roots, along with poor oral health conditions, were reported by Hewlett in 2022 [14]. These findings highlight the need to emphasize this concept in undergraduate dental training.

Few studies have reported the perspective of dental students on caries risk assessment and applying conservative approaches of caries management in adult patients. Therefore, the purpose of the present study was to assess dental students' knowledge, attitude and self-reported practice regarding caries risk assessment and apply Minimally Invasive Dentistry in Iran and Ghana.

Methods and Materials

This cross-sectional study was conducted between 2020 and 2022 using a convenience sampling method. All final-year dental students at Tehran University of Medical Sciences (International Campus) in Iran and the University of Ghana Dental

School were invited to participate.

Sample size calculation

A convenience sampling approach was employed. In both universities, all eligible final-year dental students were invited to take part in the study. Non-English-speaking dental students and those who did not provide informed consent were excluded from both universities.

Ethical consideration

The information sheet clearly stated that participation was voluntary and that the results would be published anonymously and for scientific purposes only. The study was approved by the Ethics Committee of Tehran University of Medical Sciences (Code: IR.TUMS.DENTISTRY.REC.1400.010) and the University of Ghana Dental School (Code: CPDD/010/015/2021). For ethical compliance, the purpose of the study was clearly explained to each participant, and signed informed consent was obtained from all participants.

Questionnaire Development

Data were collected using a previously validated online questionnaire [15]. In both dental schools, final-year dental students completed the questionnaire, which was distributed electronically. A reminder was sent after two weeks. The questionnaire consisted of three parts: (1) knowledge assessment, comprising a 17-item checklist; (2) attitude assessment, including six statements; and (3) management of two case-scenario patients (low-risk and high-risk). Demographic characteristics were assessed, including age, gender, university, year of dental study, previous university degree, and prior attendance at a workshop on caries risk assessment (CRA). In the knowledge section, participants were asked to answer each item with "yes," "no," or "I do not know." In the attitude section, responses ranged from "completely agree" to "completely disagree." The final part of the questionnaire presented two case scenarios (low-risk and high-risk), and participants were asked to select their preferred stage for restorative treatment.

Data analysis

Descriptive statistics, including percentages and mean scores, were reported. For knowledge and attitude, correct answers were scored as "1" and incorrect answers as "0." In the third part of the questionnaire, self-reported practice was assessed

using a weighted score based on caries risk diagnosis (10 points) and risk-based management of proximal and occlusal lesions (correct vs. incorrect answers scored as 1 vs. 0 for high- and low-risk scenarios). Normality was tested for each domain using the Kolmogorov-Smirnov test and confirmed (knowledge: $p = 0.43$; attitude: $p = 0.28$; self-reported practice: $p = 0.16$). Proper management was defined as follows: for low-risk patients, restoring proximal and occlusal lesions at the DEJ, outer half of dentine, or inner half of dentine stage (C, D, E); for high-risk patients, restoring lesions at the outer or inner dentine stage (D, E) [16].

The sum score for each domain—knowledge, attitude, and proper management of proximal and occlusal surfaces (40 points)—was calculated and entered into the model. A linear regression model was used to adjust for the effects of background variables (age, gender, university, year of dental study, previous university degree, and prior workshop attendance on CRA) on the sum scores for knowledge, attitude, and self-reported management. Each outcome variable (knowledge, attitude, and self-reported practice) was analyzed separately using the enter method, with model assumptions satisfied. There were no missing data, and no collinearity was detected in the models.

Results

All final-year students at both universities were invited to participate. Of the 259 final-year dental students at Tehran University of Medical Sciences (International Campus), 153 responded (59%); of the 48 students at the University of Ghana Dental School, 32 responded (67%) and completed the questionnaire. Students who did not provide informed consent were excluded from the study. Demographic characteristics of the participants are presented in Table 1.

