A PILOT STUDY ON ATTITUDES TOWARDS ARTIFICIAL INTELLIGENCE AMONG UNDERGRADUATE AND GRADUATE DENTAL STUDENTS IN MEXICO

DOI: https://doi.org/10.26758/16.1.7

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Abstract

Objective. This study aimed to examine differences in attitudes toward artificial intelligence (AI) between undergraduate and graduate dental students in Mexico and to assess how these attitudes relate to ethical attitudes in clinical practice.
Methods. A comparative, correlational, and cross-sectional study was conducted with 35 dental students from a public university in northern Mexico, including 25 graduate students in endodontics and 10 undergraduate students in dentistry. Participants completed two culturally adapted instruments: the Attitudes and Perceptions about the Use of AI in Dentistry Questionnaire and the Ethical Attitude of Dentists Scale (EADS). Descriptive statistics, *t*-tests, and Pearson´s correlation analyses were performed.
Results. Graduate students showed significantly more favorable attitudes towards AI than undergraduates ($p = .049$, $d = –0.77$). Ethical attitude, measured through EADS scores, did not differ significantly by academic level, although graduates scored higher in the domain of *Upholding the profession's position in relationships* ($p = .023$, $d = 0.89$). A moderate significant correlation emerged between AI attitudes and overall EADS scores within the graduate subgroup ($r = .48$, $p = .015$). This correlation was particularly pronounced in domains related to maintaining patient trust and providing information that benefits the patients.
Conclusions. Academic level played a central role in shaping perceptions of AI, with graduates showing more positive attitudes despite comparable ethical attitudes across groups. Among graduates, technological openness appears to be more closely integrated with ethical awareness. These findings underscore the need for early, structured AI education combined with ethics-based training to support the responsible integration of AI into dental practice.

Keywords: attitudes, artificial intelligence, dental students, postgraduates, ethics.

Suggested citation (APA):

Carrillo-Várguez, L.H., Camacho-Vega, D.O., Hernández-Porras, I., & Carrillo-Várguez, A.G. (2026). A Pilot Study On Attitudes Towards Artificial Intelligence Among Undergraduate And Graduate Dental Students In Mexico, *Anthropological Researches and Studies, 16,* 94-106. https://doi.org/10.26758/16.1.7

Introduction

Digital transformation in healthcare has progressively replaced analog methods with sophisticated electronic systems that enable the acquisition, storage, and large-scale analysis of clinical data. In dentistry, digital imaging, computer-aided design and manufacturing, and virtual treatment planning have created a substrate upon which algorithmic methods can operate to support clinical decision-making and enhance the precision of restorative, implantologic, and endodontic procedures, enabling more precise and personalized interventions (Machoy et al., 2020). Building on this foundation, Artificial Intelligence (AI), particularly machine learning and deep learning, has become increasingly prominent in medicine and dentistry, providing tools capable of learning from massive databases and recognizing patterns invisible to the human eye (Schwendicke et al., 2020).

Among the most notable innovations are neural networks and fuzzy logic systems applied to caries detection and oral cancer prognosis, respectively. Deep learning models have achieved sensitivities greater than 90% for identifying periapical lesions and caries in radiographic images (Ossowska et al., 2022). Concurrently, mobile platforms such as AICaries utilize convolutional networks to diagnose caries in children from smartphone photographs, integrating interactive oral health education (Xiao et al., 2021). Furthermore, the use of hybrid models of feature selection and machine learning algorithms has improved prognosis prediction in oral cancer by combining clinical-pathological and genomic markers, achieving promising results in risk stratification and survival prediction (Chang et al., 2013). Complementarily, fuzzy logic has been applied to assess the risk of malignant transformation of potentially premalignant lesions based on oxidative stress parameters (malondialdehyde and proton donor capacity), generating risk scores on a scale of 1 to 10 that facilitate clinical decision-making (Scrobotă et al., 2017).

However, these advancements introduce complex ethical and professional challenges. Diagnostic automation demands robust regulatory frameworks that guarantee data privacy and security, as well as rigorous validation protocols to avoid biases and errors in AI-assisted decision-making (Amiri et al., 2024). While the technical and clinical advancements of AI have been a primary focus, the broader ethical implications for all users (including providers, patients, and other stakeholders) as well as for developers and the industry demand a comprehensive framework to ensure responsible and equitable implementation. Data governance, patient privacy, and cybersecurity are additional non-trivial challenges, particularly when mobile platforms and cloud-based processing are used; policy frameworks and technical safeguards must be established to protect sensitive health information while enabling the beneficial use of shared data (Schwendicke et al., 2020). Moreover, responsibility and liability in AI-assisted decision-making remain ethically and legally ambiguous in many jurisdictions, creating a pressing need for regulatory clarity, clinical oversight mechanisms, and standards for algorithmic explainability (Amiri et al., 2024).

