BMC Oral Health

https://doi.org/10.1186/s12903-026-09557-z

Article in Press

Sustainability and green dentistry among dental students in Türkiye: assessment of knowledge, attitudes, practices and educational needs

Received: 28 March 2026

Accepted: 3 August 2026

Published online: 18 August 2026

Cite this article as: Boyraz Ş. & Cihangir İ. Sustainability and green dentistry among dental students in Türkiye: assessment of knowledge, attitudes, practices and educational needs. *BMC Oral Health* (2026). https://doi.org/10.1186/s12903-026-09557-z

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SUSTAINABILITY AND GREEN DENTISTRY AMONG DENTAL STUDENTS IN TÜRKİYE: ASSESSMENT OF KNOWLEDGE, ATTITUDES, PRACTICES AND EDUCATIONAL NEEDS

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ABSTRACT

Background: The healthcare sector contributes substantially to environmental degradation, and dentistry—characterised by high resource consumption and waste generation—plays a notable role. International bodies increasingly advocate integrating sustainability and green dentistry principles into dental education. However, comprehensive assessments of dental students' knowledge, attitudes, practices, and perceived curricular needs remain scarce. This study aimed to

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evaluate sustainability- and green dentistry-related knowledge, attitudes, practices, and perceptions of curricular integration among dental students in Türkiye.

Methods: A cross-sectional survey study was conducted during the 2025–2026 academic year among undergraduate dental students enrolled in dental faculties across Türkiye. Ethical approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Yozgat Bozok University. A 43-item structured online questionnaire assessed knowledge, attitudes, practices, and curriculum perceptions related to sustainability and green dentistry. A total of 418 students participated. Domain scores were standardised to a 0–100 scale and compared using the Friedman test. Differences according to gender, year of study, and prior sustainability education were analysed.

Results: A total of 418 dental students participated in the study. Students demonstrated highly positive attitudes toward sustainability and green dentistry (76.67 ± 19.51), whereas knowledge (45.02 ± 24.19) and practice (61.63 ± 21.99) scores were moderate. Significant differences were observed among the four assessed domains—knowledge, attitude, practice, and curriculum evaluation scores ($p < 0.001$)—with attitude scores being the highest and knowledge scores being the lowest. Previous sustainability-related education was associated with significantly higher knowledge scores ($p < 0.001$); however, no significant differences were observed in attitude or practice scores. Overall, the findings suggest a possible discrepancy between students' positive attitudes and their sustainability-related knowledge and self-reported practices.

Conclusions: Although dental students strongly support sustainability, insufficient knowledge and limited integration into self-reported practices underscore the need for structured, practice-oriented curricular integration to support the adoption of sustainable clinical practices.

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Keywords: Sustainability; Green dentistry; Dental education; Curriculum integration; Knowledge–attitude–practice.

BACKGROUND

In the Brundtland Report published in 1987, the United Nations defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [1]. This concept was later embedded within a global policy framework through the United Nations 2030 Sustainable Development Goals (SDGs) [2]. Today, sustainability is regarded not only as the reduction of environmental impacts but also as a holistic approach encompassing the protection of human health and the improvement of quality of life. In this context, the healthcare sector represents a critical field that simultaneously bears the responsibility of protecting public health and reducing environmental impacts.

Healthcare services contribute substantially to global environmental impacts through energy consumption, resource use, waste generation, and supply chains. Previous estimates indicate that the healthcare sector is responsible for approximately 4–5% of global greenhouse gas emissions [3]. This has led to the emergence of the concepts of "sustainable healthcare" and "green health." Developing strategies to reduce the environmental impact of healthcare services has become a priority for the World Health Organization and other international organisations [4,5]. Given the contribution of healthcare systems to global carbon emissions, it is inevitable that healthcare professionals adopt sustainable practices and assume leadership roles in this area.

