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Evaluating Dental Students' Knowledge and Attitudes Toward Antisepsis and Infection Control: An Educational Intervention Pilot Study

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Abstract: Background: Infection control is fundamental in dental practice, especially following the COVID-19 pandemic, which highlighted the variability in students' adherence to disinfection protocols. This study aimed to evaluate the knowledge, attitudes, and practices of 4th- and 5th-year dental students at the National and Kapodistrian University of Athens regarding antisepsis and infection control, and to assess the effectiveness of an educational intervention. Methods: A pre-post interventional study was conducted involving two in-person seminars, supplementary e-learning materials, and a structured questionnaire administered before and after the intervention. The survey assessed knowledge, clinical practices, and attitudes toward infection control, including vaccination history and prior exposure incidents. Results: The intervention led to statistically significant improvements in infection control knowledge, especially in risk-based sterilization strategies, disinfectant classification, and PPE use. Students with prior hepatitis B vaccination and antibody testing demonstrated higher baseline scores and more significant knowledge gains. However, some misconceptions, particularly regarding surface disinfection and prosthetic care, persisted after the intervention. Conclusions: The findings support the effectiveness of structured educational interventions in improving infection control awareness among dental students. Practical, simulation-based training and earlier curriculum integration are recommended to enhance compliance and ensure safe clinical practice.

Keywords: Infection control; Dental education; Antisepsis; Disinfection protocols; Educational intervention; Personal protective equipment (PPE); Sterilization; Dental students; COVID-19; Occupational exposure

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1. Introduction

Infection control in dental practice plays a critical role in protecting both patients and dental healthcare professionals from the transmission of infectious agents [1]. Dental procedures frequently involve exposure to blood and saliva, both of which can contain a variety of microorganisms capable of spreading infections within the clinical environment [2]. The use of high-speed instruments and ultrasonic scalers generates aerosols that may contain pathogens, which can settle on various surfaces within the dental operatory [3]. Additionally, surfaces can become contaminated through direct contact with gloved hands, ungloved hands, or contaminated instruments [4]. Surfaces commonly affected include the dental chair, lamp and instrument table handles, X-ray machines, countertops, and flooring [5]. Studies have identified numerous pathogens on these surfaces, including *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*, *Klebsiella pneumoniae*, *Mycobacterium tuberculosis*, *Legionella pneumophila*, and *Escherichia coli*, along with viruses such as hepatitis B and C, HIV, Epstein–Barr virus, herpes simplex virus, and cytomegalovirus although the most common isolated bacteria from the various surfaces are species of Staphylococcus, Streptococcus, Pseudomonas, Bacillus and

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Micrococcus [3,6]. These microorganisms can survive for extended periods in the clinical environment, emphasizing the need for comprehensive disinfection protocols more than ever [7].

To address surface contamination, various disinfectants are recommended, including alcohol-based solutions, iodophors, phenolic compounds, and chlorine-based agents like sodium hypochlorite [8]. The disinfection protocols used so far typically require the removal of visible contaminants followed by the application of a suitable disinfectant with a recommended contact time of at least 10 minutes [9]. While both surface disinfection and the use of protective barriers are effective in reducing microbial load, the choice of method often depends on the type of surface and practitioner preference [10]. A combined approach is generally advised for optimal infection control [4].

The outbreak of COVID-19 in late 2019 drastically changed infection control practices in dentistry [11,12]. Due to the virus's high transmissibility through respiratory droplets and contaminated surfaces, dental professionals faced an elevated occupational risk [13,14]. In response, infection control protocols were rapidly updated to control the viral spread in dental settings [15–17]. Key recommendations included increased frequency of air exchange, disinfection of air conditioning systems, and surface cleaning with agents such as 0.5% sodium hypochlorite, 70% alcohol, or hydrogen peroxide-based solutions [18–22]. Despite the widespread availability of infection control guidelines, research suggests that dental students may exhibit inconsistent compliance and varying levels of understanding regarding these protocols [23]. As is evident from the results of various studies, a large percentage of students are unaware of decontamination protocols or do not apply them in dental clinical practice [24–27]. Nevertheless, dental students' knowledge, attitudes, and practices as future practitioners are essential to ensuring a safe clinical environment [28].