Consequently, the convergence of digital transformation and artificial intelligence not only redefines diagnostic and therapeutic practices in dentistry but also propels a patient-centric approach to treatment. This practice is underpinned by dependable data and augmented by sophisticated tools that optimize prevention, personalize treatment, and elevate the ethical and educational standards of the profession.

Hence, investigating students' attitudes towards artificial intelligence (AI) in healthcare is necessary, as they represent the next generation of professionals and agents of transformation who will integrate algorithmic tools into everyday practice. Their knowledge, attitudes, and competencies will therefore be determinative for its implementation trajectory. A systematic review showed that, although only 44% of medical, dental, and nursing students exhibited medium to high knowledge about AI, only 65% expressed positive attitudes regarding its application in healthcare. This underscores the importance of strengthening training in these areas to close the gap between enthusiasm and technical experience (Amiri et al., 2024).

Disciplinary and geographic surveys in dentistry corroborate this educational gap. Studies from diverse settings indicate that most students believe AI should be included in undergraduate and graduate curricula. For example, a study in Turkey revealed that 74.6% of students believed that AI should be integrated into the undergraduate curricula and 79.8% into graduate programs (Yüzbaşıoğlu, 2020). Similarly, in India, only 55.7% of respondents affirmed that AI should be included in undergraduate training, identifying the lack of technical resources and trained personnel as the primary obstacles (Singh et al., 2023).

Students' attitudes not only reflect their predisposition to adopt emerging technologies but also directly influence their practical integration; those who present traits of openness and agreeableness tend to trust the value of AI more and demand more robust educational content in this area (Ozbey & Yasa, 2025). In Korea, for instance, 93.1% of dental hygiene students obtained information about AI from online sources, but only a small percentage had curricular exposure to the topic, which emphasizes the need to develop specific training programs that include both technical fundamentals and ethical reflection (Jeong et al., 2023).

Consequently, academic institutions must redesign curricula to combine foundational technical content (basic statistics, machine-learning concepts, model evaluation metrics, and data quality) with applied clinical modules and ethical-legal instruction that covers consent, privacy, fairness, and the clinician's supervisory role over algorithmic outputs. Such curricular integration should be accompanied by accessible, hands-on learning experiences, such as case studies, simulated decision-support scenarios, and critically appraised implementations, that cultivate the competencies required to interrogate, validate, and responsibly deploy AI in patient care (Jeong et al., 2023; Singh et al., 2023).

Therefore, students' attitudes towards AI are closely intertwined with ethical awareness and moral attitudes in clinical contexts. Multiple empirical studies indicate that more positive and reflective attitudes (particularly those with strong cognitive – knowledge and affective – emotional– components) are associated with greater ethical awareness and attitudes regarding AI use, whereas the mere frequency of AI use does not reliably predict ethical behavior (Asiksoy, 2024; Buele et al., 2025; Choi et al., 2024; Kwak et al., 2022; Saklaki & Gardikiotis, 2024). Moral attitude –understood as the capacity to recognize ethical issues, foresee potential harms (e.g., privacy breaches, algorithmic bias), and appreciate stakeholder interests functions as a proximal determinant of ethical awareness about AI, and students with higher moral attitudes report greater readiness to apply precautionary, patient-centered measures when interacting with algorithmic systems (Buele et al., 2025). Attitude–ethics correlation has been observed in general student populations and in high-ability scientific cohorts, although effect sizes vary by sample and context. Importantly, educational interventions that explicitly combine AI literacy with ethics training (including digital/media literacy) have been shown to strengthen attitudes towards AI and ethical attitudes, indicating a modifiable pathway from technical competence to ethically aligned practice (Saklaki & Gardikiotis, 2024). Operationalizing ethical attitudes with instruments such as the Ethical Attitude of Dentists Scale (EADS) – a 44-item, three-factor measure that evaluates profession-level stewardship, trust-preserving clinical conduct, and patient-centered information disclosure – permits testing whether attitude-to-behavior translation is mediated by digital literacy, AI self-efficacy, and prosocial professional values, and whether personality traits moderate these relationships (Ebadi et al., 2022).