Regarding participants' knowledge of CRA, the majority identified the following factors as increasing caries risk: tooth morphology (deep fissures), xerostomia, fermentable carbohydrate consumption, use of orthodontic appliances, inadequate fluoride exposure, elevated cariogenic bacterial count, visible dental plaque, and untreated caries (at least one tooth) (Table 2).

The mean knowledge score of all participants

regarding caries risk assessment and MID was 13.21 (SD = 2.01; 95% CI [12.96–13.35]; range: 6–17). The mean attitude score was 2.9 (SD = 0.4; 95% CI [2.84–2.96]; range: 1–5), and the mean self-reported practice score was 2.2 (SD = 0.6; 95% CI [2.12–2.28]; range: 1–4).

The assessment of respondents' *attitudes* revealed that, although more than 97% of participants believed that CRA is important for both children and adults, a smaller percentage (80%) were confident that they could perform CRA effectively (Figure 1).

In low-risk patient scenario, 29% of subjects chose to restore caries lesions just at the DEJ (Figure 2).

In the high risk patient 32% of participants decided to restore caries at the DEJ level in both dental schools (Figure 3).

Linear regression model was used to adjust the effect of background variables such as gender, university, year of study of dentistry, previous university degree, and previous workshop attendance on CRA on the sum scores of *knowledge*, *attitude* and *self-reported management*. This analysis revealed that there was no significant association between *knowledge* score and background variables. Linear regression analysis of the impact of background variables and *attitude* showed that female students ($p = 0.02$) and students from Ghana had better *attitude* towards risk-based management of caries ($p = 0.001$). (Table 3). There was no significant association between self-reported practice score and background variables. There was a weak correlation between *knowledge* and *attitude*, as well as knowledge and self-reported practice of participants (Pearson correlation coefficient: $r = 0.08$; $p > 0.2$).

Discussion

The present study reveals that senior dental students in Iran and Ghana possess good level of knowledge of risk-based management of tooth decay, however their attitude and self-reported practice require enhancement. The results of linear regression analysis showed no significant association between background variables such as workshop attendance, study year, dental school, gender, age, and previous degree and students' *knowledge* and *self-reported practice* of risk-based management of tooth decay.

			Frequency	%
Gender	Ghana	Male	19	59.4
		Female	13	40.6
		Total	32	100
	TUMS	Male	60	39.2
		Female	93	60.8
		Total	153	100
Having previous degree	Ghana	Yes	25	78.1
		No	7	21.9
		Total	32	100
	TUMS	Yes	24	15.7
		No	129	84.3
		Total	153	100
History of attending CRA workshop	Ghana	Yes	11	34.4
		No	21	65.6
		I do not know	0	0
	TUMS	Yes	43	28.1
		No	103	67.3
		I do not know	7	4.6
Age	Ghana	Total	153	100
		20-25 years	25	78.1
		26-30 years	7	21.9
	TUMS	Above 30 years	0	0
		Total	32	100
		20-25 years	122	79.7
	TUMS	26-30 years	26	17.0
		Above 30 years	5	3.3
		Total	153	100

Table 1. Demographic characteristics of the study subjects

Female students and those from Ghanaian dental schools had better *attitude* towards caries risk assessment and the application of non-invasive management of non-cavitated caries lesions. There was a weak correlation between knowledge score of participants, their attitude and self-reported practice of risk-based management of dental caries.

In the present study, the level of knowledge of senior dental students regarding the risk-based management of dental caries was good. A greater percentage of participants identified xerostomia, tooth morphology, increased cariogenic bacterial count, and consumption of fermentable carbohydrates as factors that should be considered in CRA. However, only 64% of participants considered the presence of white spot lesions as a risk factor for dental caries. These findings are similar to those of Francisco et al. [17], who considered the presence of white spot lesions in

high-risk subjects. Furthermore, in the present study, more than two-thirds of participants (80%) agreed that previous caries experience is an important risk factor, which contrasts with the findings of Pakdaman et al [15].

