# The Dentist's Role in Cultivating Environmental Awareness for Sustainability and promotion of Climate Consciousness

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*Article*

# The Dentist's Role in Cultivating Environmental Awareness for Sustainability and Promotion of Climate Consciousness

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**Featured Application: This research provides valuable insights into the environmental attitudes and practices of dentists and dental students, highlighting their role in promoting sustainability and climate consciousness within dental practice. The findings offer guidance for integrating environmental education into dental curricula and continuing education programs, ultimately enhancing more eco-friendly behaviors among dental professionals. This work contributes to the broader goal of advancing environmental sustainability in healthcare practices.**

**Abstract:** This study examines the attitudes and practices of dentists and dental students towards environmental issues within their professional context. Data was selected based on their responses on a Google Forms e-questionnaire, designed specifically for the study. The sample consisted of 78 professional dentists and 75 dental students in Greece and their attitudes towards environmental protection, awareness of the environmental impact of dental practices, and factors influencing the adoption of environmentally friendly practices were assessed. Results reveal generally positive attitudes towards environmental protection, with students demonstrating higher levels of proper waste management practices. Dentists express awareness of their environmental impact but exhibit varying levels of engagement in eco-friendly practices. Factors such as moral consciousness and believing in the severity of climate change significantly influence environmental awareness in dental practice. Notably, dental students exhibit greater environmental awareness compared to practicing dentists. These findings emphasize the importance of integrating environmental education into dental curricula and continuing education programs to foster sustainable practices in dental care. Future research could explore interventions to enhance environmental consciousness among practicing dentists and assess the long-term impact of environmental education initiatives on dental care sustainability.

**Keywords:** dentistry; environmental attitudes; sustainability; dental practice; environmental education; waste management; carbon footprint; climate change; moral consciousness; dentistry students; dentists

## 1. Introduction

In a world where the temperature of the environment is constantly rising and climate change is one of the major problems of modern society, it is necessary to change our attitude towards the environment [1]. Over-consumption and destruction of natural resources are some examples of

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human activities that occur daily which lead to the disruption and destruction of the natural environment, putting the whole ecosystem at risk [2]. More specifically, higher rates of consumption, thus higher rates of production require greater use of energy and materials following greater amounts of waste. Increased extraction and exploitation of natural resources, accumulation of waste, and concentration of pollutants can damage the environment and, in the long term, limit economic activity [3].

The Industrial Revolution beginning in 1760 and having its peak in the 19th century was an era with great success in terms of technology, and society and provided multiple services. However, it resulted in huge amounts of pollutants emitted into the atmosphere which have negative effects on human health [4]. Undeniably, environmental pollution is an international issue affecting public health worldwide and has multiple folds [5]. Specifically, studies have shown the effects in early human life such as cardiovascular, respiratory, mental, and perinatal disorders [5], resulting in infant mortality or chronic disease in adulthood [6]. Water pollution also has harmful effects on human life [7]. The quantity and quality of water are issues that have stigmatized humanity during the last century [8] and will worsen by climate change, with higher temperatures, melting glaciers, and intensified water cycle taking place [9], leading to potentially more floods and droughts [10]. For all these reasons, the awakening of the community and taking the necessary measures are crucial to maintaining balance in nature. The concept of environmental consciousness is associated with awareness, personal commitment, and energy to support the efforts to solve them [11]. Citizens are acting as representatives of change on a worldwide level with the primary objective of accomplishing sustainability and creating a healthy relationship with the environment [12].

Ironically, another major factor affecting the environment and consequently leading to serious health conditions is the pollution caused by hospitals and healthcare institutions [13]. Untreated medical waste and the process of surface waste burning lead to the contamination of water and soil affecting the environment greatly [14]. Additionally, harmful microorganisms such as drug-resistant microorganisms contained in medical waste can infect healthcare professionals as well as the public [15]. This has led to more regulations being made, requiring the correct disposal of medical waste to reduce the negative consequences [16]. Widely recognized as the most effective means of ensuring healthcare sustainability from environmental, social, and economic standpoints is prevention. However, to achieve this, healthcare needs to shift from a system of illness-centric treatment to a more health-centric approach by supporting the health of the planet to support our health too under the scope of sustainability. For this purpose, new policies are required focusing on primary care, public health, and universal and just access to healthcare resources [17].

Dentistry is a profession that contributes to climate change and increasing environmental pollution. Even though dentists, individually, don't produce significant amounts of waste, the profession generates an impactful accumulated amount of waste to the environment [18,19]. The most important factors contributing to the carbon footprint of NHS dental services, according to the findings of a survey by the Center for Sustainable Healthcare commissioned by Public Health England, are the daily attendance of patients and medical staff at the dental practice at 64.5%, followed by material supply at 19% and energy use at 15.3% [20].

Aside from that, the use of restorative materials which is promoted within the profession greatly affects the environment. The placement and removal of resin-based restorations result in pollutants in the form of particles via human excretion into the environment, which can contaminate the waste system. Amalgam is still widely used in dentistry even though mercury waste is found to be harmful to the environment [21,22]. To reduce the risk of cross-contamination single-use materials and tools made of plastic are used in the profession [19]. Moreover, during dental practice, chair barriers, millions of sterilization pouches, and light handle covers are discarded, 4.8 million lead foils are produced, 28 million liters of X-ray fixer, and 3.7 tons of mercury are wasted annually and 360 gallons of water wasted daily [23].

According to a 2007 article by the Canadian Dental Association, "green" dentistry is a sector of environmental sustainability aiming to minimize the industry's harmful effects on the environment and promote environmental awareness among professionals and patients [24]. With "green"

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dentistry sustainable practices are encouraged to reduce waste and consumption. The basic "green" dentistry model themes are water and energy conservation, infection control management, amalgam management, radiography management, and supply management [25]. Furthermore, the reduction of the use of chemicals and the increasing use of low-volatility products can also be of great importance to the improvement of patient general health. In addition, dentists of modern practices who are aware of environmental issues consider the consumption of resources, use of electricity and water, chemical waste, and patient volume and try to implement environmentally friendly alternatives [26,27]. Overall, eco-friendly dental practices reduce environmental waste, conserve energy, water, and money, introduce technological innovations, and emphasize the well-being of patients [28].

Generally, dentists must comply with regulations related to waste management, follow environmental standards, and minimize the environmental impact, while at the same time, dental waste should be handled and disposed of accordingly [19]. A way for dental offices to achieve a reduced carbon footprint is to develop a proper plan for waste management [27]. Concerning this, everyone involved in the generation, handling, and discarding of medical waste should be included in the decision-making process. Dentists and dental staff, but patients as well, should be informed and aware of the environmental risks of dental waste and contribute to the reduction of the environmental footprint to fulfill sustainability in healthcare [16]. As stated in the Code of Ethics for Dentists in the European Union « The dentist should be conscious of the social nature of his/her profession and must direct society's attention to public health issues and the promotion of quality of care» [29]. In particular, through the daily attendance of patients of various generations at the doctor's office, it is possible, having the required knowledge, to become a catalytic factor in the formation of environmental consciousness.

To date, there has been no research focused on the role of dentists in promoting environmental awareness, and this topic has not been thoroughly examined. Therefore, this study aims to present the perspectives of a sample of Greek dental students and dentists on the environmental crisis and sustainability. It investigates their views on the ethical foundation for developing environmental awareness, the current ecological impact of private dental practices, potential improvements, and the influence of education in fostering awareness. Specifically, it emphasizes the need for dental offices to adopt greener practices and highlights the essential role dentists play in this process, as well as their social responsibility to promote ecological consciousness among patients and colleagues.

## 2. Materials and Methods

### *2.1. Study Design*

In this study, we used a systematic method for data collection, specifically the questionnaire study technique. This technique has been widely used in other studies regarding environmental sustainability [30–32]. For this study, two questionnaires were made, one targeting students (Appendix A) with inclusion criteria: dental students in 1st to 5th year of undergraduate studies at the Department of Dentistry at the National and Kapodistrian University of Athens, and the other for the postgraduate students of the same Department and the dental academic personnel (only dentists) (Appendix B) with inclusion criteria: postgraduate students of the Dental School of Athens and dentists working in the University as academic personnel and assistants at the labs and clinics. The questionnaires were distributed digitally, through social media closed groups, and manually in written form which included the instructions and a QR code leading to the online questionnaire. Specifically, they were handed out before lessons, seminars, during labs, and in clinics. They were distributed for one month after which the results were gathered.