Dentistry is considered one of the healthcare fields with a significant environmental impact due to the extensive use of single-use plastics, high energy and water consumption, the production and

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disposal processes of dental materials, and emissions associated with patient and staff transportation [6]. Infection control requirements and the widespread use of disposable products in dental clinics are among the primary contributors to waste generation. Although modern dental practices are essential for infection control and patient safety, the increased use of personal protective equipment and single-use products—particularly following the COVID-19 pandemic—has further amplified the environmental footprint of dentistry [7]. In this context, "green dentistry" has emerged as a holistic approach that aims to deliver high-quality and safe oral healthcare while minimising environmental impact. Green dentistry encompasses principles such as rethinking, reducing, reusing, and recycling, and includes practices such as energy and water conservation, improved waste management, and the use of environmentally friendly materials and technologies [7,8].

The implementation of sustainable and green dentistry practices depends not only on clinical infrastructure and policy regulations but also on knowledge, attitudes, and behaviours in this field. Dental students occupy a critical position as future oral health professionals. The knowledge and attitudes acquired during undergraduate education play a decisive role in the adoption of sustainable practices throughout professional life. Organisations such as the Association for Dental Education in Europe (ADEE) and the FDI World Dental Federation explicitly recommend the integration of sustainability principles into dental education and highlight the educational needs in this area [9,10].

Despite this, studies comprehensively addressing sustainability and green dentistry among dental students in terms of knowledge, attitudes, behaviours, and educational needs remain limited. Most existing research focuses on specific subtopics or relies on single-dimensional assessments.

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Therefore, the aim of this study was to evaluate dental students' levels of knowledge, attitudes, behaviours, and educational needs regarding sustainability and green dentistry. The findings are expected to contribute to the development of dental education curricula, the planning of sustainability-based course content, and the wider adoption of environmentally responsible dental practices in the future.

METHODS

Study Design and Ethical Approval

The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Yozgat Bozok University (Decision No: 2025-GOKAEK-2522_2025.12.17_842; Date: 17 December 2025) and was conducted in accordance with the Declaration of Helsinki [11].

This cross-sectional descriptive study was conducted to evaluate dental students' knowledge, attitudes, and practices regarding sustainability and green dentistry, as well as their perceptions of the adequacy of the current dental curriculum in this area. The questionnaire used in this study was developed based on previously published instruments and relevant literature, particularly studies by Fisal et al. [12] and Durnall et al. [13], and was adapted to the context of dental education in Türkiye.

Study Population and Sample Size

All students enrolled in Dentistry programmes in Türkiye during the 2025–2026 academic year (N = 33,900) were considered eligible to participate (YÖK Atlas, 2025). Accordingly, the target population consisted of dental students across Türkiye. The required sample size was calculated

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using Cochran's formula with finite population correction for proportion estimation. The minimum required sample size was determined as 380 students. A total of 418 students were included in the study, exceeding the calculated minimum sample size. In this formula, N represents the population size; z corresponds to the z-score for a 95% confidence level (1.96); p denotes the estimated population proportion (assumed to be 0.5); and d represents the margin of error (0.05).

$$n = \frac{N \cdot z^2 \cdot p(1-p)}{d^2(N-1) + z^2 \cdot p(1-p)}$$

Data Collection Instrument and Procedure

The questionnaire used in this study was developed based on previously published instruments and relevant literature, particularly studies by Fisal et al. [12] and Durnall et al. [13], and was adapted to the context of dental education in Türkiye. The original questionnaire items were derived from English-language sources. The questionnaire items were translated into Turkish and culturally adapted for undergraduate dental students in Türkiye. The translated version was reviewed by two faculty members experienced in restorative dentistry and dental education to evaluate linguistic clarity, item relevance, and content appropriateness. Necessary modifications were made according to expert feedback before administration. Internal consistency of the questionnaire domains was assessed using Cronbach's alpha coefficients. No formal psychometric validation study was conducted; therefore, the assessment focused on linguistic adaptation, content review, and internal consistency evaluation.

The final questionnaire consisted of 43 items organised into five sections: demographic information, knowledge level (11 items), attitudes toward sustainability and green dentistry (15 items), sustainable practice behaviours (8 items), and evaluation of curriculum integration and

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educational needs (6 items). The survey was administered via Google Forms (Google LLC, Mountain View, CA, USA) and distributed on 1 January 2026 through institutional communication channels by the designated student representative of each academic year. Participation was voluntary, and a convenience sampling approach was used. Since the questionnaire was distributed through online institutional communication channels, the exact number of students who received or viewed the invitation could not be determined; therefore, a precise response rate could not be calculated. Undergraduate dental students (Years 1–5) enrolled in dental faculties in Türkiye who were able to read and understand Turkish were eligible to participate. Postgraduate students were not included.