In the present study, 94% of dental students at Tehran University of Medical Sciences (TUMS) agreed that low socioeconomic status (SES) is a risk factor for dental caries, whereas only 78% of participants from Ghana considered low SES as a risk factor. This difference in response may be attributed to variations in oral health-seeking behavior between the two countries. In Iran, dental services provided at dental schools are affordable compared with those in private dental clinics. Consequently, students mostly encounter patients from low SES backgrounds who have difficulty affording the cost of dental treatment in the private sector and are predominantly at high risk. In Ghana, however,

Statement	University	Correct		Incorrect		Do not know	
A.Knowledge		N	%	N	%	N	%
History of dental caries in the past year	Ghana	29	90.6	3	9.4	0	0
	TUMS	119	77.8	23	15.0	11	7.2
History of dental restoration in the past 3 years	Ghana	10	31.3	20	62.5	2	6.3
	TUMS	33	21.6	100	65.4	20	13.1
Dental caries is transmissible	Ghana	17	53.1	12	37.5	3	9.4
	TUMS	77	50.3	74	48.4	2	1.3
Presence of white spot lesion	Ghana	24	75.0	7	21.9	1	3.1
	TUMS	94	61.4	54	35.3	5	3.3
Tooth morphology (deep fissures)	Ghana	31	96.9	1	3.1	0	0
	TUMS	150	98.0	3	2.0	0	0
Xerostomia	Ghana	32	100	0	0	0	0
	TUMS	149	97.8	4	2.6	0	0
Fermentable carbohydrate consumption	Ghana	28	87.5	0	0	4	12.5
	TUMS	143	93.5	7	4.6	3	2.0
Using orthodontic appliances (fixed)	Ghana	30	93.8	1	3.1	1	3.1
	TUMS	146	95.5	5	3.3	2	1.3
Low socioeconomic status	Ghana	25	78.1	2	6.1	5	15.6
	TUMS	143	93.5	7	4.6	3	2.0
Use of acidic drinks *	Ghana	0	0	31	96.9	1	3.1
	TUMS	145	94.8	7	4.6	1	0.7
Exposure to inadequate fluoride	Ghana	32	100	0	0	0	0
	TUMS	130	85.0	16	10.5	7	4.6
Dentine radiolucency	Ghana	24	75	4	12.5	4	12.5
	TUMS	121	79.1	24	15.7	8	5.2
Increased cariogenic bacteria count	Ghana	30	93.8	0	0	2	6.3
	TUMS	142	92.8	7	4.6	4	2.6
Visible dental plaque	Ghana	29	90.6	2	6.3	1	3.1
	TUMS	131	85.6	18	11.8	4	2.6
Having gastrointestinal disease *	Ghana	1	3.1	22	68.8	9	28.1
	TUMS	17	11.1	115	75.2	21	13.7
Untreated caries (at least one tooth)	Ghana	29	90.6	3	9.4	0	0
	TUMS	130	85.0	14	9.2	9	5.9
Discolored front teeth *	Ghana	11	34.4	9	28.1	12	37.5
	TUMS	76	49.7	36	23.5	41	26.8

Table 2. Frequency distribution of students' knowledge on risk factors related to caries risk assessment in TUMS (international branch) (n=153) and Ghana (n=32)

