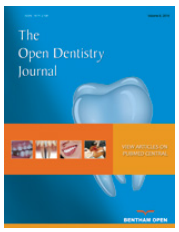

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RESEARCH ARTICLE

An Audit of Saudi Dental Students' Opinions and Attitudes toward Digital Dentistry

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Abstract:

Background:

Digital technologies have gained prominence recently and are increasingly essential to the development of dentistry. Hence, the aim of this research was to examine the utilization of digital technology among dental students in the Kingdom of Saudi Arabia.

Methods:

Electronic surveys were delivered to dental students in Saudi Arabia in a random manner. A total of 816 questionnaires were collected, of which 778 were considered eligible for inclusion in the study. The survey sought data pertaining to gender, age, and educational level, and individuals' involvement in the study was entirely voluntary. The participants were instructed to fill out the questionnaires in accordance with their observations and personal experiences. The acquired data was analyzed using descriptive statistics, which included numerical values and percentages. The statistical analyses employed in this study involved the utilization of the Chi-square test and Fisher's Exact test to evaluate the obtained outcomes.

Results:

Out of a total of 778 students, 758 (97.43%) possessed knowledge regarding digital dentistry, of which 715 (91.9%) acquired knowledge through their college education. Conversely, a comparatively smaller subset of 20 students (2.6%) lacked awareness regarding digital dentistry. The findings of the study indicate that interns and clinical students exhibited significantly greater levels of knowledge compared to preclinical students ($p < 0.01$). In relation to the implementation of digital dentistry in clinical practice, 677 (87.0%) responded yes, whereas 101 (13.0%) expressed a negative viewpoint. In the context of digital technology utilization, 695 (89.3%), expressed the view that digital dentistry is advantageous in terms of diagnostic capabilities. Conversely, 79 (10.2%), held the belief that digital dentistry has the potential to effectively facilitate clinical treatment. A total of 766 (98.5%) participants had a positive perception regarding the enhancement of dental procedure quality through the implementation of digital dentistry. 737 students (94.7%) expressed the belief that digital dentistry would ultimately supplant conventional dental services. A significant majority of the sample 765 (98.3%) replied yes to both questions regarding higher learning outcomes and the necessity of acquiring skills and training.

Conclusion:

The findings of this study found that dental students possess a strong understanding of digital technology, perhaps serving as a source of motivation for engaging in practice.

Keywords: Digital application, Dental students, Dental education, Digital dentistry, Digital technology, Electronic surveys.

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1. INTRODUCTION

Digital technologies have gained prominence recently and are increasingly essential to the development of dentistry [1]. A state-of-the-art computerized system called computer-aided design and computer-aided manufacture (CAD/CAM) technology can scan prepared teeth for crowns, bridges, inlays, and other restorative treatments [2]. Additionally, computer-aided communication and information access in dentistry are growing, as are digital radiography and photography [3]. They are now widely used in dentistry diagnostics and procedures that are mostly reliant on digital techniques, including implant surgery, treatment planning, and impression-taking [3].

The student experience in today's dentistry school is

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increasingly shaped by technology [1], which also drives innovation in the field. Considering the advancements in learning methods and tools, it is essential to understand educational methodologies to maximize educational efficiency [4]. The effectiveness of pre-clinical teaching could be increased by several advances, including virtual anatomy, haptic feedback systems, and improved digital charting techniques [1]. The prevailing educational approach in the majority of higher education institutions involves the utilization of conventional laboratory techniques, such as waxing, casting, finishing, and tooth preparation exercises, for the education of dental students. These activities are typically conducted on a phantom head, also known as a simulation unit [5]. Consequently, the matter at hand pertained to the use of novel digital technologies, such as computer-aided learning (CAL), while simultaneously recognising the importance of manual skill training in the field of dental care [5]. In order to educate dental-related skills, simulation systems and digital haptic have become important instruments [6]. Tactile input has been utilised in several applications to offer immediate feedback, such as identifying cephalometric landmarks, enhancing understanding of dynamic occlusion, evaluating tissue compliance during surgical procedures, and facilitating implant placement by drilling [7]. By employing three-dimensional (3D) virtual models, students can get a deeper comprehension of structural relations that may be difficult to discern in real-world settings [8]. Robot-based simulation systems that may be programmed to simulate a range of physiological conditions are also beneficial for dental treatments and patient management [9]. Haptic systems gain appeal since they lessen the requirement for instructor supervision in schools, which is a problem due to a lack of instructors [10]. The integration of both professor-led instruction and virtual reality input is found to enhance the quality of education, as compared to relying solely on one method over the other [11].