Additionally, variations in academic levels appear to play a significant role in shaping students' attitudes and perceptions towards artificial intelligence. Undergraduate students, who typically have limited clinical exposure and fewer opportunities to interact with advanced digital tools, often report lower confidence and greater uncertainty regarding the reliability, ethical implications, and applicability of AI in healthcare (Jeong et al., 2023; Singh et al., 2023). In contrast, graduate students who engage more deeply with complex diagnostic processes and digital workflows tend to develop more positive and informed perceptions of AI's potential benefits in

clinical decision-making and patient care (Yüzbaşıoğlu, 2020; Amiri et al., 2024). Personality traits and professional identity formation may further reinforce these differences. For instance, graduates typically exhibit higher openness and agreeableness traits associated with greater receptivity to AI integration in dentistry (Ozbey & Yasa, 2025). Collectively, these findings suggest that academic level is an important determinant of how future professionals evaluate the usefulness, risks, and ethical considerations of AI, underscoring the need for stage-appropriate educational intervention.

For all the reasons outlined above, the purpose of this study aimed to examine the differences in attitudes towards artificial intelligence (AI) between undergraduate and graduate dental students in Mexico and to assess how these attitudes relate to ethical attitudes in clinical practice.

Materials and methods

Study design

A comparative, correlational, and cross-sectional study was conducted during the months of April and May 2025.

Participants

This study utilized a convenience sample of 35 students (mean age: 26.34 years; standard deviation: 3.65; 52% female). The sample consisted of 25 graduate students (endodontics program) and 10 undergraduate students (dentistry) enrolled at the Faculty of Dentistry of the Autonomous University of Baja California, in Tijuana, Mexico.

The post-hoc power analysis in G*Power 3.1 assessed the attitude of our sample (Graduates = 25, Undergraduates = 10, total N = 35) to detect a large effect (Cohen's $d = 0.80$) using an independent-means t test with $\alpha = .05$. The model yielded $\delta = 2.1381$, a critical t-value of 1.692, and a statistical power of 0.6733. Given the sample size and effect, the study had only a two-thirds probability of detecting true effects. This post-hoc power reflects the limitations of the sample size and confirms the underpowered status (<80% power). These results classify this study as a pilot, suggesting that future studies should recruit a larger, more balanced sample for adequate statistical power.

Instruments

Two instruments were used to measure students' attitudes and ethical perceptions towards the use of AI in dentistry. The first was the *Attitudes and Perceptions about the Use of AI in Dentistry Questionnaire* (Karan-Romero et al., 2023), which contains 15 opinion statements evaluated on a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree) (reliability $\alpha = .890$). The second was the *Ethical Attitude of Dentists Scale (EADS*) (Ebadi et al., 2022) (reliability $\alpha = .864$), composed of 44 items distributed across three ethical domains: (1) Maintaining the standing of the profession in relationships (reliability $\alpha = .585$), (2) Providing dental services while maintaining trust in the profession (reliability $\alpha = .862$), and (3) Providing information for the benefit of the patient (reliability $\alpha = .776$).

Both instruments were culturally adapted into Spanish using *back-translation and monolingual and bilingual test* procedures. This process was employed to assess the recommended minimum standards for applying an instrument developed in a different language (Maneesriwongul & Dixon, 2004). Subsequently, three experts evaluated the content validity of both instruments employing the Content Validity Coefficient (CVC) methodology proposed by

Hernández-Nieto (2002). All items attained a CVC > 0.71, demonstrating acceptable validity and concordance.

For a rigorous CFA, a sample size of N > 470 is considered the absolute minimum, based on a 5:1 Subject-to-Parameter ratio for EADS. For the *Attitudes and Perceptions about the Use of AI in Dentistry Questionnaire,* a sample size of N > 155 (15 items, 1 factor) is required. Consequently, Construct Validity for the instruments was not feasible, and Content Analysis was conducted.

The estimated time to complete both instruments was approximately 15 to 20 minutes. Additional sociodemographic information was collected, including the participants' age, sex, and academic level.

Procedure

The questionnaires were distributed digitally via e-mail invitations. All participants were provided with comprehensive information regarding the study's objectives and procedures and were required to sign an informed consent form prior to participation. The study was conducted in accordance with the Declaration of Helsinki and relevant national legislation governing human subjects research and data protection in Mexico. To guarantee anonymity, each participant was assigned a unique numerical identifier rather than using their real name.

Statistical analysis

Descriptive Analysis: Data were analyzed using JASP 0.19.3 statistical software. Descriptive statistics (mean and standard deviation) were calculated for variables such as age, sex, and academic level.

Comparative Analysis: To compare data between undergraduate and graduate students, *t*-Student for independent samples was employed for the overall questionnaire of Attitudes and Perceptions on the use of AI in Dentistry and Ethical Attitude of Dentists Scale (EADS). Additionally, comparisons were made between Attitudes and Perceptions of the use of AI in Dentistry and each domain of the EADS scale: 1) Upholding the profession's position in relationships, 2) Providing dental services while maintaining patient trust, and 3) Providing information for the patient's benefit.