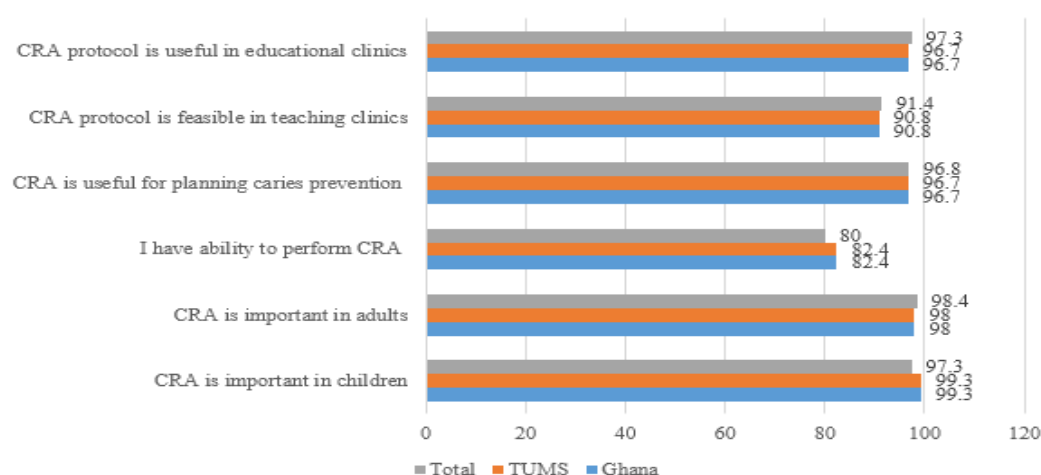


Figure 1. Frequency distribution of responses of all participants on the attitude towards performing caries risk assessment (%)

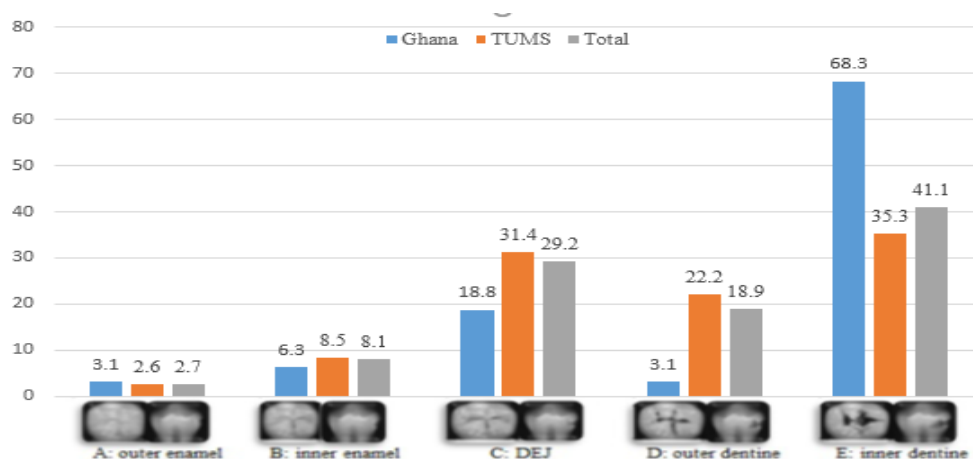


Figure 2. Frequency distribution of responses of all participants on the attitude towards performing caries risk assessment (%)

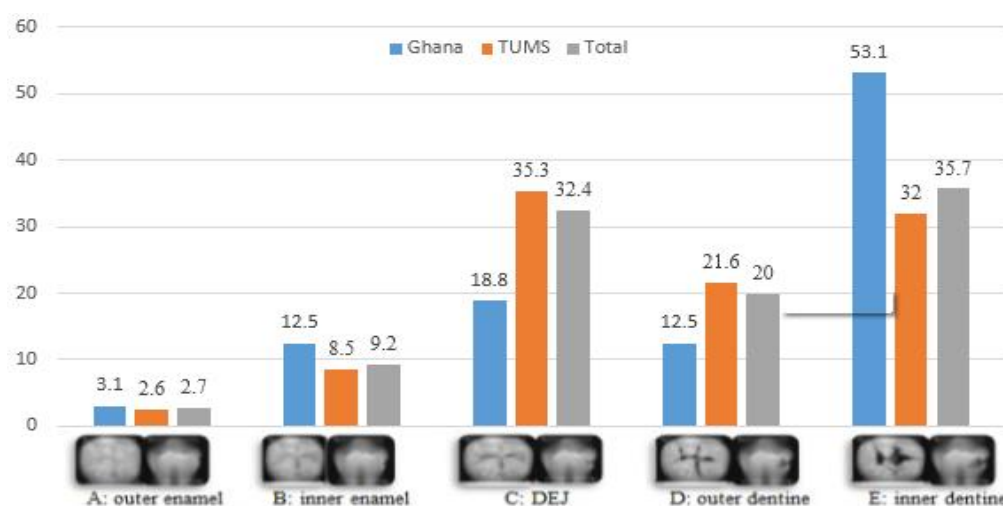


Figure 3. Frequency distribution of self-reported practice of respondents presented as restorative treatment decision of proximal and occlusal lesions in *high-risk patient scenario* (%)