Aside from the advantages already highlighted, managing curricula with digital technology presents considerable obstacles, necessitating adaptation due to the overlap between analog and digital educational objectives [1]. The adoption of digital expertise into teaching institutions in dentistry started on a global scale and has developed at varying speeds depending on regional resources and needs [11]. Several dentistry disciplines have been combined, and 3D teaching packages have been developed to aid students in developing their spatial awareness, clinical correlations interactivity, and critical thinking. Digitalization, which addresses many factors like e-learning and web-based knowledge transmission, appears to have considerably impacted dentistry education overall [11]. Additionally, the use of 3D imaging and digital radiography in diagnostics as well as practice-based training for dental simulator motor skills, and integrating intraoral scanners (IOS) with 3D printing, prototyping, and digital surface mapping, are all examples of how digitalization is influencing these fields [11].

In order to facilitate evidence-based decision-making and comprehensively extract essential information in the era of big data and analytics, it may be imperative for students to acquire supplementary computer programming skills, hence requiring their enrolment in computer courses [1]. In this manner, digital technology might develop into a desired educational objective and skill that eventually takes the place of other subjects in the curriculum [12]. Another worry is that if students prefer connecting with technology over patients, teachers, and classmates, their ability to engage patients may suffer. Another issue to consider is the potential lack of manual dexterity among students, which may hinder their ability to conduct dental treatments at the needed competency levels utilising analogue methods [12]. Lastly, the failure of low socioeconomic societies to progress in educational technology may result in possible social injustice [12].

Due to its significance for future practice, the use of digital technologies in dentistry has attracted the attention of many scholars. To better understand the existing situation, close the knowledge gap in this important field, and provide a foundation for future research, it is imperative to carry out a study on the use of digital technology among Saudi Arabian dental students. A scientific investigation is additionally necessary to assist academicians in assessing the current situation and enhancing potential future outcomes in relation to this crucial field to adjust the curriculum appropriately. Therefore, the objective of this study was to examine the utilisation of digital technology among dental students in Saudi Arabia and enhance the educational results in dental education.

2. MATERIALS AND METHODS

The University of Hail's research council granted its ethical approval before a cross-sectional questionnaire-based descriptive study was carried out from May 2022 to December 2022. A self-administered online survey was used to gather the data. The study protocol (NO: H-2021-145) was approved by our university's institutional review board. Written consent was acquired and participation in the survey was voluntary. The subject of anonymity was strictly respected. The sole purpose of the data was for this study, and it was kept private. The inclusion criteria were dental students from Saudi Arabia. Based on the sample size calculator provided by OpenEpi®, the anticipated sample size for the study was determined to be 750, ensuring a statistical power of 84% at a significance level of 5%.

A self-administered, 12-question structured questionnaire was used to conduct a pilot study with a practical sample of 20 dental students. Participation in the study was entirely optional, and the questionnaire asked for information on gender, age, and academic level. The participants in this study were requested to complete questionnaires based on their personal experiences and observations. Based on their feedback, the questionnaire did not need to be changed at all. Students studying dentistry in Saudi Arabia received the computerized surveys at random. The participants in this study were Saudi nationals and dental students who could complete a self-administered questionnaire. This study did not include people who did not have a dental education or subjects who were not Saudi.