In this context, the present study investigates the knowledge, attitudes, and clinical practices related to antisepsis and infection control among 4th and 5th-year dental students at a public university dental department. Additionally, the study evaluates the effectiveness of an educational intervention designed to enhance students' awareness and adherence to recommended infection control measures. Furthermore, it investigates students' attitudes toward infection control practices and the extent to which they implement recommended measures during their clinical practice. To address these objectives, the study is guided by the following null hypotheses: H_{01} – there is no statistically significant difference in students' knowledge regarding antisepsis and infection control before and after the educational intervention; H_{02} – there is no significant difference in the self-reported practices related to disinfection, sterilization, and antisepsis pre- and post-intervention; and H_{03} – the educational intervention has no impact on students' attitudes toward infection control within dental clinical settings.

2. Brief literature review on the subject

Across various countries, compliance with basic infection control protocols among dental students has shown both promising and concerning trends. For example, in Brazil, a survey by de Souza et al. (2006) reported that 99.5% of students used gloves consistently, while 84.2% wore goggles and 100% wore masks, reflecting a relatively high level of adherence to protective measures [29]. Similarly, in Saudi Arabia, a study by El-Maweri et al. (2015) found that 98.8% of students consistently wore gloves and 90.8% wore masks [30]. Conversely, Singh et al. (2011) reported poor compliance in India, with only two out of 245 students regularly using all forms of personal protective equipment (PPE), and 61.2% not vaccinated against hepatitis B [31]. In Pakistan, nearly half of the dental students in a study by Qamar et al. (2020) did not use hand antiseptics, and only one-third wore PPE during clinical practice [26]. Also, Ataş et al. (2020) in Turkey found that all students used masks and gloves, with 73.6% using face shields and 86.7% using hand antiseptics frequently. [32]. Another study conducted among dental students in India showed that 91.3% of students disinfected the dental chair, x-ray machine, and other parts of the equipment before use while 61.3% asked their patients to rinse with antiseptic solution before dental practice to limit microbes spreading in the room [27]. A different survey was conducted again in undergraduate dental students in India and revealed

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compliance of 80% of the students with the use of gloves, masks, head caps and gown and they also washed their hands before and after examining patients. However, most of them did not use protective goggles [33].

In addition, vaccination against the hepatitis B virus (HBV) remains a cornerstone of infection control in dental education; however, vaccination coverage and follow-up serological testing vary significantly across different regions. In Saudi Arabia, although 90% of dental students had received at least one dose of the HBV vaccine, only 37.4% had undergone post-vaccination serological testing to confirm immunity [30]. In stark contrast, a recent study from India reported that just 3.8% of dental students were vaccinated against HBV, despite full compliance with hand hygiene protocols [27]. Furthermore, in a survey of undergraduate dental students in India, 30% stated that they were not vaccinated against hepatitis B, and at the same time, many vaccinated students didn't check their antibody levels after vaccination [33]. Also, in a study by Antoniadou et al. (2024), the importance of vaccination was further reported in the context of occupational exposure. The authors reported a notable incidence of clinical injuries among undergraduate dental students, particularly during the fourth and fifth years of study, when clinical procedures become more frequent and complex. Their prevention protocol emphasized the need for intensive immunization coverage, proper training in sharps handling, and continuous reinforcement of infection control practices, including post-exposure protocols and immunity monitoring [34]. These findings show that there are disparities in preventive practices and immunization awareness worldwide.