### *2.2. Questionnaire of the Study*

On top of each questionnaire, an introductory message was included describing the aim of this study and offering instructions. It was noted that the fulfillment of the questionnaire was voluntary and confidential and that the volunteers could refuse involvement. Also, it was mentioned that the

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questionnaire is anonymous and in no way leads to the collection of personal data. For the participation, no reward of any kind was provided. Participants could fill out the questionnaire only once. Completing the questionnaire implied acceptance of the personal data protection rules. Ethical approval was obtained from the Board of Ethics of the Department of Dentistry, School of Health Sciences, National and Kapodistrian University of Athens (No.621/16.01.2024).

The students' questionnaire (Appendix A) included the following sections: Part A, consisted of demographic information (gender, year of study, family's residential area) (Q1-Q3) as well as some general questions of environmental content (Q4-Q7). Part B, consisted of questions regarding general attitude towards the environment (QB1-QB14). Part C, consisted of questions about environmental consciousness in the context of dental practice (QC1-QC12). These three parts contained multiple-choice questions. Lastly, Part D included open-ended questions about thoughts and opinions on education and strengthening of environmental consciousness (QD1-QD7).

Specifically, the questionnaire examined the demographic characteristics of the sample including gender, year of study family's residential area as seen in questions Q1-Q3. Questions Q4-Q6 inquired about the environmental actions the participants take individually or/and in their family environment and question Q7 is about the knowledge of amalgam's environmental hazard. These questions had multiple-choice answers. Questions QB1-QB3 examined students' opinions about the severity of climate change, the abundance of natural resources, and the moral basis of ecological consciousness. Moreover, questions QB4-QB7 addressed the capability and importance of promoting environmental awareness on an academic level. Students' perspective on the government's duty to take the appropriate measures to protect the environment was inquired in question QB8. Questions QB9-QB11 were related to students' realization of their daily activities affecting the environment as well as their preferred means of transport. Students' behavior on the use and buying of non-environmentally friendly products and recycling waste was examined in questions QB12-QB14. These questions required answers in terms of a 5-point Likert scale, where 1= Strongly disagree, 2= Disagree, 3= Don't know/ don't answer, 4= Agree, 5= Strongly agree. Questions QC1-QC3 were related to participants' beliefs on environmental consequences of everyday dental activities including proper waste management and their thoughts on opening a dental office near public transportation. Thoughts on the use of environmentally friendly dental products and the future options they could take regarding those were addressed in questions QC4-QC9. Question QC10 was associated with students' point of view regarding instructions given to the patients on water saving during brushing. Lastly, from questions QC11-QC12 information was collected about their desire to participate in conferences with environmental content and their acknowledgment of their social position as future dentists in promoting ecological consciousness to their patients and colleagues. All these questions also required answers in terms of a 5-point Likert scale in the same way that was previously used. Open-ended questions QD1-QD7 gather students' thoughts and opinions on ways in which environmental awareness could be taught in higher education institutions, the most burdensome environmental factors used in dental practice, the characteristics of a "green" dental office, ways in which the manufacturers of dental materials can contribute to environmental protection, actions dentists can take during dental practice to be more environmentally friendly as well as ways to promote environmental awareness to their patients. Finally, students' opinions on social actions dentists can undertake outside the office to help promote an eco-friendly social culture are also collected through these questions.

The dentists' questionnaire (Appendix B) includes the following sections: Part A investigated the demographic information of the sample (gender, occupational dental title, area practicing dentistry) (Q1-Q3) and included some general questions of environmental content (Q4-Q12). Part B focused on questions regarding dentists' general attitude towards the environment (QB1-QB14). Part C included questions QC1-QC19 regarding environmental consciousness in the context of dental practice. These three parts contained multiple-choice questions. Lastly, Part D gathered proposals by dentists on the strengthening of environmental consciousness and the role of education with open-ended questions (QD1-QD7).

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As reported previously the questionnaire gathered information about the demographic characteristics of the dentists participating in the study including gender, occupational title, and area practicing dentistry in Q1-Q3. Questions Q4-Q12 examined the sample's attitude on recycling and participating in environmental protection actions outside of and in their workplace, their knowledge on the proper disposal of dental amalgam as well as their academic education on "green" dentistry. The following questions QB1-QB14, were the same as described in Appendix A, concerning dentists' perspectives on environmental issues, education and its role in promoting environmental awareness and also their role in accomplishing this, and lastly their thoughts on buying and choosing eco-friendly products. Moreover, questions QC1-QC14 were in the same context as mentioned in Appendix A with the addition of dentists' environmental actions concerning water waste during dental practice, choosing an eco-friendly supplier, and therefore buying and using non-harmful environmental products. The use of digital dental services, LED lamps, and special software in the workplace was addressed in questions QC15-QC17 to investigate the sample's environmental concern and subsequently their implementation in the dental office. Also, questions QC18-QC19 examined dentists' will to participate in environmental conferences and their opinions on promoting environmental awareness from their professional role. All the questions above required answers in terms of a 5-point Likert scale, where 1= Strongly disagree, 2= Disagree, 3= Don't know/ don't answer, 4= Agree, 5= Strongly agree as seen also in Appendix A. Lastly, open-ended questions QD1-QD7 gathered dentists' opinions and thoughts on the same concerns as mentioned before in Appendix A.

### *2.3. Statistical Analysis*

Statistical analysis of the data collected from the survey of this study was analyzed with IBM SPSS v.28. Variables of demographic and environmental practices of dentists and dentistry students' samples were presented with absolute and relative frequencies (N, %). Cronbach's alpha indices were used to examine the reliability of the questionnaire. Likert scale variables were summarized with descriptive statistics (M, SD) and the distributions were examined in terms of normality via skewness and kurtosis [33,34]. Variables were considered interval scales and normally distributed, therefore parametric tests were used to examine the associations between variables. Specifically, differences between groups (dentists, dentistry students) and between genders (male, female participants) were assessed with independent samples t-tests, differences between places of origin/dental practice (Rural or Semi-urban areas, Athens, and Other urban area) with the use of One-Way Analysis of Variance (ANOVA). Due to the ordinal nature of the variables, results were confirmed with non-parametric tests (Mann-Whitney and Kruskal-Wallis, respectively). Effect sizes with Cohen's d and $\eta 2$ were calculated to estimate the magnitude of the differences between groups. Partial correlation coefficients adjusted for the effect of group (dentists/dentistry students) were calculated to detect relationships between variables of general attitude towards the environment and variables of environmental awareness in the context of dental practice [33]. Multivariate effects of independent variables Group, Gender, Place, and variables of General Attitudes Towards Environmental Issues, on the dependent variables of Environmental Awareness in the Context of Dental Practice, were examined by Multivariate Analysis of Variance (MANOVA).

## 3. Results

In the sample of this study participated dentists (n=78) (70.5% female), who are academic personnel, or they collaborate with the Department of Dentistry (response rate=16.77%) from whom most of them are primarily working in private dental practices (66.7%), located in Athens and suburbs (71.8%). The majority reported recycling at home (91.1%) yet recycling at the dental office was less (52.5%), and the same was recorded for the environmental protection actions at home (46.1%) and at the dental office (29.5%). Amalgam separator in dental units was reported only by 38.5% of participating dentists, and use of a specialist contamination removal of waste at 69.2%. Heating at dental offices with electricity (55.1%) or oil (29.5%) were the two most frequent energy sources. 44.9% reported participation in social actions for environmental protection, and 60.3% awareness of the

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legislation for the use and disposal of dental amalgam. "Green" dentistry training was implemented through undergraduate studies (48.70%) or non-formal education (20.50%) (Table 1).