dental services are mainly provided in governmental hospitals, with primary dental services covered under the National Health Insurance Scheme (NHIS). As a result, patients choose governmental hospitals for treatment by a dentist rather than spending extra time seeking care at a dental school.

In the present study, a greater percentage of participants declared that CRA is important for both child and adult subjects; however, a smaller percentage (80%) were confident in their ability to perform CRA. A similar study reported that 75% of students at Tehran University of Medical Sciences

(TUMS) and 81% of students at Shahid Beheshti University were confident that they could perform CRA based on university instructions [18]. In contrast, a study conducted in India found that only 67% of senior dental students reported that they could perform CRA. In the same study, 80.2% of postgraduate students stated that they could perform CRA, which may reflect the inadequacy of relevant courses in the undergraduate curriculum [19]. In the present study, 94% of participants correctly identified the case presented in the low caries risk scenario. Only 20 participants (11%)

	Unstandardized Coefficients		Standardized Coefficients		Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta	t		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	3.459	.165		20.944	.000	3.133	3.785		
Gender	-.144	.065	-.160	-2.216	.028	-.272	-.016	.976	1.024
Name of your school	-.280	.085	-.238	-3.287	.001	-.448	-.112	.976	1.024

Table 3. Linear regression analysis of the effect of background variables on the *attitude* of participants

chose to restore enamel caries, and 40% of participants decided to restore the tooth before the caries lesion reached the outer dentin in a low-risk patient. In the study by Pakdaman et al. [15], more than 50% of participants chose to restore proximal lesions that had just reached the dentinoenamel junction (DEJ) in a low-risk patient. Drachev et al. [20] reported that in northern Russia, 50% of dentists chose to restore proximal enamel caries, whereas one-third chose to restore when the lesion reached the DEJ. Furthermore, one-third of the participants in that study chose to restore occlusal caries limited to enamel, while two-thirds chose to restore when the lesion reached the outer dentin [20]. In another study conducted in a comprehensive care unit, 89% of participants chose to restore occlusal caries just at the DEJ, whereas 60% chose to restore proximal caries at the DEJ [18]. Compared with previous studies, fewer participants in the present study chose to restore caries before it reached the outer dentin. This finding is in line with current protocols reporting that non-cavitated caries lesions must be treated conservatively, as in low-risk patients, in whom the chance of caries arrest is high—especially when the caries lesion is not yet cavitated [16]. No significant association was found between knowledge and background variables, including workshop attendance, year of dental study, dental school, gender, and age. This finding is consistent with the results of a previous local study, which reported a positive association between previous degree and knowledge of CRA; specifically, participants without a prior non-dental degree demonstrated better knowledge regarding CRA [18]. Conversely, in the study by Bhardwaj et al. [21], postgraduate dental students demonstrated better

knowledge of the risk-based management of dental caries. These findings may reflect the need for additional training and education of undergraduate students in the risk-based management of dental caries. In the current study, the overall attitude toward CRA was moderate. This finding is consistent with the study by Ketaki et al. [22], who reported an overall positive attitude toward the risk-based management of dental caries among dental interns in Pune. In the present study, female students and those studying in Ghana demonstrated a positive attitude toward caries risk assessment. This result contrasts with the findings of Suliman et al. [23], who reported that, at the university clinic of Ajman University, male dentists tended to manage dental caries non-invasively. Considering cultural influences, female students may be more conservative and motivated toward accepting the concept. Given that caries risk assessment and the concept of minimally invasive dentistry are taught in both universities, a greater emphasis on restorative treatment in some countries may make the delivery of non-invasive methods more challenging, which could explain the differing attitudes observed. In the present study, a weak correlation was observed between dental students' knowledge, attitude, and self-reported practice. In contrast, the study by Ketaki et al. [22] reported that dental interns' knowledge was strongly correlated with their attitude toward CRA. In the study by Evans et al. [16], conducted in the fluoridated country of Australia, it was recommended that low- and medium-risk adult patients should be managed non-invasively. Specifically, when radiolucency extends up to the dentinoenamel junction (DEJ), proper patient coaching on oral hygiene instructions,