Prior to participation, all students were provided with detailed information about the purpose, procedures, and content of the study. Electronic informed consent was obtained before access to the questionnaire. Participation was voluntary, and no financial or academic incentive was provided. Responses were collected anonymously, and no personally identifiable information (such as name, surname, or student ID number) was requested. Participants were informed that they could skip any question they did not wish to answer and withdraw from the study at any stage. Incomplete responses were evaluated according to the missing data strategy described in the statistical analysis section. Due to the low proportion of missing data, no imputation method was applied.

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Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics (Version 29.0; IBM Corp., Armonk, NY, USA). Prior to analysis, data were screened for missing responses. The proportion of missing data was low (<5% across variables). Participants with incomplete questionnaire

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responses were excluded using listwise deletion for domain score analyses to ensure a consistent sample size across domains. Item-level descriptive analyses were reported using available valid responses. No imputation method was applied. The internal consistency reliability of the questionnaire domains was evaluated using Cronbach's alpha coefficients. Cronbach's alpha was not calculated for the curriculum evaluation section because this section included categorical items assessing educational exposure and preferences rather than items measuring a single psychometric construct. Domain scores were calculated separately for knowledge, attitude, practice, and curriculum evaluation sections. To allow comparison among questionnaire domains with different score ranges, raw domain scores were transformed into a standardized 0–100 scale using the following formula:

Standardized score = [(raw score − minimum possible score) / (maximum possible score − minimum possible score)] × 100.

The normality of quantitative variables was assessed using the Shapiro–Wilk test. Descriptive statistics were presented as mean ± standard deviation and median (minimum–maximum) values for continuous variables, and frequencies and percentages for categorical variables. As the domain scores were obtained from the same participants and represented related measurements across different sustainability dimensions, differences among knowledge, attitude, practice, and curriculum evaluation scores were analysed using the Friedman test. For the Friedman test, only participants with available scores for all four domains (knowledge, attitude, practice, and curriculum evaluation) were included to ensure paired comparisons across repeated measurements.

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Comparisons of domain scores according to demographic characteristics, including gender, year of study, and previous sustainability-related education, were performed using the Mann–Whitney U test or Kruskal–Wallis test, as appropriate. Effect sizes were calculated to evaluate the magnitude of observed differences. Effect size (r) was reported for Mann–Whitney U tests, while eta-squared (η^2) values were calculated for Kruskal–Wallis analyses. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 418 undergraduate dental students were included in this study. The questionnaire demonstrated acceptable internal consistency, with Cronbach's alpha coefficients of 0.792 for the knowledge domain, 0.868 for the attitude domain, and 0.672 for the practice domain. Of the participants, 59.7% (n = 249) were female and 39.1% (n = 164) were male. Five participants (1.2%) did not report their gender and were excluded only from gender-based analyses. Regarding year of study, the highest participation rate was observed among second-year students (31.1%), followed by third-year (20.6%), fourth-year (19.6%), first-year (14.8%), and fifth-year students (13.9%). Regarding previous sustainability/green dentistry education, 23 students (5.5%) reported having received prior education, whereas 394 students (94.3%) reported no previous education. One participant (0.2%) did not provide a response for this variable and was excluded only from analyses involving previous education status (Table 1).

Participants' responses regarding knowledge, attitudes, practices, and curriculum evaluation related to sustainability and green dentistry are presented in Table 2. After screening for missing responses, complete cases were used for domain score comparisons. For descriptive item-level analyses, valid response numbers were reported for each questionnaire item.