**Table 1.** Demographics and environmental practices of dentists (N=78).

| | | N | % |
|---|---|---|---|
| Gender | Male | 21 | 26.9% |
| | Female | 55 | 70.5% |
| | Other | 2 | 2.6% |
| Professional dental qualification | Dentist, in a private dental practice (I work alone) | 9 | 11.5% |
| | Dentist in a private dental practice (I work with staff) | 19 | 24.4% |
| | Dentist in a poly dental practice (partner, I work with staff and partners) | 24 | 30.8% |
| | Faculty member | 3 | 3.8% |
| | Graduate student (MSc, PhD, postdoc) | 11 | 14.1% |
| | Other | 18 | 23.1% |
| Dentistry practice locations | Athens and suburbs | 56 | 71.8% |
| | Other large urban centres Greece (county capitals) | 11 | 14.1% |
| | Towns and villages in Greece (island country) | 2 | 2.6% |
| | Abroad | 8 | 10.3% |
| | Other | 4 | 5.1% |
| Recycling at home | Yes always | 35 | 44.9% |
| | Yes, sometimes | 36 | 46.2% |
| | No | 7 | 9.0% |
| | I don't know/I don't answer | 0 | 0.0% |
| Recycling at dental office | Yes always | 21 | 26.9% |
| | Yes, sometimes | 20 | 25.6% |
| | No | 31 | 39.7% |
| | I don't know/I don't answer | 6 | 7.7% |
| Environmental protection actions at home | Yes always | 10 | 12.8% |
| | Yes, sometimes | 26 | 33.3% |
| | No | 40 | 51.3% |
| | I don't know/I don't answer | 2 | 2.6% |
| Environmental protection actions at dental office | Yes always | 8 | 10.3% |
| | Yes, sometimes | 15 | 19.2% |
| | No | 50 | 64.1% |
| | I don't know/I don't answer | 5 | 6.4% |
| Amalgam separator in dental machine | Yes | 30 | 38.5% |
| | No | 20 | 25.6% |
| | I don't know/I don't answer | 28 | 35.9% |
| Use of a specialist contamination removal | Yes | 54 | 69.2% |
| | No | 12 | 15.4% |
| | I don't know/I don't answer | 12 | 15.4% |
| Heating at dental office | Electricity | 43 | 55.1% |
| | Oil | 23 | 29.5% |
| | Gas | 6 | 7.7% |
| | Other (Heat pump/Fireplace etc.) | 6 | 7.7% |
| Participation in social actions for environmental protection | Yes | 35 | 44.9% |
| | No | 42 | 53.8% |
| | I don't know/I don't answer | 1 | 1.3% |

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| | | | |
|---|---|---|---|
| Awareness of the legislation for use and disposal of dental amalgam | Yes | 47 | 60.3% |
| | No | 25 | 32.1% |
| | I don't know/I don't answer | 6 | 7.7% |
| "Green dentistry" training | Undergraduate studies | 38 | 48.7% |
| | Postgraduate studies | 1 | 1.3% |
| | Continuing education | 7 | 9.0% |
| | Non-formal education | 16 | 20.5% |
| | Other | 16 | 20.5% |

Dental students (n=75) (response rate=10%) were 69.3% female, with a family residence in Athens or the suburbs (56%). 72% reported that their family was involved in the waste recycling process outside their home, and 77.4% were personally involved in environmental protection actions in their home/family. Of the participants, 57.30% had participated in social actions to protect the environment and 50.7% were familiar with the environmental hazard of dental amalgam (Table 2).

**Table 2.** Demographics and environmental practices of dentistry students (N=75).

| | | N | % |
|---|---|---|---|
| Gender | Male | 23 | 30.7% |
| | Female | 52 | 69.3% |
| Year of studies | 2nd | 35 | 46.7% |
| | 3rd | 5 | 6.7% |
| | 4th | 9 | 12.0% |
| | 5th | 19 | 25.3% |
| | On degree | 7 | 9.3% |
| Family residence | Athens and suburbs | 42 | 56.0% |
| | Other large urban centres (county capitals) | 14 | 18.7% |
| | Towns, villages (mainland) | 10 | 13.3% |
| | Abroad | 9 | 12.0% |
| Is your family involved in the waste recycling process outside your home? | Yes always | 36 | 48.0% |
| | Yes, sometimes | 18 | 24.0% |
| | No | 20 | 26.7% |
| | I don't know/I don't answer | 1 | 1.3% |
| Are you personally involved in environmental protection actions in the home/family you live in? | Yes always | 23 | 30.7% |
| | Yes, sometimes | 35 | 46.7% |
| | No | 17 | 22.7% |
| | I don't know/I don't answer | 0 | 0.0% |
| Have you participated in social actions to protect the environment? | Yes | 43 | 57.3% |
| | No | 32 | 42.7% |
| Are you familiar with the environmental hazard of dental amalgam? | Yes | 38 | 50.7% |
| | No | 33 | 44.0% |
| | I don't know/I don't answer | 4 | 5.3% |

*3.1. General Attitudes Towards Environmental Issues*

Overall, the sample presented positive attitudes towards environmental protection and the role of education in developing environmental awareness, indicated by the high mean scores for statements such as "climate change is one of the biggest problems of our time" (M=4.43, SD=1.07), "ecological consciousness is based on moral consciousness" (M=4.47, SD=0.82) as well as the importance of integrating "interventions with an environmental content into the continuing education of dentists" (M=4.14, SD=1.11). Dentists presented more positive attitudes compared to

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dental students, for the adoption of environmental content into their continuing education ($p<.05$, Cohen's d =0.43).

The adoption of environmental practices in everyday life was at a moderate to high level relative to avoiding toxic products (M=3.48, SD=1.06) and reducing the amount of waste through appropriate packaging selection (M=3.27, SD=1.45), yet knowledge about the ecological origin of packaging materials and use of public transport or bicycle to work was towards the lower levels (mean values equal to or less than 3 in a 5-point Likert scale). Dental students presented significantly higher adoption of waste management practices compared to dentists ($p<.05$, Cohen's d =0.68) (Table 3).

**Table 3.** Differences between dentists and dentistry students on variables of general attitude towards the environment.

| | Group | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total (N=153) | | Dentists (N=78) | | Dentistry students (N=75) | | Cohen's d |
| | M | SD | M | SD | M | SD | |
| QB1. Climate change is one of the biggest problems of our time. | 4.43 | 1.07 | 4.50$_a$ | 1.02 | 4.36$_a$ | 1.13 | 0.13 |
| QB2. There is an abundance of environmental resources. | 2.05 | 1.24 | 2.06$_a$ | 1.27 | 2.03$_a$ | 1.22 | 0.03 |
| QB3. Ecological consciousness is based on moral consciousness. | 4.47 | .82 | 4.41$_a$ | .84 | 4.53$_a$ | .79 | 0.15 |
| QB4. Education alone can develop environmental awareness. | 3.14 | 1.28 | 3.23$_a$ | 1.23 | 3.05$_a$ | 1.33 | 0.14 |
| QB5. Dentists have the right knowledge to be able to promote environmental awareness. | 2.80 | 1.14 | 2.65$_a$ | 1.20 | 2.96$_a$ | 1.06 | 0.27 |
| QB6. It is important to integrate interventions with an environmental content into the continuing education of dentists. | 4.14 | 1.11 | 4.37$_a$ | .85 | 3.91$_b$ | 1.29 | 0.43 |
| QB7. Education to develop environmental awareness should be integrated into all levels of education. | 4.60 | .76 | 4.69$_a$ | .69 | 4.51$_a$ | .81 | 0.25 |
| QB8. Outdoor activities help promote environmental awareness. | 4.35 | .86 | 4.26$_a$ | .90 | 4.45$_a$ | .81 | 0.23 |
| QB9. Government agencies have taken the necessary measures to protect the environment. | 1.88 | .95 | 1.77$_a$ | .98 | 1.99$_a$ | .91 | 0.23 |
| QB10. My daily activities affect the environment. | 4.22 | .99 | 4.27$_a$ | .92 | 4.17$_a$ | 1.07 | 0.10 |
| QB11: I know which products I use in my daily life are toxic to the environment and I avoid them. | 3.48 | 1.06 | 3.42$_a$ | 1.16 | 3.53$_a$ | .96 | 0.10 |
| QB12: I choose products based on the volume of their packaging to reduce the amount of waste in my home. | 3.27 | 1.45 | 2.81$_a$ | 1.27 | 3.75$_b$ | 1.47 | 0.68 |
| QB13: I prefer to use public transport or a bicycle instead of a car to go to work. | 3.03 | 1.52 | 2.92$_a$ | 1.56 | 3.13$_a$ | 1.48 | 0.14 |
| QB14: When I buy a product, I think about the type of raw materials used for its packaging and whether they are of ecological origin. | 2.76 | 1.37 | 2.83$_a$ | 1.40 | 2.68$_a$ | 1.34 | 0.05 |

*Note.* Values in the same row and subtable not sharing the same subscript are significantly different at $p< .05$ in the two-sided independent samples t-tests (confirmed by non-parametric Mann-Whitney Tests).
M: Mean (minimum=1, maximum=5), SD: Standard deviation, d: Cohen's d effect size of t-test.