Correlational analysis: Pearson's correlation coefficient was used to investigate the relationship between age, sex, academic level, the questionnaire of Attitudes and Perceptions on the use of AI in Dentistry, EADS, and each domain of the EADS scale.

Results

Descriptive statistics were computed for all performance measures across undergraduate and graduates students. Overall, both groups demonstrated mean scores within comparable ranges, with minor variations in the dispersion indices (see Table 1).

Table 1

Descriptive results by group

Variable	Group	Mean	SD	SE	Coefficient of variation
Attitudes and Perceptions about the Use of AI	1	3.408	0.605	0.191	0.178
	2	3.859	0.583	0.117	0.151
Ethical Attitude	1	4.267	0.311	0.098	0.073
	2	4.225	0.276	0.055	0.065
1. Upholding the profession's position in relationships	1	4.163	0.284	0.090	0.068
	2	3.953	0.215	0.043	0.054
2. Providing dental services while maintaining patient trust	1	4.340	0.377	0.119	0.087
	2	4.432	0.407	0.081	0.092
3. Providing information for the patient's benefit	1	4.525	0.432	0.137	0.096
	2	4.800	0.368	0.074	0.077

Note: The data includes the mean (*M*), standard deviation (*SD*), standard error (*SE*), and coefficient of variation (*CV*) for each group on each test. Group 1 = Undergradute students, Group 2 = Graduate students.

Subsequently, Independent samples *t*-tests were conducted to compare demographic and test-related variables between students categorized as undergraduates and graduates. The results are summarized in Table 2.

A significant difference emerged for age, $t(33) = -3.82$, $p < .001$, with graduates showing higher age values than undergraduates. The effect size was large (Cohen's $d = -1.43$), indicating substantial group differences in this demographic variable. No significant group differences were observed for sex, suggesting that the groups were comparable in terms of gender distribution.

In relation to performance variables, there was a statistically significant difference between the groups in terms of *Attitudes and Perceptions regarding the Utilization of AI*. The *t*-test yielded a value of -2.05 with a *p*-value of .049, indicating a medium effect size (Cohen's $d = -0.77$). This suggests that undergraduate students performed at a lower average level compared to graduate students on this initial assessment. For its part, no significant difference was found in *Ethical Attitude*.

However, when examining specific domains of EADS, a significant difference was found in *Upholding the profession's position in relationships* $t(33) = 2.39$, $p = .023$, with a large effect size (Cohen's $d = 0.89$). This indicates that graduates outperformed the undergraduates in this domain.

In summary, the pattern indicates that the most significant disparities between the two groups were observed in terms of age, Attitudes and Perceptions regarding the Utilization of AI, and specific academic performance metrics, particularly in the domain of *Upholding the profession's position in relationships*.

Table 2

Comparisson between groups

Variable	*t*	df	*p*	Cohen's *d*	SE Cohen's *d*
Age	-3.815	33	< .001	-1.427	0.492
Sex	0.104	33	0.918	0.039	0.374
Attitudes and Perceptions about the Use of AI	-2.047	33	0.049*	-0.766	0.411
Ethical Attitude	0.394	33	0.696	0.147	0.376
1. Upholding the profession's position in relationships	2.386	33	0.023*	0.893	0.424
2. Providing dental services while maintaining patient trust	-0.614	33	0.543	-0.230	0.378
3. Providing information for the patient's benefit	-1.901	33	0.066	-0.711	0.407

Note. SE = Standard Error
* $p < .05$

Finally, Pearson's correlation coefficients were computed to examine the relationships among age, sex, and performance measures within the combined sample of graduate and undergraduate students. Refer to Table 3 for details.

For undergraduates, no significant correlations were observed between age, sex, and any test performance variable ($p > .05$).

In contrast, the performance variables exhibited a consistent and robust pattern of strong intercorrelations among the EADS components. *Ethical Attitude* demonstrated a high correlation with *Upholding the profession's position in relationships* ($r = .922$, $p < .001$), *Providing dental services while maintaining patient trust* ($r = .929$, $p < .001$), and *Providing information for the patient's benefit* ($r = .909$, $p < .001$), indicating a high degree of convergence across EADS.

Furthermore, the EADS subcomponents exhibited strong correlations with one another, including the association between Domain 1 and Domain 2 ($r = .721$, $p = .019$) and between Domain 3 and both Domain 1 ($r = .831$, $p = .003$) and Domain 2 ($r = .806$, $p = .005$). These findings suggest substantial internal coherence in the EADS assessment structure.