Furthermore, attitudes toward managing patients with infectious diseases are critical in the literature. A United Arab Emirates study revealed a significant difference between 4th and 5th-year students, with 4th-year students more willing to treat infected patients (68.5%) compared to 44.4% of 5th-year students [35]. Halboub et al. (2015) also observed that 58.9% of 5th-year students in Yemen expressed positive attitudes toward treating such patients versus 31.0% of 4th-year students [36]. Finally, gender differences were also noted by Noura et al. (2017), where male students were significantly more open to treating patients with infectious diseases compared to their female counterparts [37]. Another survey showed that students were less willing to treat an HIV patient than an HBV patient (10.9% vs. 3.0%) [28]. However, the majority would help those patients. When asked if they would take additional protection measures, 2-3% said they would not consider it necessary. The rest stated that 88-89% would take protection measures for themselves, 93-95% would take additional disinfection and sterilization of instruments and only 75% stated that they would disinfect the dental unit to a greater extent [28]. In a similar survey conducted in India, more than half of the students were not sure about treating patients with infectious diseases and would not take a detailed history to exclude HIV/HBV status (>40%) [33].

Another recurring theme in the literature is the disconnection between positive attitudes and the actual implementation of infection control protocols. In Jaipur, India, Deogade et al. (2018) reported that while many students were satisfied with their infection control knowledge, actual compliance in prosthodontic clinics ranged from 14.4% to 100% [24]. Further, at Istanbul Aydin University, while 93.9% of students wore gloves and 91% disinfected the dental chair between patients, only 29.3% washed their hands before wearing gloves, highlighting inconsistency in hand hygiene practices [25]. A recent survey showed that although most students used masks and gloves on every patient, 7.9% never wore masks and less than half used protective goggles even though they were available in the clinic [28].

We should further mention that the COVID-19 pandemic significantly influenced students' awareness and practices. Ataş et al. (2020) in Turkey found that 74.9% of the students felt psychologically impacted by the pandemic [32]. Additionally, Elagib et al. (2021) observed that while PPE usage was moderate in Saudi Arabia, it remained low in Sudan, with anesthesia and suture needles being the most common causes of percutaneous injuries [38]. In another survey, almost half of the student participants were injured during dental practices [28]. 55% of those who were injured did not seek the source patient's bloodborne virus status while 80.5% did not contact any health care provider for post-exposure prophylaxis (PEP) [28]. An additional study was carried out at the

National and Kapodistrian University of Athens, Department of Dentistry, focusing on student injuries during their clinical practice [34]. The results showed high injury rates with needles being the main cause followed by burs and dental probes. Injuries occurred mainly in the fingers and the most dangerous treatments were periodontal, endodontic, and restorative procedures. [34]. According to another survey, 90% of students were injured by a contaminated instrument during clinical practice and more females had blood or saliva splashes on their eyes compared to male students [33].

Finally, educational programs have been carried out from time to time for health students on infection control [39]. In a related study, a short infection control training program was implemented for second-year dental students for the first time in 2004 and the students' knowledge and ability to practice infection control before and after the program was compared [40]. There was a significant increase in the number of students who managed to pass the course at their initial attempt, 42% and 78%, in the 2004 and 2005 academic years, respectively. There was also a significant improvement in the students' vigilance and knowledge of infection control and both staff and students found the program particularly supportive [40]. Another survey was later conducted among third-year students at a private dental university in India to assess students' knowledge, attitudes, and practices regarding infection control and waste management. An appropriate training program was carried out, followed by re-evaluation, and then the results were compared. A significant improvement in the student's ability to practice effective infection control was shown after the intervention [41]. One more study showed that after teaching the appropriate infection control and protective equipment methods using video, a significant improvement in the knowledge of a large percentage of students (41%) was observed. This knowledge is related to the use of protective barriers and personal protection equipment, the management of sharp instruments, hand washing, and disinfection [42]. A more recent study was conducted among third-year dental students comparing the students' response to infection control issues before and after the implementation of various relevant educational methods. The results showed that there was a significant improvement in students' knowledge and 96% of the students stated that after the program they noticed an improvement in their ability to practice effective infection control [43]. Finally, a similar survey conducted in Cyprus in 2025 assessed sixth-semester dental students' knowledge of infection prevention and cross-contamination. The findings likewise indicated notable improvements in students' knowledge, further supporting the effectiveness of targeted educational interventions in this domain [44].