### *3.2. Environmental Awareness in the Context of Dental Practice*

Participants knew that dental practice affects the environment and acknowledged their responsibility in indorsing ecological awareness (Table 4), as indicated by the high mean scores reported for the statements "I believe that my daily dental activities affect the environment" (M=3.95, SD=1.15) and "Due to my professional position, I have a responsibility to promote ecological

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awareness at a social level" (M=3.92, SD=1.17). Moreover, participants overall reported a strong intention to adopt behaviors that protect the environment, including the use of public transport and the selection of environmentally friendly dental machinery, i.e., "I would choose to open a practice close to the means of transport to avoid using a car" (M=3.82, SD=1.28), "I would choose to get a new model of a dental machine/device since it is more environmentally friendly" (M=3.80, SD=1.08). Yet, there is only moderate agreement with the statement "When giving oral hygiene instructions I emphasize the importance of saving water when brushing" (M=3.09, SD=1.53), with dentists reporting lower levels of water-saving instructions compared to dental students' intentions ($p<.05$, Cohen's d =0.46).

Dentists were slightly more aware of the environmental effects of daily dental activities compared to dental students ($p<.05$, Cohen's d =0.31). Nevertheless, compared to the intentions of students, practicing dentists were less likely to use dental materials from environmentally certified suppliers ($p<.05$, Cohen's d =0.78), purchase environmentally friendly products ($p<.05$, Cohen's d =0.73), perform waste sorting in the dental practice ($p<.05$, Cohen's d =0.41), and more likely to choose products based on the ease of use rather than environmental impact ($p<.05$, Cohen's d =0.39) (Table 4).

**Table 4.** Differences between dentists and dentistry students on variables of environmental awareness in the context of dental practice.

| | Group | | | | | | Cohen's d |
|---|---|---|---|---|---|---|---|
| | Total (N=153) | | Dentists (N=78) | | Dentistry students (N=75) | | |
| | M | SD | M | SD | M | SD | |
| QC1: I believe that my daily dental activities affect the environment. | 3.95 | 1.15 | 4.13$_a$ | 1.10 | 3.77$_b$ | 1.18 | 0.31 |
| QC2: I would choose to open a practice close to the means of transport to avoid using a car. | 3.82 | 1.28 | 3.77$_a$ | 1.34 | 3.87$_a$ | 1.23 | 0.08 |
| QC3: I do proper waste sorting while practicing dentistry. | 3.73 | 1.21 | 3.49$_a$ | 1.30 | 3.97$_b$ | 1.07 | 0.41 |
| QC4: I choose dental products according to their ease of use rather than their environmental impact. | 3.59 | 1.10 | 3.79$_a$ | 1.10 | 3.37$_b$ | 1.08 | 0.39 |
| QC5: Before purchasing dental products/devices, I consider their impact on the environment. | 3.13 | 1.22 | 2.72$_a$ | 1.19 | 3.56$_b$ | 1.11 | 0.73 |
| QC6: I would buy a dental product/device that is more expensive but environmentally friendly. | 3.33 | 1.29 | 3.21$_a$ | 1.30 | 3.45$_a$ | 1.28 | 0.19 |
| QC7: It is my selection criterion that the company that supplies me with dental materials has ecological certification. | 3.51 | 1.28 | 3.05$_a$ | 1.29 | 3.99$_b$ | 1.10 | 0.78 |
| QC8: A dental product that is toxic to the environment is the fault of the manufacturer, not the consumer-dentist. | 2.65 | 1.26 | 2.67$_a$ | 1.28 | 2.64$_a$ | 1.26 | 0.02 |
| QC9: I would choose to get a new model of a dental machine/device since it is more environmentally friendly. | 3.80 | 1.08 | 3.65$_a$ | 1.16 | 3.95$_a$ | .98 | 0.27 |
| QC10: When giving oral hygiene instructions I emphasize the importance of saving water when brushing. | 3.09 | 1.53 | 2.76$_a$ | 1.52 | 3.44$_b$ | 1.46 | 0.46 |
| QC11: I participate in environmental conferences. | 3.23 | 1.34 | 3.19$_a$ | 1.26 | 3.27$_a$ | 1.42 | 0.06 |
| QC12. Due to my professional position, I have a responsibility to promote ecological awareness at a social level. | 3.92 | 1.17 | 3.95$_a$ | 1.19 | 3.89$_a$ | 1.16 | 0.05 |

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*Note.* Values in the same row and subtable not sharing the same subscript are significantly different at p< .05 in the two-sided independent samples t-tests (confirmed by non-parametric Mann-Whitney Tests).
M: Mean (minimum=1, maximum=5), SD: Standard deviation, d: Cohen's d effect size of t-test.

Results in Table 5 present the responses relative to environmental practices adopted by the sample of dentists. Respondents indicated a moderately high level of engagement in reducing water waste at their workplace with moderate variability in the responses (M=3.65, SD=1.48), which shows that while a significant portion of respondents takes steps to reduce water waste, there is still a considerable variation in how actively they are engaged in these practices.

**Table 5.** Descriptive statistics for the questions of environmental practices of practicing dentists (N=78).

| | M | SD |
|---|---|---|
| QC13. I take measures to reduce water waste in my workplace. | 3.65 | 1.48 |
| QC14. I choose dental materials based on the company's carbon footprint if it is listed. | 2.40 | 1.18 |
| QC15. I choose dental products based on the volume of packaging materials. | 2.51 | 1.14 |
| QC16. I choose dental materials based on their risk to the environment | 3.01 | 1.34 |
| QC17. I choose to use digital dental services to reduce the environmental impact of my work | 3.53 | 1.41 |
| QC18. I use LED lamps in my workplace to reduce energy consumption | 4.18 | 1.08 |
| QC19. I use special software at my workplace (for appointment management, history taking, etc.) to reduce paper consumption | 4.04 | 1.29 |

The low agreement in the choice of dental materials based on carbon footprint (M=2.40, SD= 1.18), indicates a relatively low level of concern or practical consideration for the carbon footprint of dental materials. This suggests that, on average, the environmental impact of the materials' production is less of a priority in decision-making processes. Similarly, there was a low level of concern about the volume of packaging materials in choosing dental products (M=2.51, SD= 1.14). This implies that the environmental impact of packaging is not a major factor in the selection process for most respondents, with a consistent but low level of agreement. The choice of dental materials based on environmental risk (M=3.01, SD=1.34) showed a moderate level of concern for the environmental risk posed by dental materials, supporting a somewhat higher priority given to environmental risks compared to the carbon footprint or packaging volume but with considerable variation in responses.

Further, participants' responses reflected a moderate to high inclination towards adopting technology that minimizes the environmental footprint of dental practices (M=3.53, SD=1.41). The high use of LED lamps (M=4.18, SD=1.08) suggests a widespread adoption of energy-efficient lighting (LED lamps) as a straightforward and effective measure to improve environmental sustainability in the workplace. Using software for various administrative tasks to minimize paper use was highly supported (M=4.04, SD=1.29), showcasing a strong trend towards digitalization as a means of reducing the environmental impact associated with paper consumption.

Additionally, female dentists, compared to male dentists, were more in support of the statement that climate change is one of the biggest problems of our time (p<.05, Cohen's d=0.96) and that ecological consciousness is based on moral consciousness (p<.05, Cohen's d=0.90), presenting statistically significant differences with a strong effect size. In the sample of dental students, there was a higher agreement of female students, compared to male students, with the statement that climate change is one of the biggest problems of our time, yet the difference was not statistically significant (p>.05, Cohen's d=0.41). Both male and female students presented high levels of agreement with the statement that ecological consciousness is based on moral consciousness (p>.05, Cohen's d=0.10). No significant difference was detected between male and female dentists relative to the importance of integrating interventions with an environmental content into the continuing education actions of dentists (p>.05, Cohen's d=0.50), yet female dental students were significantly more positive with continuing education about environmental issues (p<.05, Cohen's d=0.49). No

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significant differences were detected between genders or places of origin/dental practice for the variables of environmental awareness in the context of dental practice (Appendix C).

*3.3. Open-Ended Questions*

By studying the results from the open-ended questions of the questionnaire, part D, we identify several similarities and differences between dental practitioners and students (Table S1). Specifically, regarding how environmental awareness could be taught and strengthened in universities, the highest percentages are gathered from three categories of responses jointly to dentists and students. The categories that dentists focus on are environmental actions (volunteering, recycling, etc.) and the integration of courses with ecological content into the curriculum with a percentage of 28.95% respectively as well as awareness-raising conferences and seminars with a percentage of 26.32%. As far as students are concerned, the conferences/seminars come first with a percentage of 40% followed by the integration of courses with ecological content (32%) and environmental actions (29.33%).