Table 3

Correlations for Undergraduate Students

Variable	Age	Sex	Attitudes and Perceptions about the Use of AI	Ethical Attitude	Domain 1	Domain 2	Domain 3
Age	—						
Sex	-0.053	—					
Attitudes and Perceptions about the Use of AI	-0.31	0.223	—				
Ethical Attitude	-0.111	-0.132	0.047	—			
1. Upholding the profession's position in relationships	-0.192	-0.004	0.071	0.922***	—		

Variable	Age	Sex	Attitudes and Perceptions about the Use of AI	Ethical Attitude	Domain 1	Domain 2	Domain 3
2. Providing dental services while maintaining patient trust	-0.011	-0.263	0.039	0.929***	0.721*	—	
3. Providing information for the patient's benefit	-0.084	-0.061	-0.059	0.909***	0.831**	0.806**	—

Note: EADS Domain 1 = Upholding the profession's position in relationships, Domain 2 = Providing dental services while maintaining patient trust, Domain 3 = Providing information for the patient's benefit * $p < .05$, ** $p < .01$, *** $p < .001$

Similarly, Pearson's correlations were computed for graduates to investigate the relationships among age, sex, and performance across variables and domains. Table 4 provides a comprehensive overview of the correlations for graduates.

Age exhibited no statistically significant correlations with Attitudes and Perceptions about the Use of AI or the three EADS domains ($p > .05$). However, age demonstrated a trend-level negative correlation with EADS ($r = –.372$, $p = .067$), and a significant negative correlation with Domain 3 ($r = –.423$, $p = .035$), indicating that younger participants tended to perform slightly better on this specific subtest. Sex was not significantly associated with any of the performance variables ($p > .05$).

In contrast, various domains of the performance assessments exhibited strong internal correlations. *Attitudes and Perceptions about the Use of AI* demonstrated a moderate correlation with EADS ($r = .479$, $p = .015$), indicating shared variance between general performance metrics across tests. Additionally, *Attitudes and Perceptions about the Use of AI* exhibited positive associations with Domains 2 and 3 ($r = 527$, $p = 007$ and $r = 439$, $p = 029$, respectively).

The EADS displayed very strong correlations with all domains, including Domain 1 ($r = .858$, $p < .001$), Domain 2 ($r = .966$, $p < .001$), and Domain 3 ($r = .701$, $p < .001$). These relationships reflect the high internal consistency and coherence within the EADS measures.

Furthermore, most EADS domains exhibited strong intercorrelations. Domain 1 correlated significantly with Domain 2 ($r = .708$, $p < .001$), while Domain 3 demonstrated positive associations with both EADS ($r = .701$, $p < .001$) and Domain 2 ($r = .735$, $p < .001$).

In summary, the findings indicate that while demographic variables (age and sex) exhibited limited associations with performance, the *Ethical Attitude* indicators demonstrated exceptionally high internal consistency, and *Attitudes and Perceptions about the Use of AI* demonstrated a moderate correlation with overall EADS performance.

Table 4

Correlation for Graduate Students

Variable	Age	Sex	Attitudes and Perceptions about the Use of AI	Ethical Attitude	Domain 1	Domain 2	Domain 3
Age	—						
Sex	0.36	—					
Attitudes and Perceptions about the Use of AI	0.153	-0.172	—				
Ethical Attitude	-0.372	-0.174	0.479*	—			
1. Upholding the profession's position in relationships	-0.332	-0.081	0.277	0.858***	—		
2. Providing dental services while maintaining patient trust	-0.322	-0.203	0.527**	0.966***	0.708***	—	
3. Providing information for the patient's benefit	-0.423	-0.189	0.439*	0.701***	0.348	0.735***	—

Note: EADS Domain 1 = Upholding the profession's position in relationships, Domain 2 = Providing dental services while maintaining patient trust, Domain 3 = Providing information for the patient's benefit * $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

The present study offers novel insights into the perceptions of artificial intelligence (AI) in dentistry among dental students at various training stages and their associations with their ethical orientation in clinical practice. By encompassing both undergraduate and graduate participants, this study contributes significantly to understanding how academic progression influences the intersection between technology acceptance and ethical attitudes.

A key finding revealed a substantial disparity in attitudes towards AI between undergraduates and graduate students, with the latter exhibiting more favorable perceptions of AI's potential applications in dentistry. This observation aligns with prior studies, indicating that exposure to advanced clinical scenarios and diagnostic complexity tends to enhance students' appreciation of AI-supported tools (Karan-Romero et al., 2023; Yüzbaşıoğlu, 2020). Graduate programs, particularly those in fields such as endodontics, frequently utilize digital imaging,

computer-assisted planning, and algorithm-supported decision aids, which may foster familiarity and trust in AI technologies (Machoy et al., 2020; Ossowska et al., 2022). In contrast, undergraduates may have had more limited exposure to such tools and may remain more cautious or uncertain about AI's reliability and its clinical implications.