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Table 1. Demographic characteristics of the participants (N = 418)

Variable	Category	N:418	%
Gender	Female	249	59.7
	Male	164	39.1
	Missing	5	1.2
Year of Study	Year 1	62	14.8
	Year 2	130	31.1
	Year 3	86	20.6
	Year 4	82	19.6
	Year 5	58	13.9
Previous Education on Sustainability/Green Dentistry	No	394	94.3
	Yes	23	5.5
	Missing	1	0.2

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Table 2. Assessment of participants' knowledge, attitudes, practices, and evaluation of the current curriculum

A. Knowledge items

Item	Yes n (%)	No n (%)
1. Are you familiar with the term "Green Dentistry"?	56 (13.4%)	362 (86.6%)
2. Do you know which components are implemented within the concept of Green Dentistry?	36 (8.6%)	381 (91.4%)
3. Are you aware of the types of waste that can be reduced?	178 (42.7%)	239 (57.3%)
4. Do you know the types of waste materials that can be recycled?	304 (72.7%)	114 (27.3%)
5. Do you know the types of waste materials that can be reused?	265 (63.4%)	153 (36.6%)
6. Are you aware of the colour coding of recycling bins and the types of waste assigned to	302 (72.4%)	115 (27.6%)

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each?		
7. Do you know which materials cannot be recycled or reused?	287 (69.0%)	129 (31.0%)
8. Are you aware of the environmental harm caused by non-recyclable waste materials?	328 (78.7%)	89 (21.3%)
9. Do you know the different types of plastics?	179 (42.9%)	238 (57.1%)
10. Do you believe that you have sufficient knowledge about Green Dentistry?	46 (11.1%)	370 (88.9%)
11. Are any educational materials on Green Dentistry provided during your clinical training?	89 (21.5%)	325 (78.5%)

B. Attitude items

Item	**Agree / Strongly agree n (%)**	**Neutral / Disagree n (%)**
1. Green Dentistry is a sustainable approach that reduces environmental impact.	386 (93.5%)	27 (6.5%)
2. Green Dentistry provides numerous long-term benefits.	387 (93.5%)	27 (6.5%)
3. Green Dentistry should be universally recommended.	389 (94.2%)	24 (5.8%)
4. Energy conservation is an advantage of Green Dentistry practices.	382 (92.5%)	31 (7.5%)
5. Water conservation is an advantage of Green Dentistry practices.	391 (94.7%)	22 (5.3%)
6. Green Dentistry can reduce financial burden.	371 (89.6%)	43 (10.4%)
7. Digital radiography is more environmentally friendly than conventional film radiography.	378 (91.7%)	34 (8.3%)
8. Implementing Green Dentistry in daily clinical settings is very important.	381 (92.3%)	32 (7.7%)
9. Infection control and sterilisation processes in dental offices may be a significant source of waste and pollution.	379 (91.8%)	34 (8.2%)
10. Transitioning from current practice to Green Dentistry is difficult.	246 (59.7%)	166 (40.3%)
11. It is difficult to find products compatible with Green Dentistry.	274 (67.0%)	135 (33.0%)

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12. Recycling waste is an additional burden for dental students.	201 (49.3%)	207 (50.7%)
13. High cost is a factor influencing the adoption of Green Dentistry.	337 (81.8%)	75 (18.2%)
14. Lack of time is a factor influencing the adoption of Green Dentistry.	324 (78.5%)	89 (21.5%)
15. Insufficient knowledge is a factor influencing the adoption of Green Dentistry.	363 (87.7%)	51 (12.3%)

C. Practice items

Item	**Yes n (%)**	**No n (%)**
1. Have you attended any training related to Green Dentistry (e.g., workshops, videos, lectures)?	55 (13.3%)	357 (86.7%)
2. Have you ever applied the concept of Green Dentistry in your dental practice?	65 (15.7%)	348 (84.3%)
3. Do you use environmentally friendly or sustainable products in your daily life?	293 (70.9%)	120 (29.1%)
4. Do you prefer digital images instead of conventional films?	332 (80.6%)	80 (19.4%)
5. Do you prefer electronic devices rather than paper-based tools for your notes or assignments?	308 (74.4%)	106 (25.6%)
6. Do you reduce water waste during handwashing?	360 (87.2%)	53 (12.8%)
7. Do you unplug electrical devices after use?	350 (84.7%)	63 (15.3%)
8. Do you use LED bulbs to reduce energy consumption?	298 (72.0%)	116 (28.0%)