Concerning the factors in the operation of a dental practice that burden the environment the most, the first in the dentists' perception are the use of plastic consumables and packaging (56.58%), the use of amalgam and resins (15.79%) and the consumption of paper and water at a rate of 10.53% respectively. From the students' point of view, the first factor is again considered to be the use of plastics and consumables, although in a lower percentage (38.67%) with the use of amalgam being second again (29.33%) followed by the use of harmful chemicals (14.57%).

Questioned about the features a dental office should have to be considered "green", dentists primarily focus on recycling (36.84%), using digital media (23.68%), and implementing energy-saving methods (15.79%). For their part, the students consider the use of environmentally friendly tools and devices (42.67%) and recycling (34.67%) to be more important characteristics.

Regarding how manufacturers and retailers of dental tools and materials could contribute to the protection of the environment, the sampled dentists focus on using recycled/recyclable materials for their products and packaging (23.68%), creating products environmentally friendly (22.37%) and reducing the volume of packaging (14.47%). The students seem to show more emphasis on creating environmentally friendly products (48%) and less on using recycled/recyclable materials for their products and packaging (14.67%).

As for which actions/decisions the dentist can make/take during clinical practice that are more environmentally friendly, these are mainly focused on four categories that share the largest percentage of opinions of both doctors and students. These are: 1) recycling/sorting waste, 2) using environmentally friendly equipment and materials, 3) saving water and paper and 4) avoiding waste of dental materials.

To the question regarding how dentists could participate in the promotion of environmental awareness among their patients and colleagues, the majority of dentists answered, by using informative videos, brochures, and posters in the waiting room of the practice (18.42%). Other ways are recycling (15.79%), promoting environmentally friendly oral hygiene products and practices to patients (15.79%), and information/awareness sessions (15.79%). The students seem to show greater importance in promoting environmentally friendly oral hygiene products and practices to patients (41.33%), while regarding informative videos, brochures, and posters in the waiting room (18.67%) and informing patients and promoting environmental sessions and actions (13.33%) the percentages are close to those of dentists.

Finally, in terms of the actions that a dentist can undertake or participate in and can have a positive impact on the formation of a social-environmental culture outside the practice area, dentists mostly focused on volunteering (32.89%), organizing /participating in educational seminars on the environment (14.47%) and in visits/speeches to educational institutions (11.84%). Dental students also focused on the same actions in the same order, placing a little more emphasis on volunteering (44%) and organizing/participating in educational seminars for the environment (28%).

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*3.4. Factors Affecting the Adoption of Environmentally Friendly Practices in the Dental Office*

Table 6 presents the partial correlations between variables of general attitudes towards environmental issues and the variables of environmental awareness in the context of the dental practice, controlling for the group (dentists/dentistry students), to measure the strength and direction of association between variables after removing the influence of the group on their relationship. It was found that participants who believe that their daily dental activities affect the environment had also the conviction that climate change is one of the biggest problems of our time (r=.514, p<.01), ecological consciousness is based on moral consciousness (r=.368, p<.01), integration of interventions with an environmental content into the continuing education of dentists is important (r=.362, p<.01), integration of environmental content into all levels of education (r=.377, p<.01) and individuals' daily activities affect the environment (r=.427, p<.01). Moreover, considerations of products' packaging materials' environmental impact were associated with environmental considerations when buying dental products/devices (r=.322, p<.01), as well as when selecting suppliers (r=.304, p<.01). Choosing products based on the volume of their packaging to reduce the amount of waste was linked to supplier selection based on environmental certification (r=.304, p<.01) and promoting water saving when giving oral hygiene instructions (r=.380, p<.01). Participants who believe that ecological consciousness is based on moral consciousness, would also buy a dental product/device that is more expensive but environmentally friendly (r=.309, p<.01) and consider their responsibility to promote ecological awareness at a social level (r=.418, p<.01). Support of integrating environmental content into continuing education of dentists was related to water waste reduction in the workplace (r=.392, p<.01) and carbon footprint consideration for dental materials (r=.346, p<.01). Participants who would choose to get a new model of a dental machine/device since it is more environmentally friendly (r=.308, p<.01) and take measures to reduce water waste in the dental practice (r=.319, p<.01), have also the conviction that climate change is one of the biggest problems of our time.

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**Table 6.** Partial correlation coefficients between variables of general attitude towards the environment and variables of environmental awareness in the context of dental practice.

| | QB1. | QB2. | QB3. | QB4. | QB5. | QB6. | QB7. | QB8. | QB9. | QB10. | QB11. | QB12 | QB13 | QB14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QC1. | .514** | -.243** | .368** | 0.016 | -0.109 | .362** | .377** | .251** | -0.104 | .427** | 0.135 | 0.024 | 0.141 | .256** |
| QC2. | .294** | -0.044 | .186* | 0.031 | 0.061 | 0.141 | .181* | 0.049 | -0.132 | 0.034 | 0.034 | 0.037 | .233** | 0.104 |
| QC3. | 0.081 | 0.016 | .180* | 0.106 | 0.113 | 0.044 | 0.027 | -0.025 | 0.116 | -0.133 | .256** | .227** | 0.096 | .271** |
| QC4. | -0.153 | -0.013 | -.181* | -0.07 | 0.019 | -.199* | -0.033 | -0.004 | -0.002 | 0.058 | -0.052 | -0.08 | -0.084 | -.257** |
| QC5 | .202* | -0.132 | .299** | 0.049 | .178* | .233** | .214** | 0.098 | 0.07 | 0.084 | .291** | .194* | 0.127 | .322** |
| QC6. | .252** | -0.061 | .309** | 0.114 | 0.081 | .294** | .264** | 0.128 | -0.059 | .195* | .222** | .208* | 0.073 | .227** |
| QC7 | .228** | 0.003 | .188* | .242** | 0.123 | .190* | 0.094 | 0.016 | 0.005 | 0.134 | .207* | .304** | 0.114 | .304** |
| QC8 | -.162* | .329** | -.203* | 0.153 | 0.124 | -.177* | -0.12 | -0.043 | .192* | -0.133 | 0.022 | 0.065 | -0.008 | 0.004 |
| QC9 | .308** | -0.085 | .256** | .175* | 0.035 | .247** | .186* | 0.034 | -0.067 | 0.074 | 0.113 | .272** | .163* | .257** |
| QC10 | 0.126 | -0.009 | .217** | .265** | .272** | .209** | 0.121 | 0.061 | 0.108 | -0.087 | .214** | .380** | 0.143 | .267** |
| QC11 | .319** | -0.077 | .236** | .257** | 0.135 | .392** | .240** | .225** | .161* | 0.107 | .301** | .180* | 0.151 | 0.133 |
| QC12 | .298** | -.291** | .418** | 0.085 | 0.016 | .346** | .283** | 0.155 | 0.071 | 0.093 | .264** | .210** | 0.029 | .201* |

*Note.* ** $p <$ .01, *$p <$ .05. The correlations were calculated controlling for group (dentists/dentistry students). QB1. Climate change is one of the biggest problems of our time, QB2. There is an abundance of environmental resources, QB3. Ecological consciousness is based on moral consciousness, QB4. Education alone can develop environmental awareness, QB5. Dentists have the right knowledge to be able to promote environmental awareness, QB6. It is important to integrate interventions with an environmental content into the continuing education actions of fellow dentists, QB7. Education to develop environmental awareness should be integrated into all levels of education, QB8. Outdoor activities help promote environmental awareness, QB9. Government agencies have taken the necessary measures to protect the environment, QB10. My daily activities affect the environment, QB11: I know which products I use in my daily life are toxic to the environment and I avoid them, QB12: I choose products based on the volume of their packaging to reduce the amount of waste in my home, QB13: I prefer to use public transport or a bicycle instead of a car to go to work, QB14: When I buy a product I think about the type of raw materials used for its packaging and whether they are of ecological origin, QC1: I believe that my daily dental activities affect the environment, QC2: I would choose to open a practice close to the means of transport to avoid using a car, QC3: I do proper waste sorting while practicing dentistry, QC4: I choose dental products according to their ease of use rather than their environmental impact, QC5: Before purchasing dental products/devices, I consider their impact on the environment, QC6: I would buy a dental product/device that is more expensive but environmentally friendly, QC7: It is my selection criterion that the company that supplies me with dental materials has ecological certification, QC8: A dental product that is toxic to the environment is the fault of the manufacturer, not the consumer-dentist, QC9: I would choose to get a new model of a dental machine/device since it is more environmentally friendly, QC10: When giving oral hygiene instructions I emphasize the importance of saving water when brushing, QC11: I participate in environmental conferences, QC12. Due to my professional position, I have a responsibility to promote ecological awareness at a social level, QC11. I take measures to reduce water waste in my workplace, QC12. I choose dental materials based on the company's carbon footprint, as long as it is listed.