A total of 816 questionnaires were collected, out of which 778 were deemed suitable for incorporation into the research. Completed questionnaires were coded in Windows Excel and statistically analysed using Statistical Package for the Social Science Software version 28 (IBM SPS Statistics). The

acquired data was subjected to calculations of descriptive statistics, including numbers and percentages. The statistical techniques employed in this study included frequencies, crosstabs, chi-square, and Fisher's exact tests. These methods were utilised to assess the statistical significance of gender and study level variations in the perception and knowledge of digital dentistry among dental students in Saudi Arabia.

3. RESULTS

A total of 778 participants answered the questionnaire. Among participants, females were 476 (61.2%), and males were 302 (38.8%). The highest number of subjects, 51 (66.2%), were clinical students, followed by interns 209 (26.9%) and preclinical students 54 (6.9%).

Table **1** illustrates the distribution of questions and corresponding scores pertaining to the domain of digital dentistry. Tables **2** and **3** display the influence of gender and study level on the understanding of digital dentistry. Out of a total of 778 students surveyed, a significant majority of 758 students (97.43%) showed knowledge and awareness of the concept of digital dentistry. Conversely, a small minority of 20 students (2.6%) indicated a lack of familiarity with digital dentistry. There were no significant differences between men and women regarding ideas about digital dentistry ($p > 0.05$), as displayed in Table **2**. Intern and clinical students revealed higher knowledge levels than preclinical students ($p < 0.01$), as exposed in Table **3**. The vast majority of students, specifically 715 individuals comprising 91.9% of the total, acquire knowledge through their attendance at college. There were statistically significant associations between gender and field of study ($p < 0.05$).

Table 1. Distribution of the Responses to the Knowledge of digital dentistry.

Variable		Response n (%)
Idea Digital Dentistry	Yes	758 (97.4)
	No	20 (2.6)
Yes specify	College	715 (91.9)
	Textbook and articles	28 (3.6)
	Internet	22 (2.8)
	Conference	11 (1.4)
Use digital	Yes	677 (87.0)
	No	101 (13.0)
Digital technology useful	Diagnostic satisfaction	695 (89.3)
	Clinical treatment achieved	79 (10.2)
Digital improve	Patient satisfaction	13 (1.7)
	Quality of treatment achieved	15 (1.9)
	Time-saving	6 (0.8)
	Improved accuracy in comparison to previous	4 (0.5)
	High level of predictability of outcome	6 (0.8)
	More than one	734 (94.3)
Digital improve quality compared to traditional	Yes	766 (98.5)
	No	12 (1.5)
Replace traditional	Yes	737 (94.7)
	No	41 (5.3)
Better learning outcomes	Yes	765 (98.3)
	No	13 (1.7)
Require skills and training	Yes	765 (98.3)
	No	13 (1.7)

Table 2. Influence of gender responses of the participants about digital dentistry.

Variable		Gender		P-value
		Male	Female	
Idea Digital Dentistry	Yes	291 (96.4)	467 (98.1)	0.060
	No	11 (3.6)	9 (1.9)	
Yes specify	Collage	273 (90.7)	442 (93.1)	0.015
	Textbook and article	9 (3.0)	19 (4.0)	
	Internet	14 (4.7)	8 (1.7)	
	Conference	5 (1.7)	6 (1.3)	
Use digital	Yes	250 (82.8)	427 (89.7)	0.002
	No	52 (17.2)	49 (10.3)	

(Table 2) contd.....