Contrary to their pronounced differences in attitudes, both educational groups demonstrated comparable levels of ethical attitudes, as assessed by the Ethical Attitude of Dentists Scale (EADS). This uniformity suggests that ethical understanding in dentistry, at least concerning fundamental principles such as honesty, beneficence, and patient autonomy, is emphasized early in dental training and remains consistent as students progress through their education. This interpretation aligns with the notion that ethical formation in dentistry is strongly rooted in foundational coursework and professional socialization, wich frequently occurs before clinical specialization.

Upon disaggregating the EADS into its domains, subgroup distinctions were observed. Graduate students demonstrated superior performance in the domain *Upholding the profession's position in relationships*, implying that professional identity and collegial responsibility are more strongly internalized at advanced training stages. This observation aligns with prior findings that clinical immersion fosters heightened awareness of interprofessional accountability and the broader societal expectations associated with dental practice (Rasmussen & Musaeus, 2024). Undergraduate students with limited practical experience may prioritize patient-level ethical obligations but have not yet fully developed a comprehensive understanding of the profession's collective moral standards.

Regarding the correlation between attitudes towards AI and ethical attitudes, the results exhibited significant disparities between the groups. In the combined sample, attitudes towards AI did not correlate with EADS scores or any of its domains. This absence of association challenges the assumption that enthusiasm for technological innovation is inherently correlated with enhanced ethical awareness (Asiksoy, 2024; Saklaki & Gardikiotis, 2024). Instead, the findings suggest that attitudes towards AI and ethical values may function as independent constructs within more heterogeneous student populations, particularly when variations in academic experience, clinical exposure, and digital literacy are present.

Conversely, within the graduate subgroup, moderate and statistically significant correlations emerged between attitudes towards AI and ethical attitudes, particularly within the domains of *patient trust and information provision*. This pattern suggests that, for students already engaged in advanced clinical practice, receptiveness to AI may be embedded within a broader ethical framework prioritizing transparency, responsibility, and patient-centered communication. This interpretation aligns with prior findings indicating that clinical maturity strengthens the integration of technological judgment with moral and professional considerations (Maart & Mulder, 2024; Rokhshad et al., 2023).

The stronger associations observed among graduate students may reflect a more realistic understanding of AI's capabilities and limitations than undergraduate students. Consistent with Schwendicke et al. (2020) and Amiri et al. (2024), effective AI adoption necessitates a dual recognition of its diagnostic advantages and risks, particularly concerning privacy, data governance, oversight, and algorithmic bias. Graduate students encountering these issues in complex clinical contexts may therefore be better equipped to integrate AI-related decisions with ethical reasoning.

Across the EADS, all domains exhibited very high internal correlations, reaffirming the tool's convergent structure and supporting the notion that ethical behaviors in dentistry, professional conduct, trust maintenance, and patient communication are deeply interconnected (Ebadi et al., 2022). In contrast, attitudes towards AI showed no association with EADS scores among undergraduates, reinforcing the likelihood that ethical formation precedes the meaningful integration of AI considerations into moral reasoning. Prior research has documented similar patterns, noting that early stage students often rely on general moral rules without connecting them

to digital or algorithmic contexts (Choi et al., 2024; Jeong et al., 2023). Nevertheless, robust analyses, such as Confirmatory Factorial Analysis, should be conducted in future research to validate the construct of each test.

The present findings underscore the significant pedagogical implications. First, the pronounced disparities in attitudes towards AI across educational levels underscore the necessity for structured AI education throughout the dental curriculum (Islam, 2022; Dashti et al., 2024). Early curricular exposure may mitigate uncertainty among undergraduates and cultivate more balanced and informed perspectives on AI's clinical applications. Second, the emergence of AI-ethics correlations exclusively among graduate students suggests that ethical instruction must explicitly incorporate AI-related cases and dilemmas rather than treating digital technologies as peripheral to clinical ethics. Integrating case-based learning involving algorithmic errors, data privacy concerns, and informed consent for AI-supported decisions can effectively bridge this gap (Rokhshad et al., 2023).

Furthermore, the findings emphasize the increasing significance of developing AI literacy as a component of ethical competence. As highlighted in prior research (Amiri et al., 2024; Saklaki & Gardikiotis, 2024), ethical behavior with AI tools necessitates an understanding of both their strengths and systemic challenges. Students must be prepared not only to utilize AI tools but also to critically evaluate their outputs and mitigate risks to patient welfare.

Finally, future research should employ longitudinal designs to monitor the evolution of technological and ethical competencies across academic stages and determine the effectiveness of specific educational interventions in enhancing the integration of AI awareness with ethical decision-making.