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MANOVA results presented in Table 7, indicate that the level of environmental awareness in the context of dental practice is significantly affected by the convictions that climate change is one of the biggest problems of our time (p=.010, η2=.18), ecological consciousness is based on moral consciousness (p=.046, η2=.15), individual daily activities affect the environment (p<.001, η2=.25) and consideration of the ecological origin of packaging materials when buying products (p=.012, η2=.17). More specifically, higher environmental awareness in the context of dental practice is linked to a more robust understanding of the severity of climate change and importance of environmental protection, as well as the awareness of the individual's responsibility towards environmental effects through buying behaviors. It should be noted that dental students present a higher overall level of environmental awareness in the context of dental practice, compared to practicing dentists (p<.001, η2=.28).

**Table 7.** MANOVA results of multivariate tests: Effects of independent variables of Group, Gender, Place and variables of General Attitudes Towards Environmental Issues, on variables of Environmental Awareness in the Context of Dental Practice.

| Effect | Pillai's Trace | F | Hypothesis df | Error df | P | $\eta^2$ |
|---|---|---|---|---|---|---|
| Intercept | 0.24 | 3.58 | 11 | 122 | <.001 | 0.24 |
| Group | 0.28 | 4.37 | 11 | 122 | <.001 | 0.28 |
| Gender | 0.06 | 0.64 | 11 | 122 | .791 | 0.06 |
| Place | 0.19 | 1.18 | 22 | 246 | .264 | 0.10 |
| QB1. Climate change is one of the biggest problems of our time. | 0.18 | 2.38 | 11 | 122 | .010 | 0.18 |
| QB2. There is an abundance of environmental resources. | 0.13 | 1.61 | 11 | 122 | .104 | 0.13 |
| QB3. Ecological consciousness is based on moral consciousness. | 0.15 | 1.89 | 11 | 122 | .046 | 0.15 |
| QB4. Education alone can develop environmental awareness. | 0.11 | 1.35 | 11 | 122 | .203 | 0.11 |
| QB5. Dentists have the right knowledge to be able to promote environmental awareness. | 0.09 | 1.07 | 11 | 122 | .388 | 0.09 |
| QB6. It is important to integrate interventions with an environmental content into the continuing education of dentists. | 0.13 | 1.65 | 11 | 122 | .094 | 0.13 |
| QB7. Education to develop environmental awareness should be integrated into all levels of education. | 0.06 | 0.71 | 11 | 122 | .724 | 0.06 |
| QB8. Outdoor activities help promote environmental awareness. | 0.03 | 0.32 | 11 | 122 | .980 | 0.03 |
| QB9. Government agencies have taken the necessary measures to protect the environment. | 0.11 | 1.41 | 11 | 122 | .175 | 0.11 |
| QB10. My daily activities affect the environment. | 0.25 | 3.74 | 11 | 122 | <.001 | 0.25 |
| QB11: I know which products I use in my daily life are toxic to the environment and I avoid them. | 0.10 | 1.20 | 11 | 122 | .292 | 0.10 |
| QB12: I choose products based on the volume of their packaging to reduce the amount of waste in my home. | 0.10 | 1.16 | 11 | 122 | .319 | 0.10 |
| QB13: I prefer to use public transport or a bicycle instead of a car to go to work. | 0.08 | 0.90 | 11 | 122 | .544 | 0.08 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| QB14: When I buy a product, I think about the type of raw materials used for its packaging and whether they are of ecological origin. | 0.17 | 2.34 | 11 | 122 | .012 | 0.17 |

## 4. Discussion

In the present cross-sectional study, students of the Department of Dentistry of the National and Kapodistrian University of Athens and practicing dentists working in the department, provided information about their knowledge of environmental issues and their beliefs and actions regarding sustainability and environmental awareness to promote ecological consciousness. The importance of achieving sustainability in healthcare, especially in the field of dentistry, has already been discussed in previous studies [19,35–38].

### *4.1. Demographic Characteristics and Environmental Habits*

In our study we came up with an important observation regarding gender; specifically, females were more eager to participate in the study in contrast to males as in both questionnaires females represent more than half of the sample. This can be explained by the fact that women are found to be more inclined toward environmental issues and are more concerned about these matters than men [39,40]. Additionally, regarding the dentists' sample, a statistical difference that is noted is that females have a higher environmental consciousness supporting the findings of McCright and contrasting the research of Hayes which claim that women are less concerned about environmental issues than men [41,42]. However, in our study, these results might occur due to the difference in sample size between males and females as mentioned before. The study also showed that both students and dentists participate in the waste recycling process and environmental protection actions in their households, but these attitudes are not carried through to dentists' workplaces as also mentioned elsewhere [22]. Moreover, the use of amalgam separators in the dental office is significantly low, even though a high percentage of the sample is aware of the hazards of the use and disposal of dental amalgam as discussed also in the study of Spaveras and Antoniadou (2021) [22]. Long working hours, dentists' stress and burnout might be associated with factors leading to disinterest in accomplishing sustainability within the working environment [43]. Also, a high percentage of students mention that their family participates in the waste recycling process outside their home, and they individually are involved in environmental protection actions in their homes as also discussed elsewhere [27]. The purpose of these actions is personal fulfillment and a sense of responsibility which derives from the idea of change and being part of a worldwide team that focuses on the common good [44,45]. Unfortunately, half of the students' sample doesn't acknowledge the environmental hazard of dental amalgam which originates from a lack of education addressing this matter as can be shown from various studies [22,37,46,47].

### *4.2. General Attitudes Towards Environmental Issues*

Both dentists and dental students have positive attitudes regarding environmental issues as they acknowledge climate change as one of the biggest crises of our times, moral consciousness as the main factor in developing ecological consciousness, and the important role of continuing education in developing environmental awareness among dentists, matters that have been discussed thoroughly [27,48–50]. Another interesting result that derives from this study shows that dentists are more positive about the integration of environmental subjects into continuing education programs compared to students as mentioned also in the study of Antoniadou et al. (2023) [27]. Generally, students seem to be aware of environmental issues from the media rather than the educational system [27,51]. As discussed elsewhere too, dental students were not able to recognize the impacts of global warming sufficiently, proving the importance of education in developing environmental consciousness [30,52]. Furthermore, both students and dentists show a relatively positive attitude regarding the avoidance of toxic products and excessive product packaging to reduce waste. It has been proven that packaging, especially in medicine where it is intended as single-use, contributes to

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a great amount of plastic waste, in turn leading to water and soil pollution [53,54]. However, the samples' knowledge of the ecological origin of packaging materials and utilization of public transport or bicycles instead of cars to work is significantly low. Within dentistry, transportation of dentists, employees, and patients by car produces high carbon emissions contributing to human health damage [55,56]. Reduction of travel can be accomplished by scheduling web conferences, and teleconferences, sharing cars with other employees, and gathering laboratory work in route to work [55–57]. Overall, concerning their views on environmental sustainability, dental students have a higher adaptation of waste management practices compared to dentists which can be explained by their age differences as it has been proven that younger people are more sensitized and better educated regarding environmental issues [27,58].

### *4.3. Environmental Awareness in the Context of Dental Practice*

Concerning environmental behaviors within dental practices, participants acknowledge their responsibility in promoting environmental awareness inside the dental office and at a social level and they show a will to adopt more eco-friendly behaviors regarding the purchase of ecological products and building a greener dental office. By developing corporate environmental responsibility, employees are more eager to adopt a more environmentally friendly lifestyle. That's the result of setting up common goals and policies and working towards implementing practices as a whole, targeting environmental sustainability [59]. Even though dentists are shown to be more aware of the environmental effects of their daily dental activities in contrast with the students, they are less likely to choose an ecological product and value the ease of use rather than its ecological origin. On the contrary, students' behavior regarding the purchase of dental products is more eco-friendly. This finding supports the idea that young people are driven by environmental concerns leading them to buy more eco-friendly products and are more likely to adopt this behavior in their daily lives and subsequently in their careers [60,61]. Moreover, the promotion of manufacturers that consider a sustainable form of packaging such as the minimum use of plastic coating will also help other dentists to enhance environmentally friendly consumer behavior [62,63]. Overall, regarding the carbon footprint of dental materials both groups indicate a low level of concern revealing that through decision-making process, materials' production is not taken into consideration. According to related studies, dental service contributes to carbon footprint with various factors including the use of amalgam/composite restorations, so it is of great importance for dentists to find new low-carbon pathways [55,64]. Another finding from our study is the high integration of technology in the dental office which is reinforced by both dental students and dentists resulting in the reduction of paper consumption as well as dentistry's carbon footprint. Such integration contributes to the development of a more ecological dental practice as described in related studies [27,65,66].