Variable		Gender		P-value
		Male	Female	
Digital technologies useful	Diagnostic	261 (87.3)	434 (91.4)	0.019
	Clinical	38 (12.7)	41 (8.6)	
Digital improve	Patient satisfaction	4 (1.3)	9 (1.9)	0.022
	Digital improve	4 (1.3)	11 (3.2)	
	Time saving	4 (1.3)	2 (0.4)	
	Improved accuracy in comparison to previous	1 (0.3)	3 (0.6)	
	High level of predictability of outcome	2 (0.7)	4 (0.8)	
	More than one	287 (95)	447 (93.9)	
Digital improve quality compared to traditional	Yes	294 (97.4)	472 (99.2)	0.035
	No	8 (2.6.)	4 (0.8)	
Replace traditional	Yes	283 (93.7)	454 (95.4)	0.077
	No	19 (6.3)	22 (4.6)	
Better learning outcomes	Yes	297 (98.3)	468 (98.3)	0.225
	No	5 (1.7)	8 (1.7)	
Require skills and training	Yes	298 (98.7)	467 (98.1)	0.196
	No	4 (1.3)	9 (1.9)	

Table 3. Influence of study level responses of the participants about digital dentistry.

Variable		Study Level			P-value
		Pre-clinical Student	Clinical Student	Intern	
Idea Digital Dentistry	Yes	46 (85.2)	507 (98.4)	205 (98.1)	0.001
	No	8 (14.8)	8 (1.6)	4 (1.9)	
Yes specify	Collage	41 (77.4)	485 (94.4)	189 (90.4)	0.026
	Textbook and article	5 (9.4)	14 (2.7)	9 (4.3)	
	Internet	4 (7.5)	10 (1.9)	8 (3.8)	
	Conference	3 (5.7)	5 (1.0)	3 (1.4)	
Use digital	Yes	28 (51.9)	475 (92.2)	174 (83.3)	0.007
	No	26 (48.1)	40 (7.8)	35 (16.7)	
Digital technologies useful	Diagnostic	40 (75.5)	479 (93.4)	176 (84.6)	0.068
	Clinical	13 (24.5)	34 (6.6)	32 (15.4)	
Digital improve	Patient satisfaction	0 (0.0)	10 (1.9)	3 (1.4)	0.024
	Treatment Quality	4 (7.4)	5 (1.0)	6 (2.6)	
	Time saving	1 (1.9)	3 (0.6)	2 (1.0)	
	Improved accuracy in comparison to previous	0 (0.0)	0 (0.0)	4 (1.9)	
	High level of predictability of outcome	3 (5.6)	3 (0.6)	0 (0.0)	
	More than one	46 (85.2)	494 (95.9)	194 (92.8)	
Digital improve quality compared to traditional	Yes	51 (94.4)	511 (99.2)	204 (97.6)	0.208
	No	3 (5.6)	4 (0.8)	5 (2.4)	
Replace traditional	Yes	41 (75.9)	501 (97.3)	195 (93.3)	0.013
	No	13 (24.1)	14 (2.7)	14 (6.7)	
Better learning outcomes	Yes	48 (88.9)	510 (99.0)	207 (99.0)	0.001
	No	6 (11.1)	5 (1.0)	2 (1.0)	
Require skills and training	Yes	47 (87.0)	510 (99.0)	208 (99.5)	0.000
	No	7 (13.0)	5 (1.0)	1 (0.5)	

In relation to the utilisation of digital dentistry in clinical practise, a significant majority of the subjects 677 (87.0%), responded affirmatively, indicating their endorsement of this approach. Conversely, 101 individuals (13.0%), expressed a negative response, indicating their reluctance or opposition towards the implementation of digital dentistry in their clinical practise. There were statistically significant associations between digital dentistry and the relative factors ($p < 0.05$), as shown in Tables **2** and **3**. Women and clinical students had higher digital dentistry use than men and either intern or preclinical students, respectively.