For all these reasons, it is imperative that academic institutions adapt their curricula to incorporate AI modules applied to healthcare, combining theory, practice and ethical discussions. In this way, future professionals will not only acquire essential digital competencies but will also be prepared to critically supervise and validate intelligent tools, ensuring responsible and patient-centered clinical practice.

Conclusion

The relationship between attitudes towards AI and ethical attitudes was not uniform across the sample. Moderate correlations were observed among graduate students, particularly in domains related to maintaining patient trust and providing clear information for patient benefit. This suggests that at advanced stages of training, technological openness becomes more meaningfully integrated with ethical decision-making, potentially reflecting greater clinical maturity and a deeper understanding of AI's implications for patient care.

These findings underscore the need for dental curricula to incorporate structured AI education early in training, ensuring that students develop informed and balanced perspectives before entering advanced clinical environments. Additionally, ethical instruction should explicitly address AI-related dilemmas, such as data governance, transparency, algorithmic bias, and informed consent, to help students connect traditional ethical principles with emerging technological contexts.

Although limited by its sample size and single-institution design, this study highlights the critical intersections between digital competency and ethical preparedness in dental education. Future research should expand these analyses using longitudinal, multi-institutional designs to track how AI attitudes and ethical orientations evolve over time and in response to targeted curricular interventions.

Ultimately, preparing future dentists for responsible AI integration requires a dual commitment to technological literacy and ethical rigor in the curriculum. By fostering both, academic institutions can ensure that the adoption of AI in dentistry remains safe, reflective, and centered on patient welfare.

Competing interests

The authors declare no conflicts of interest.

Ethics Committee Approval

This research was conducted within the framework of a larger study approved by the Ethics Committee of the Faculty of Medicine and Psychology at the Autonomous University of Baja California, Tijuana, Mexico (No. 373/20.05.2025).

Consent to participate

Informed written consent was obtained from each participant at the time of recruitment. The subjects were informed that they could withdraw from the study at any stage, and they were assured confidentiality.

References

1. Amiri, Hamidreza., Peiravi, S., Shojaee, S. S. R., Rouhparvarzamin, M., Nateghi, M. N., Etemadi, M. H., ShojaeiBaghini, M., Musaie, F., Anvari, M. H., & Anar, M. A. (2024). Medical, dental, and nursing students' attitudes and knowledge towards artificial intelligence: A systematic review and meta-analysis. *BMC Medical Education*, *24*. https://doi.org/10.1186/s12909-024-05406-1
2. Asiksoy, G. (2024). An Investigation of University Students' Attitudes Towards Artificial Intelligence Ethics. *International Journal of Engineering Pedagogy (iJEP)*, *14*(8), 153-169. https://doi.org/10.3991/ijep.v14i8.50769
3. Buele, J., Sabando-García, Á. R., Sabando-García, B. J., & Yánez-Rueda, H. (2025). Ethical Use of Generative Artificial Intelligence Among Ecuadorian University Students. *Sustainability*, *17*(10), 4435. https://doi.org/10.3390/su17104435
4. Chang, S.-W., Abdul-Kareem, S., Merican, A. F., & Zain, R. B. (2013). Oral cancer prognosis based on clinicopathologic and genomic markers using a hybrid of feature selection and machine learning methods. *BMC Bioinformatics*, *14*(1). https://doi.org/10.1186/1471-2105-14-170
5. Choi, J.-I., Yang, E., & Goo, E.-H. (2024). The Effects of an Ethics Education Program on Artificial Intelligence among Middle School Students: Analysis of Perception and Attitude Changes. *Applied Sciences*, *14*(4), 1588. https://doi.org/10.3390/app14041588
6. Dashti, M., Ghasemi, S., & Khurshid, Z. (2024). Integrating Artificial Intelligence in Dental Education: An Urgent Call for Dedicated Postgraduate Programs. *International Dental Journal*, *74*(6), 1466-1468. https://doi.org/10.1016/j.identj.2024.08.008
7. Ebadi, A., Shojaei, A., Larijani, B., Sadegh Akhoundi, M., & Khorshidian, A. (2022). The ethical attitude of dentists scale: Development and psychometric properties. *Journal of Medical Ethics and History of Medicine*. https://doi.org/10.18502/jmehm.v15i12.11568
8. Hernández-Nieto, R. A. (2002), *Contributions to Statistical Analysis*. Universidad de Los Andes.
9. Islam, N. M., Laughter, L., Sadid-Zadeh, R., Smith, C., Dolan, T. A., Crain, G., & Squarize, C. H. (2022). Adopting artificial intelligence in dental education: A model for academic leadership and innovation. *Journal of Dental Education*, *86*(11), 1545-1551. https://doi.org/10.1002/jdd.13010