### *4.4. Thoughts and Opinions on Education and Strengthening of Environmental Consciousness*

Moreover, from the open-ended questions we gather important information on the opinions and thoughts of the sample regarding ways in which environmental consciousness can be enhanced. These actions with the higher agreement seem to be the ones focusing on protecting the environment such as volunteering and integrating courses with ecological context into the curriculum and organizing conferences and seminars addressing these matters with the latter being more famous among students. Such methods have been described in various studies as significant factors in promoting pro-environmental behavior [67–69]. Concerning the sample's opinion on the most burdensome factors towards the environment used in dentistry single-use plastics, amalgam and resin-based restoration materials, water, and paper waste represent the most common answers mentioned also elsewhere [22]. Composite materials have been identified as a clear environmental pollutant [22], amalgam has been widely studied for its harmful effect on the environment [22,70,71] and single-use plastics in dentistry are accused of hurting the environment [72,73]. Moreover, our study revealed that dentists consider recycling and the use of digital media in the dental office as the most important features for it to become "green" whereas students believe that the use of environmentally friendly products is a greater factor for a "green" dental office. Concerning digital

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dentistry, it has been noted that an increasing number of practices are turning towards the frequent use of digital media, contributing among other things to the adaptation of an eco-friendlier approach [74–76]. In addition, dentists express their opinion on methods the manufacturers can implement to become more environmentally friendly with the most common answer being the use of recycled/recyclable materials for their products and packaging followed by the creation of ecological products, a belief also shared among 49% of students. It is of great importance that dentists choose a manufacturer who promotes environmental awareness by producing sustainable materials, has ethical working conditions, and has a list of chemicals and sources of raw materials available to the public [75–77]. Our study also examined the sample's thoughts on practical decisions made in dental practice that are considered more eco-friendly revealing that recycling, water/paper saving, use of environmentally friendly products, and rational use of materials during dental practice are the dominant views of both doctors and students. The implementation of these practices leads to the promotion of environmental consciousness encouraging the adaptation of sustainability and achieving a "green" dental office [25,78,79].

Methods to cultivate ecological consciousness in patients and colleagues by dentists are also gathered in this study. The highest portion of the sample focuses on informative brochures, videos in the waiting room, proper recycling/ sorting of waste and/ or cooperation with competent bodies, informing patients of environmental issues, and especially students seem to emphasize more on promoting environmentally friendly oral hygiene products and practices to patients. Informal conversations, discussions amongst colleagues, and organizing staff meetings to adopt eco-friendly behavior can help promote environmental awareness in the workplace. Also, informing patients of the importance of preventive care will result in lower patient journeys in the dental office and, overall, less clinical waste, resulting in the reduction of $CO_2$ emissions and generally less waste and pollution [65,80,81]. Regarding actions dentists can undertake outside of the workplace to contribute to the formation of a social-environmental culture, volunteering is jointly answered by the sample, with a clear emphasis on the students, followed by participation in lectures/conferences. According to a study, some practical suggestions involve actively participating in local peer group events and academic or industry research initiatives, as well as cooperating and engaging in societies, businesses, and educational ventures [80].

Our study, while shedding light on the attitudes and behaviors of dental students and practitioners towards environmental consciousness, is not without its limitations. Firstly, the sample primarily consists of individuals from the Department of Dentistry at the National and Kapodistrian University of Athens, potentially limiting the generalizability of our findings to a broader population of dental professionals. Additionally, the reliance on self-reported data through questionnaires introduces the possibility of social desirability bias, where participants may respond, they believe are socially acceptable rather than reflective of their true attitudes and behaviors [82]. Furthermore, the cross-sectional design of our study captures a snapshot of attitudes and behaviors at a single point in time, preventing the establishment of causal relationships or tracking changes over time. Our low response rates also raise concerns about the representativeness of our sample too. Lastly, our study focuses predominantly on environmental attitudes and behaviors within the context of dentistry, overlooking broader environmental practices that may influence participants' ecological consciousness.

Moving forward, future research endeavors could address these limitations further and enhance our understanding of environmental consciousness in the field of dentistry. Longitudinal studies tracking changes in attitudes and behaviors over time would provide valuable insights into the development and sustainability of environmental awareness among dental students and practitioners. Diversifying the sample to include participants from various regions and backgrounds would enhance the generalizability of findings. Employing a mixed-methods approach, combining quantitative surveys with qualitative interviews or focus groups, could offer a deeper understanding of the factors influencing environmental consciousness in dental settings. Furthermore, intervention studies implementing strategies to promote environmental awareness within dental education and practice settings would help assess the effectiveness of different approaches. Additionally,

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comparative studies between different dental schools or regions could identify variations in environmental attitudes and behaviors, studying factors contributing to differences in ecological consciousness.

In the pursuit of enhancing environmental consciousness within the field of dentistry, it is essential to recognize that our actions today shape the world of tomorrow. As Mahatma Gandhi once said, "The future depends on what you do today." Through collaborative efforts, education, and a commitment to sustainable practices, dental professionals and students can play a significant role in controlling the environmental impact of dental services and promoting a greener future for all stakeholders.

## 5. Conclusions

Our study provides valuable insights into the attitudes and behaviors of dental students and practitioners towards environmental consciousness within the context of dentistry. Firstly, there is a notable gender disparity in participation, with females demonstrating a greater inclination towards environmental issues. Both students and dentists display positive attitudes towards environmental issues, acknowledging climate change as a significant crisis and recognizing the importance of continuing education in fostering environmental awareness. However, there are discrepancies between students and dentists regarding the integration of environmental subjects into education programs and the adoption of eco-friendly behaviors in dental practices. Environmental behaviors such as waste management practices and the use of digital technology in dental offices show promise in reducing environmental impact.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

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## Appendix A. Students' Questionnaire

Introductory message

ONLY FOR UNDERGRADUATE DENTAL STUDENTS

The questionnaire of this study includes a general part (A) with demographic data, part (B) and part C include questions exploring participants' views on environmental awareness/attitude and (D) section consists of open-ended questions that explore general opinions on how dentists influence the development of environmental awareness and practices within society.

The survey is designed to be anonymous, ensuring that no personal information is collected during the process. Participation is voluntary and no reward of any kind is provided for your participation. You can fill in the questionnaire ONLY once. Completing the questionnaire implies acceptance of the personal data protection rules. The results of this study will be used for scientific

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publications and actions to improve working conditions in the departments involved. For observations, comments, and clarifications you can contact the research group.

**Part A: Demographic information and general environmental questions**

Q1. What's your gender? Male_Female_Other

Q2. What year are you studying in? 1o_2o_3o_4o _5o_Degree

Q3. Where does your family live? Athens and suburbs_Other big urban areas ( county capitals)_Towns, villages (continental country)_Towns, villages ( island country)_Abroad

Q4. Is your family involved in the recycling process beyond your home? Yes always_No_Yes, sometimes_Don't know/ don't answer

Q5. Are you personally involved in environmental protection actions in the home/family you live in? Yes always_No_Yes, sometimes_Don't know/ don't answer

Q6. Have you participated in social actions regarding the protection of the environment? Yes_No_Don't know/ don't answer

Q7. Do you know the environmental hazards of dental amalgam? Yes_No_Don't know/ don't answer

**Part B: General attitude towards the environment**

QB1. Climate change is one of the major problems nowadays. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB2.There is an abundance of environmental resources. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB3. Ecological consciousness is based on moral consciousness. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB4. Education alone is capable of developing environmental awareness. Strongly disagree_Disagree_Don't know/ don't answer_Agree _Strongly agree

QB5. University professors have the appropriate knowledge to promote environmental awareness. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB6. It is important to integrate a course with environmental content into the university's educational program. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB7. Education for developing environmental awareness should be integrated into all levels of education. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB8. Government agencies have taken the necessary measures to protect the environment. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB9. Outdoor activities help promote environmental awareness. Strongly disagree_Disagree_Don't know/ don't answer_Agree _Strongly agree