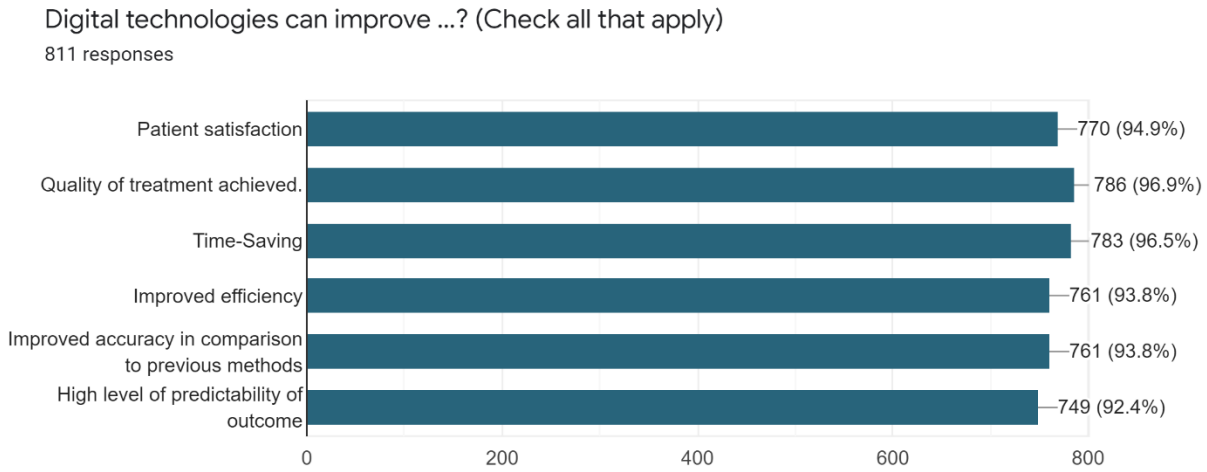

Fig. (1). Shows how digital dentistry improves clinical practice.

In the context of digital technology utilisation, a significant majority of the participants 695 (89.3%) expressed the view that digital dentistry holds utility in the realm of diagnosis. Conversely, 79 individuals (10.2%) held the belief that digital dentistry could effectively facilitate clinical treatment. There were statistically significant differences between genders ($p < 0.05$). however, there were no statistically significant differences regarding the level of study of dental students ($p > 0.05$).

Fig. (**1**) shows how digital dentistry improves clinical practice. Most responses gave more than one answer. There were statistically significant relations between gender and field of study ($p < 0.05$).

For digital to outperform conventional in terms of quality, a significant proportion of the sample, 766 (98.5%) expressed a prevailing sentiment that digital dentistry has a positive impact on the overall quality of dental operations. There were statistically significant gender differences ($p < 0.05$). There were, however, no statistically considerable variations in the level of the study of dental students ($p > 0.05$). 737 students (94.7%) expressed the belief that digital dentistry has the potential to supplant conventional dental practises in the future. There were statistically significant variations in study levels ($p < 0.05$). However, there were no statistically significant gender differences among dental students ($p > 0.05$).

Regarding higher education outcomes and the necessity for skill development and training, a significant majority of the surveyed sample, specifically 765 individuals (98.3%), responded affirmatively to both inquiries. There are no statistically significant differences between genders regarding superior learning outcomes and skill and training requirements ($p > 0.05$). However, there were statistically significant relationships ($p > 0.05$) for the study level.

4. DISCUSSION

Digital simulation technologies have already been included in dental curriculums in a number of countries for undergraduate students. Digital microscopes, digital X-ray images, virtual pathology slides, digital dentistry skill training machines, and digital assessment systems are just a few of the simulation technologies available. However, dental schools are facing a number of issues as they integrate digital dentistry into their regular curriculums. To operate advanced technologies, a large number of people must be thoroughly and efficiently trained. The digital software must connect easily with existing software, and an internal infrastructure capable of managing huge data inputs must be built. To meet demand, high-volume production in large dental institutions necessitates the cooperation of external laboratories. This outsourcing creates a new issue in terms of secure digital data transfer in conformity with regulating agencies' patient privacy and protection standards. Large dental institutions must be aware of the unique problems they face when attempting to implement a digital workflow. An appropriate infrastructure can be developed with sufficient preparation and planning, allowing for a smooth and safe transition to the digital era.