10. Jeong, H., Han, S.-S., Kim, K.-E., Park, I.-S., Choi, Y., & Jeon, K. (2023). Korean dental hygiene students' perceptions and attitudes toward artificial intelligence: An online survey. *Journal of dental education*. https://doi.org/10.1002/jdd.13189
11. Karan-Romero, M., Salazar-Gamarra, R., & León-Ríos, X. (2023). Evaluation of Attitudes and Perceptions in Students about the Use of Artificial Intelligence in Dentistry. *Dentistry Journal*, *11*. https://doi.org/10.3390/dj11050125
12. Kwak, Y., Ahn, J.-W., & Seo, Y. H. (2022). Influence of AI ethics awareness, attitude, anxiety, and self-efficacy on nursing students' behavioral intentions. *BMC Nursing*, *21*(1), 267. https://doi.org/10.1186/s12912-022-01048-0
13. Maart, R., & Mulder, R. (2024). Ethical considerations for artificial intelligence in dentistry. *South African Dental Journal*, *79*(05), 260-262. https://doi.org/10.17159/sadj.v79i05.18355
14. Machoy, M. E., Szyszka-Sommerfeld, L., Vegh, A., Gedrange, T., & Woźniak, K. (2020). The ways of using machine learning in dentistry. *Advances in Clinical and Experimental Medicine*, *29*(3), 375-384. https://doi.org/10.17219/acem/115083
15. Maneesriwongul, W., & Dixon, J. K. (2004). Instrument translation process: A methods review. *Journal of Advanced Nursing*, *48*(2), 175–186. https://doi.org/10.1111/j.1365-2648.2004.03185.x
16. Ossowska, A., Kusiak, A., & Świetlik, D. (2022). Artificial Intelligence in Dentistry—Narrative Review. *International Journal of Environmental Research and Public Health*, *19*(6), 3449. https://doi.org/10.3390/ijerph19063449
17. Ozbey, F., & Yasa, Y. (2025). The relationships of personality traits on perceptions and attitudes of dentistry students towards AI. *BMC Medical Education*, *25*. https://doi.org/10.1186/s12909-024-06630-5
18. Rasmussen, E. L., & Musaeus, P. (2024). Subject matter changes in the dental curriculum: A scoping review of the last two decades. *Journal of Dental Education*, *88*(8), 1101-1114. https://doi.org/10.1002/jdd.13530
19. Rokhshad, R., Ducret, M., Chaurasia, A., Karteva, T., Radenkovic, M., Roganovic, J., Hamdan, M., Mohammad-Rahimi, H., Krois, J., Lahoud, P., & Schwendicke, F. (2023). Ethical considerations on artificial intelligence in dentistry: A framework and checklist. *Journal of Dentistry*, *135*, 104593. https://doi.org/10.1016/j.jdent.2023.104593
20. Saklaki, A., & Gardikiotis, A. (2024). Exploring Greek Students' Attitudes Toward Artificial Intelligence: Relationships with AI Ethics, Media, and Digital Literacy. *Societies*, *14*(12), 248. https://doi.org/10.3390/soc14120248
21. Schwendicke, F., Samek, W., & Krois, J. (2020). Artificial Intelligence in Dentistry: Chances and Challenges. *Journal of Dental Research*, *99*(7), 769-774. https://doi.org/10.1177/0022034520915714
22. Scrobotă, I., Băciuț, G., Filip, A. G., Todor, B., Blaga, F., & Băciuț, M. F. (2017). Application of Fuzzy Logic in Oral Cancer Risk Assessment. *Iranian Journal of Public Health*, *46*(5), 612-619.
23. Singh, N., Pandey, A., Tikku, A., Verma, P., & Singh, B. (2023). Attitude, perception and barriers of dental professionals towards artificial intelligence. *Journal of Oral Biology and Craniofacial Research*, *13*, 584-588. https://doi.org/10.1016/j.jobcr.2023.06.006
24. Xiao, J., Luo, J., Ly-Mapes, O., Wu, T. T., Dye, T., Al Jallad, N., Hao, P., Ruan, J., Bullock, S., & Fiscella, K. (2021). Assessing a Smartphone App (AICaries) That Uses Artificial Intelligence to Detect Dental Caries in Children and Provides Interactive Oral Health Education: Protocol for a Design and Usability Testing Study. *JMIR Research Protocols*, *10*(10), e32921. https://doi.org/10.2196/32921
25. Yüzbaşıoğlu, E. (2020). Attitudes and perceptions of dental students towards artificial intelligence. *Journal of dental education*. https://doi.org/10.1002/jdd.12385