dietary advice, and appropriate fluoride therapy can enable non-invasive management of dental caries. Although this approach is evidence-based, the concept still requires further promotion within the dental community in developing countries.

A valid and reliable questionnaire [15] was employed in the current study. Nevertheless, several limitations warrant consideration when interpreting the findings. First, the cross-sectional design of the study precludes the establishment of causal relationships between the assessed variables, as data were collected at a single time point. Second, access to student participants was limited, particularly in Ghana, where the response rate was notably lower than in Iran. This geographical disparity necessitated the distribution of multiple reminders, which subsequently prolonged the data collection period beyond the anticipated timeframe. Third, random sampling was not feasible, as participation was contingent upon student availability and willingness, which may have introduced selection bias. Fourth, the assessment of self-reported practice was based on responses to paper-based patient scenarios rather than direct observation of clinical performance. Consequently, the findings reflect students' stated intentions or perceived practices rather than their actual clinical behavior. In light of these limitations, the results should be interpreted with caution, and future research employing longitudinal designs, objective clinical evaluations, and more representative sampling strategies is recommended.

Conclusion

In conclusion, while senior dental students at Tehran University of Medical Sciences (Iran) and the University of Ghana Dental School (Ghana) demonstrate satisfactory knowledge of CRA and minimally invasive dentistry (MID), their attitude and self-reported practice require further improvement. Notably, female students and those from Ghana exhibited more favorable attitudes toward the non-invasive management of dental caries. The persistent inclination to restore enamel lesions underscores the need to strengthen evidence-based caries management skills. Accordingly, competency-based education should be enhanced, with greater emphasis on risk-based and non-invasive management of non-cavitated carious

lesions within the undergraduate curriculum. Future studies involving faculty members and department managers in both countries are recommended to further address these educational gaps.

Declarations

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available because they contain participant-level information collected from dental students but may be available from the corresponding author on reasonable request, subject to applicable ethical and institutional restrictions.

Competing Interests

The authors declare that they have no financial, personal, professional, or institutional relationships or affiliations that could be perceived as having influenced, or potentially influencing, the design, conduct, analysis, interpretation, or reporting of this study. The authors have no financial interests, consultancies, advisory roles, employment relationships, patents, or other commercial interests related to the subject matter or outcomes of this research. No author has received financial support, honoraria, research funding, or other material benefits from any commercial entity or organization that could have a potential interest in the findings of this study. The authors also declare that there are no non-financial competing interests that could have influenced the work.

Authors' Contributions

The study was conceptualized and designed by **A. Pakdaman**. Data acquisition was carried out by **A. Awudu** and **P. Matondo**. Statistical analysis was performed by M.J. Kharazifard. The first draft of the manuscript was written by A. Pakdaman. Critical revision of the manuscript for important intellectual content was performed by A. Pakdaman, A. Awudu, P. Matondo, and M.J. Kharazifard. All authors reviewed and approved the final version of the manuscript.

Declaration of Generative Artificial Intelligence (AI) Utilization

In the preparation of this work, a large language model (ChatGPT, Open AI) was used for the purposes of grammar correction, punctuation refinement, and language styling to enhance journal compatibility. No AI-generated content was introduced without critical review. After the use of this tool, the generated suggestions were reviewed and edited by the authors and the editorial board, and full

responsibility for the final version of the manuscript is assumed by the authors.

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