QB10. My daily activities affect the environment. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB11: I prefer to use public transport or a bicycle instead of a car to go to my obligations. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB12. I know which products I use in my daily life are toxic to the environment and I avoid them. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB13. When I buy a product I think about the type of raw materials used for its packaging and whether they have an ecological origin. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QB14: We separate the waste in our house. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

**PART C: Environmental Awareness in the Context of Dental Practice**

QC1) I believe that my daily dental activities affect the environment. Strongly disagree_Disagree_Don't know/ don't answer_Agree _Strongly agree

QC2) I would choose to open my private practice close to public transport to avoid using a car. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC3) I do proper waste management while practicing dentistry.Strongly disagree_Disagree_Don't know/ don't answer_Agree _Strongly agree

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QC4) I choose whenever I have the opportunity to use dental products based on their ease of use rather than their environmental impact. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC5. When I start the profession, before purchasing dental products/devices I will consider their impact on the environment. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC6. I would purchase a dental product/device that is more expensive but environmentally friendly. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC7. I would consider in the future, that the company that supplies me with dental materials has ecological certification. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC8. For a dental product to be toxic to the environment, the manufacturer is at fault, not the consumer-dentist. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC9. I would choose in the future to purchase a dental machine that is more environmentally friendly. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC10. When giving oral hygiene instructions I emphasize the importance of saving water when brushing. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC11. I wish and participate in environmental conferences. Strongly disagree_Disagree _Don't know/ don't answer_Agree _Strongly agree

QC12. From my future professional position, I have a responsibility to promote ecological awareness to my patients and colleagues. Strongly disagree_Disagree _Don't know/ don't answer_Agree_Strongly agree

**Part D. Thoughts and opinions on education and strengthening of environmental consciousness**

QD1: Mention ways in which you think the importance of environmental awareness could be taught and enhanced in higher education institutions. Answer:

QD2: Which factors (processes/equipment/materials) in the operation of a dental office do you think are the most burdensome to the environment? Answer:

QD3: What characteristics do you think a modern dental office should have to be considered ecological (green)? Answer:

QD4: In what ways do you think manufacturers and merchants of dental tools and materials could contribute to environmental protection? Answer:

QD5. What actions/decisions that the dentist can make during clinical practice, do you think are more environmentally friendly? Answer:

QD6: In what ways and means do you think the dentist could participate in promoting environmental awareness to their patients within their workplace? (Note practical actions) Answer:

QD7. What social actions can a dentist undertake or participate in, that could have a positive impact on the formation of social environmental culture outside the office space? Answer:

**Appendix B. Dentists' Questionnaire**

Introductory message

ONLY FOR DENTISTS AND POSTGRADUATE DENTAL STUDENTS

The questionnaire of this study includes a general part (A) with demographic data, part (B) and part C include questions exploring participants' views on environmental awareness/attitude and (D) section consists of open-ended questions that explore general opinions on how dentists influence the development of environmental awareness and practices within society.

The survey is designed to be anonymous, ensuring that no personal information is collected during the process.. Participation is voluntary and no reward of any kind is provided for your participation. You can fill in the questionnaire ONLY once. Completing the questionnaire implies acceptance of the personal data protection rules. The results of this study will be used for scientific publications and actions to improve working conditions in the departments involved. For observations, comments, clarifications you can contact the research group.

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**Part A: Demographic information and general environmental questions**

Q1) What's your gender? Male_Female_Other

Q2) What's your occupational dental title? Dentist in a private clinic ( I work by myself)_Dentist in a private clinic (I work with personnel)_Dentist in a group practice (my own business, working with personnel and associates)_Dentist in a group practice (associate, working with personnel and associates)_Post-graduate student (master, phD, postdoctoral fellow)_Faculty member_Owner of dental clinic (I don't practice clinical dentistry)_Other

Q3) Where do you practice dentistry? Athens and suburbs_Other big urban areas ( county capitals)_Towns, villages (continental country)_Towns, villages ( island country)_Abroad_Other

Q4) Do you recycle at your house? Yes always_No_Yes, sometimes_Don't know/ don't answer

Q5) Do you recycle at the dental clinic you are working? (Your own or associate's) Yes always_No_Yes, sometimes_Don't know/ don't answer

Q6) Do you participate in environmental protection actions at your house/family? Yes always_No_Yes, sometimes_Don't know/ don't answer

Q7) Do you participate in environmental protection actions at your workplace? Yes always_No_Yes, sometimes_Don't know/ don't answer

Q8) Is there an amalgam separator in the dental unit you are working? Yes_No_Don't know/ don't answer

Q9) Do you use a special company for the removal of contaminants in your workplace?Yes_No_Don't know/ don't answer

Q10) What type of heating do you use in your workplace?Oil_Gas_Electricity_Heat pump_Fireplace_Other

Q11) Have you participated in social environmental protection actions?Yes_No_Don't know/ don't answer

Q12) Do you know the legislation regarding the use and disposal of dental amalgam? Yes_No_Don't know/ don't answer

Q13) Have you been taught about "green dentistry" regulations until now? During undergraduate studies_During postgraduate studies_During continuing education_On a social level_Other

**Part B: General attitude towards the environment**

QB1) Climate change is one of the major problems nowadays.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB2) There is an abundance of environmental resources. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB3) Ecological consciousness is based on moral consciousness. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB4) Education alone is capable of developing environmental awareness. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB5) Dentists have the appropriate knowledge to be able to promote environmental awareness.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB6) It is important to integrate interventions with an environmental content into the continuing education actions of fellow dentists. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB7) Education for developing environmental awareness should be integrated into all levels of education.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB8) Outdoor activities help promote environmental awareness.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB9) Government agencies have taken the necessary measures to protect the environment. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB10) My daily activities affect the environment.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

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QB11) I know which products I use in my daily life are toxic to the environment and I avoid them. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB12) I choose products based on the volume of their packaging to reduce the amount of waste in my home. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB13) I prefer to use public transport or a bicycle instead of a car to go to work.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QB14) When I buy a product I think about the type of raw materials used for its packaging and whether they have an ecological origin. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

**PART C: Environmental Awareness in the Context of Dental Practice**

QC1) I believe that my daily dental activities affect the environment. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC2) I would choose to open my private practice close to public transport to avoid using a car. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC3) I do proper waste management while practicing dentistry. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC4) I choose dental products according to their ease of use rather than their environmental impact. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC5) Before purchasing dental products/devices, I consider their impact on the environment. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC6) I would purchase a dental product/device that is more expensive but environmentally friendly. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC7) It is crucial to me that the company that supplies me with dental materials has ecological certification. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC8) For a dental product being toxic to the environment, the manufacturer is at fault, not the consumer-dentist. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC9) I would choose to purchase a new model of a dental machine/device since it is more environmentally friendly.

Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC10) When giving oral hygiene instructions I emphasize the importance of saving water when brushing. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC11) I take measures to reduce water waste in my workplace.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC12) I choose dental materials based on the company's carbon footprint, as long as it is listed.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC13) I choose dental products based on the volume of packaging materials.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC14) I choose dental materials based on their environmental risk.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC15) I choose to use digital dental services to reduce the environmental impact of my work. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC16) I use LED lamps in my workplace to reduce energy consumption. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC17) I use special software at my workplace (for appointment management, medical history taking, etc.) to reduce paper consumption. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC18) I wish and participate in environmental conferences.Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

QC19) Due to my professional position I have a responsibility to promote ecological awareness at a social level. Strongly disagree_Disagree_Don't know/ don't answer_Agree_Strongly agree

**Part D. Thoughts and opinions on education and strengthening of environmental consciousness**

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QD1: Mention ways in which you think the importance of environmental awareness could be taught and enhanced in higher education institutions. Answer:

QD2: Which factors (processes/equipment/materials) in the operation of a dental office do you think are the most burdensome to the environment? Answer:

QD3: What characteristics do you think a modern dental office should have to be considered ecological (green)? Answer:

QD4: In what ways do you think manufacturers and merchants of dental tools and materials could contribute to environmental protection? Answer:

QD5. What actions/decisions that the dentist can make during clinical practice, do you think are more environmentally friendly? Answer:

QD6: How do you think the dentist could participate in promoting environmental awareness among his patients and colleagues within the dental office? Answer:

QD7. What social actions can a dentist undertake or participate in that you think can have a positive impact on shaping a social environmental culture outside of the workplace? Answer:

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