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D. Curriculum Evaluation

Item	**Response**	**n (%)**
1. Should the dental profession be more actively involved in environmental sustainability?	Yes / No	371 (90.0%) / 41 (10.0%)
2. During your undergraduate education, have you been introduced to the concept of environmental sustainability?	Not exposed Briefly mentioned by staff Informal discussions with peers Student society talks/events Compulsory/elective course	211 (51.2%) 86 (20.9%) 64 (15.5%) 27 (6.6%) 24 (5.8%)

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3. Would you like your undergraduate dental programme to place greater emphasis on environmental sustainability?	Yes / No	339 (81.9%) / 75 (18.1%)
4. Have you adopted a proactive approach, individually or in a group, to learn about oral healthcare and its environmental impact?	Yes / No	166 (40.3%) / 246 (59.7%)
5. How do you think awareness of the environmental impact of oral healthcare services can be improved within the undergraduate curriculum?	Through social media Professional lectures/talks Teacher-supported group sessions Dental student association activities Student-led societies	176 (42.8%) 81 (19.7%) 57 (13.9%) 50 (12.2%) 47 (11.4%)
6. Do you believe that increasing our knowledge of environmental sustainability in oral healthcare will have an impact on our future profession and the environment?	Tremendous positive impact Some positive impact No impact Negative impact	170 (41.4%) 217 (52.8%) 17 (4.1%) 7 (1.7%)

Note: Percentages were calculated based on valid responses for each item due to missing responses.

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Comparisons of knowledge, attitude, practice, and curriculum evaluation scores according to demographic characteristics are presented in Table 3. No significant differences were observed between male and female students in any domain. Previous sustainability-related education was associated with significantly higher knowledge scores ($p < 0.001$), whereas no significant differences were observed for attitude, practice, or curriculum evaluation scores. Significant differences according to year of study were observed for attitude, practice, and curriculum evaluation scores ($p < 0.05$).

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Table 3. Comparison of raw knowledge, attitude, practice, and curriculum evaluation scores according to demographic characteristics

Variable	Category	Knowledge Mean±SD	Attitude Mean±SD	Practice Mean±SD	Curriculum Mean±SD
Gender	Male	5.26±2.84	11.14±3.42	6.74±2.49	2.06±0.90
	Female	4.78±2.49	11.79±2.46	7.02±1.90	2.13±0.74
	p-value	0.109	0.342	0.755	0.658
	Effect size (r)	0.004	0.003	0.004	<0.001
Year of study	Year 1	4.95±2.67	10.63±3.42	6.42±2.56	1.95±0.97
	Year 2	5.06±2.86	11.82±2.76	6.82±2.09	2.05±0.83
	Year 3	5.19±2.59	11.53±2.64	7.08±2.13	2.12±0.82
	Year 4	5.07±2.42	11.82±2.30	7.50±1.74	2.34±0.65
	Year 5	4.19±2.50	11.22±3.69	6.45±2.36	1.98±0.78
	p-value	0.219	0.042	0.037	0.042
	Effect size (η^2)	0.004	0.016	0.009	0.014
Previous education	Yes	8.09±2.61	11.35±3.23	7.35±2.04	2.26±0.86
	No	4.78±2.54	11.50±2.91	6.87±2.18	2.09±0.82
	p-value	<0.001	0.901	0.258	0.244
	Effect size (r)	0.251	0.004	0.098	0.052

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Note: r indicates effect size for Mann–Whitney U tests; η^2 indicates effect size for Kruskal–Wallis tests

The standardized domain scores are presented in Table 4. The mean standardized scores were 45.02 ± 24.19 for knowledge, 76.67 ± 19.51 for attitude, 61.63 ± 21.99 for practice, and 69.86 ± 27.32 for curriculum evaluation. Significant differences were observed among knowledge, attitude, practice, and curriculum evaluation scores ($p < 0.001$). Attitude scores were the highest, whereas knowledge scores were the lowest among the evaluated domains.