Dental education, like other academic areas, has experienced significant changes. Modern oral health education demands the adaptation of instructional techniques that need a higher level of thoughtful abilities. Gies [13] emphasized the initial necessity for curriculum modification in dentistry schools to “progress instruction”. Furthermore, a range of scientific research [13 - 17] has underlined the need for a pedagogical shift in dentistry education toward a more technologically based curriculum. The academic institutions themselves are seen to be driving this broad interest in curriculum change to increase the quality of oral health instruction for dentistry students. Graduates will be more equipped for a professionally competitive market if education is improved [14]. Baum [15] proposed that various variables, such as altering demographic trends, advancements in medical areas, a tremendous change in offering cutting-edge health care, and economic situations, have influenced the need for an emphasis on curriculum reform in dentistry education.

Digitalization is commonly utilized in dentistry education to improve document accessibility and facilitate cooperation

and communication among students, professors, and administrative personnel. It is vital to encourage a shift in the dental faculty's perspective to promote theoretical and practical knowledge transfer to meet these expectations. Even though dental students must now be equipped for digital dentistry, they must still learn about traditional treatment techniques and processes. They will quickly adapt to digital characteristics as they grow up in the digital environment. Digital dentistry provides various opportunities for objective, standardized evaluation of student performance, which should improve quality. It is presently a "teaching transition phase," and new dental education criteria must be created in general [11, 18 - 20].

Many studies found that digital dentistry has gained in popularity among not only dental educators but also behavioural, social, and educational professionals [18 - 21]. To improve their educational experience and future careers; therefore, dental students are suggested to use digital technology [22]. Students are immersed in digital dentistry and, as a result, are typically excited and motivated about using technology in their future jobs [23, 24]. However, no studies on students' knowledge of digital dentistry in actual practice have been published in Saudi Arabia. As a result, the current study was designed to measure dental students' knowledge and attitudes about digital dentistry.

According to the findings of this study, students had information on digital dentistry, and most of them learned about it in college. This outcome was unsurprising; meanwhile, it was in line with all prior research describing time as a critical issue for dental school administrators due to the excessive amount of knowledge delivered to students [25]. In this setting, educators have to be conscious of their responsibilities in training new dentists who will be managing persons with unique requests who will require empathy and informed consent for decisions in every treatment. The integration of digital tools and applications in the transmission of information is a common challenge for education across all disciplines. However, the field of dentistry, which heavily relies on practical training, presents a particularly complex situation. Students do not learn on their own since training modules are developed digitally. The cornerstone to successful dental education remains continuous instruction with supervision and feedback. In this context, digitalization is unquestionably a fantastic chance to deliver learning content with tremendous excitement and newly awakened passion.

According to the findings of this study, students had a favourable approach toward digital dentistry that agrees with prior research [10, 26, 27]. Students' overall behavioural intentions regarding digital dentistry revealed that they are eager to employ it in their future practice.

The study findings indicate that female participants, particularly those in intern and clinical student roles, had greater levels of expertise compared to their male counterparts and preclinical students. Women and clinical students had higher use of digital dentistry than men and either intern or preclinical students. That might be because the level of knowledge gradually increased across the classes, with preclinical students having the lowest level of knowledge and intern and clinical students having the highest level of expertise. Furthermore, that indicates a superior understanding of digital dentistry and relates to a greater intention to utilize digital technology. This pattern is an excellent predictor of student success and development as they progress through their educational experience. Determining shortcomings in perceived training quality relating to faculty, laboratory assistance, lectures, and time or might help target future efforts to address some of these exhaustive difficulties.