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Table 4. Comparison of knowledge, attitude, practice, and curriculum evaluation scores

Domain (0–100)	Mean ± SD	Median	Observed Min-Max	p-value
Knowledge	45.02 ± 24.19	45.45	0.00–100.00	<0.001
Attitude	76.67 ± 19.51	86.67	0.00–100.00	
Practice	61.63 ± 21.99	62.50	0.00–100.00	
Curriculum	69.86 ± 27.32	66.67	0.00–100.00	

Note: Minimum and maximum values represent the observed score ranges within the study sample after standardization to a 0–100 scale. The p-value was calculated using the Friedman test.

DISCUSSION

This study provides a comprehensive cross-sectional analysis simultaneously evaluating knowledge, attitudes, behaviours, and perceived curriculum adequacy regarding sustainability and green dentistry among dental students in Türkiye. The findings indicate that, although students held positive attitudes towards green dentistry, their knowledge scores were comparatively lower, and positive attitudes were not consistently accompanied by equally high self-reported practice scores. This suggests that students generally support sustainability as a professional and ethical value; however, additional education may be needed to strengthen knowledge and support the adoption of sustainable practices.

In our study, knowledge levels were significantly higher among students who had previously received education on sustainability or green dentistry. This finding indicates that knowledge is acquired largely through structured education rather than through spontaneously developed awareness. This is consistent with the study conducted by Fisal et al. in Malaysia, which reported markedly lower knowledge levels among dental students who had not received related education [12]. Similarly, a large-sample study from Romania reported limited awareness of sustainability,

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while highlighting that early-stage education could significantly improve knowledge levels [14]. By contrast, gender and year of study did not have a significant impact on knowledge levels in the present study. The literature suggests that findings regarding the influence of demographic variables on knowledge are not consistent [15,16].

In addition, students demonstrated higher levels of knowledge regarding general environmental concepts such as recycling and waste segregation compared with concepts specific to green dentistry. This may indicate that students acquire basic knowledge about environmental sustainability through everyday life experiences, whereas profession-specific sustainable practices are not sufficiently addressed. The literature also emphasises that the professional dimensions of sustainability are often not explicitly and systematically covered within educational programmes, which makes it difficult for students to link conceptual knowledge with clinical practice [17]. Therefore, profession-specific aspects of sustainability in dentistry should be addressed more explicitly and in a structured manner within dental curricula.

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The vast majority of students perceived green dentistry as an approach that reduces environmental impact, provides long-term benefits, and should be universally adopted. The absence of gender differences in attitudes may suggest that sustainability is widely accepted as a social and professional value irrespective of gender. This finding is consistent with reports from studies conducted in the United Kingdom and other European countries [14, 18]. UK-based research in particular has indicated that dental students and educators consider sustainability to be a professional responsibility and an ethical obligation [19]. Nevertheless, students' perceptions of high cost, lack of time, and insufficient knowledge as major barriers to the adoption of green dentistry indicate that strong structural barriers remain, despite positive attitudes [19-21]. This

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highlights that sustainability cannot be implemented through individual awareness alone; institutional support, appropriate infrastructure, and policy-level regulations are also required. In Türkiye, environmental sustainability in healthcare is supported by national regulations, including the Medical Waste Control Regulation and the Zero Waste Regulation, which emphasize appropriate waste segregation, reduction, recycling, and environmentally responsible waste management practices. In this context, integrating sustainability principles into dental education may contribute to preparing future dentists to comply with national environmental policies and adopt more sustainable clinical practices [22, 23].

The significant differences in attitude and behaviour scores across years of study suggest that, as clinical experience increases, students may gain a clearer understanding of the importance of sustainability. Increased direct exposure to waste generation, energy consumption, and water use within clinical workflows may help students perceive sustainability not merely as a theoretical concept, but as a practical necessity. Although practice scores were higher than knowledge scores, they remained lower than attitude scores, suggesting that positive perceptions were not fully reflected in sustainable behaviours. The limited proportion of students reporting active adoption of green dentistry practices may indicate differences between students' sustainability-related knowledge, attitudes, and self-reported practices. In the health behaviour literature, this discrepancy is often explained by the difficulty of translating beliefs into behaviour change due to structural and environmental constraints, even when individuals perceive an issue as important and appropriate [13].

In a quasi-experimental study among intern dentists in Egypt, a structured and practice-based educational programme on sustainability and green dentistry led to a significant increase in

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behaviour scores, whereas baseline behaviour levels were limited prior to the intervention [24]. Similarly, studies from the United Arab Emirates and Romania have reported that students were unable to sufficiently integrate sustainable practices into routine clinical practice and that behaviour change was largely achievable through practice-based education and clinical guidance [14, 15]. In the present study, prior education on sustainability or green dentistry did not significantly affect behaviour scores, suggesting that existing educational exposures may not be sufficiently practice-oriented to support behaviour change. This highlights the importance of pedagogical approaches that explicitly target behaviour change in sustainability education.

One of the most notable findings of this study is that the majority of students stated that sustainability and green dentistry should be more comprehensively integrated into the undergraduate curriculum. These results align with studies from different countries emphasising the need to integrate sustainability and green dentistry content into dental curricula [13, 25-27]. As also emphasised by international organisations such as the ADEE and the FDI World Dental Federation, integrating sustainability into dental education is no longer optional but increasingly regarded as a necessity [26].

The finding that curriculum evaluation scores differed significantly by year of study suggests that students perceptions regarding sustainability education may vary as they progress through their training. This implies that the absence of early curricular integration of sustainability may be perceived as an increasingly evident gap in later years. In this context, sustainability education should not be limited to theoretical teaching; rather, it should be delivered through an interdisciplinary, practice-based approach integrated into clinical training. Otherwise, the translation of positive attitudes into behaviours may remain limited. Nassar et al. reported that,

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despite the absence of sustainability content in the curriculum in the UAE, both students and educators strongly supported its inclusion [19]. The increased perception of curricular inadequacy with advancing year levels further suggests that sustainability becomes a more tangible requirement as students' contact with clinical practice increases. This finding supports the view that sustainability should be addressed as an educational component directly linked to clinical practice.

Due to its cross-sectional design, this study does not allow causal inferences regarding changes in sustainability-related knowledge, attitudes, or practices. In addition, the use of self-reported questionnaire data may have introduced response bias and social desirability bias, as participants may have reported more favourable sustainability-related attitudes or practices. Furthermore, the voluntary online sampling approach may have introduced convenience sampling and self-selection bias, as students with greater interest in sustainability may have been more likely to participate. Therefore, although the sample size exceeded the minimum requirement, the findings may not fully represent all dental students in Türkiye. Another limitation of this study is that, although the questionnaire was adapted from previously published instruments and reviewed for content appropriateness, a comprehensive psychometric validation of the adapted questionnaire was not performed. Therefore, further studies are needed to validate this instrument in different populations.

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CONCLUSION

This study demonstrates that, although dental students generally hold positive attitudes towards sustainability and green dentistry, their knowledge scores were comparatively lower, and positive attitudes were not fully reflected in self-reported sustainability-related practices. The observed

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mismatch between knowledge, attitudes, and self-reported behaviours suggests that sustainability education may require not only theoretical content but also practice-based approaches. The fact that the majority of students expressed the need for more comprehensive integration of sustainability-related content into the curriculum suggests that structural curricular improvements may be beneficial. Addressing sustainability and green dentistry from the early years of undergraduate education in a structured manner and integrating it into clinical training may contribute to educating future dentists as professionals with a strong sense of environmental responsibility. Future dental curricula should incorporate interactive and practice-oriented educational strategies, such as simulation-based learning, clinical sustainability audits, and project-based activities, to support the translation of sustainability knowledge into more sustainable clinical practices.

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DECLARATIONS

Ethical Approval: The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Yozgat Bozok University (Decision No: 2025-GOKAEK-2522_2025.12.17_842; Date: 17 December 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki. Prior to participation, all students were provided with detailed information about the study, and electronic written informed consent was obtained before access to the online survey was granted.

Consent for publication: Not applicable.

Data availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare no competing interests.

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Funding: No funding has been received in this study.

Author Contributions: Material preparation, data collection ŞB, data analysis İC. The initial draft of the article was written by İC. The final version of the article was reviewed and approved by ŞB.

Acknowledgements: None

Clinical trial number: None.

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