It stands to reason that students who believe their training to be of high quality have more information than students with lesser training, which may be related to problems in the instruction taken [19, 20]. The research, as mentioned earlier, compared student performance utilizing new digital technology to traditional approaches and polled students on their choices. They proposed that students obtain more knowledge if they believe the instruction is of good quality which significantly affects future education programs in dentistry. According to the present poll, students have a favourable attitude toward the usage of digital technology as compared to traditional ways.

Notifying dental students of the degree of technology used during training and emphasizing the value of utilizing technology might influence their willingness to utilize it in the future. Therefore, future attempts to develop dentistry education should focus on elements related to a student's behavioural intention. Enhancing student understanding and views regarding digital dental technology, from the perspective of the dental educator, is critical for students to be involved with digital technology in their practice after graduation. Furthermore, utilizing digital technology during dental procedures with relevant experiences using decent equipment with good information and plenty of training time is probable to assist students in developing favourable approaches toward using technology. Again, that might increase the likelihood of using this technology.

Surveys are utilised to evaluate the extent of knowledge acquired by practitioners/participants and facilitate researchers in reaching a broader community. They allow for the assessment of practitioners' awareness, knowledge, and practises, particularly in relation to current breakthroughs in the field of dentistry. One of the drawbacks inherent in our survey is its restricted sample size, which restricts the generalizability of the findings to a larger population. Because this was cross-sectional research, it merely revealed connections rather than causality. In addition, web-based surveys pose accessibility challenges for participants who may not have the necessary access to participate in the survey. Errors in sampling can occasionally occur in the context of online surveys, while the utilization of open-ended questions and responses may potentially introduce interviewer bias. Even though students appear to be driven toward digital dentistry, and findings show that they want to employ the technology in actual training and future practice, it was not examined; this could be highlighted in future research. The study's findings are confined to the demographic studied undergraduate dentistry students. These findings cannot be extrapolated to other groups, but they can help future studies. Differences in technology use for groups with varied characteristics should be

considered for future processes of invention and deployment of digital technologies to be acceptable for dentists and their jobs. Attitudes toward digital technology may further shape these inequalities, which should be investigated more in the future. In the future, it is important to conduct a comprehensive examination of a very large population, specifically focusing on dentists belonging to a particular specialty, age range, and level of expertise.

CONCLUSION

They were changing and implementing various educational methodologies and training to impact and boost the motivation of the students to employ digital technology in future practice. Under the limitations of this study, it could be inferred that dental students possess a remarkable understanding of digital technology, which may serve as an encouragement for their future professional endeavours. The students reported that digital dentistry is better than traditional methods during various procedures. Most students reported that digital technology would improve dental practice learning outcomes than conventional methods. However, the students emphasize that these technologies need more required skills and training. There was a relationship between student knowledge, attitudes, gender, and degree of education and the use of digital dental technologies in their training. The dentistry profession is undergoing fast technological change. It appears fitting that dentistry education adapts to a dynamic shift toward developing digital technology. Dental educators and developers of digital dental technology might benefit from considering these variances and customizing communication and training accordingly. If a technologically upgraded dental curriculum is developed, the dental profession will profit from an outstanding calibre of qualified dentists.

AUTHORS' CONTRIBUTIONS

IKA and AAM contributed to the concept of the research, study design, statistical analysis, writing the original draft, and reading and editing the final paper. FLA contributed to the concept of the research as well as revising the first draft. SMA and BBA contributed to data gathering and statistical analysis. The final manuscript was reviewed and approved by all writers.

ABBREVIATION

CAD/CAM = computer-aided design and computer-aided manufacture

ETHIAL STATEMENT

The Ethics Committee of Scientific Research, University of Hail, Saudi Arabia, approved the protocol of this study (Ethical number: H-2021-145). All methods were performed in accordance with the declaration of Helsinki.

CONSENT FOR PUBLICATION

Informed consent was waived by the ethics committee of the College of Dentistry, University of Hail.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

All the data and supporting information is provided within the article.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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