3. Materials and Methods

3.1. Study design

This study was conducted using a pre-post interventional design aimed at evaluating the knowledge, attitudes, and practices of dental students regarding antisepsis, sterilization, and infection control. The target population included 4th and 5th-year students at the Department of Dentistry, National and Kapodistrian University of Athens. The intervention involved a structured educational approach to assess its impact on improving infection control awareness and behaviors among clinical-year dental students. The study was conducted following the Declaration of Helsinki and approved by the Institutional Review Board and Ethics Committee of the Department of Dentistry, (protocol code 127786/11/12/2023).

3.2. Educational approach

The educational intervention consisted of two seminars, each lasting two hours, conducted in-person by the same educator (a specialist on the theme) and focused on key infection control topics such as disinfection, sterilization techniques, surface barriers, and antisepsis protocols. These sessions incorporated visual learning materials, including slides and videos, as well as interactive discussions [45]. Additionally, a live knowledge assessment was conducted before the seminars to gauge the students' baseline understanding [46]. Following the seminars, students were given free access to supplementary educational materials through the university's e-class platform under the course "Organization and Management of the Dental Office" [47]. These included downloadable presentations, instructional videos, and official leaflets on decontamination protocols. Students were encouraged to study the materials at their own pace over 20 days. After this period, the same questionnaire was redistributed to assess any changes in knowledge and attitudes post-intervention.

3.3. Questionnaire for the study

The instrument used was a structured questionnaire designed to evaluate three main areas: students' knowledge of infection control protocols, their attitudes toward treating patients with infectious diseases, and their self-reported clinical practices [48,49]. The questionnaire was administered digitally using Google Forms and was accessed by students via a QR code. This method allowed them to complete the survey conveniently using their mobile devices [50]. The questionnaire was distributed twice: once before the educational intervention (baseline) and again 20 days after the intervention, allowing for a direct comparison of results. No personal identifying data were collected at any stage of the study, ensuring complete anonymity and voluntary participation.

More specifically, the questionnaire consists of closed-ended multiple-choice questions, Likert scale questions, categorical questions, and open-ended questions to comprehensively examine participants' knowledge and experiences (Appendix A). The structure is divided into two main sections: Part A refers to demographic information and Part B refers to infection control knowledge and practices. Part A collects demographic information through multiple-choice questions: 1) QI, Q2, about the gender, study year (categorical questions), 2) Q3, Q4, Q5, Q6 ask about the respondent's place of origin and vaccination history, the doses of vaccination and the levels of antibodies for hepatitis B (numeric response questions). Part B included 11 questions Q1-Q11. Q1 through Likert scale questions ranging from "not at all" to "very much" assessed students' awareness of disinfectants, sterilization, antisepsis, and COVID-19's impact on infection control. Q2 included Likert scale questions ranging from "Never" to "Always" and examined the use of personal protective equipment (PPE), hand hygiene, and adherence to safety measures during clinical procedures. Q3 included multiple-choice questions to evaluate students' ability to differentiate between sterilization, disinfection, and antisepsis in clinical practice and Q4 use Likert scale questions to gauge their understanding of the level of disinfectant action required for specific pathogens (e.g., HIV, HBV, TB). Q5 via Likert scale questions classified disinfectants based on their effectiveness (e.g., strong, moderate, weak) and chemical composition (e.g., alcohols, chlorine, formaldehyde). Q6 contained multiple-choice questions to gather knowledge of instrument classification based on the risk of infection transmission (critical, semi-critical, non-critical) and Q7 through Likert scale questions assessed students' understanding of sterilization methods for different instruments and surfaces based on the risk of infection. Further, Q8, Q9 included true/false questions to examine knowledge of best practices for surface disinfection and decontamination of impressions and prosthesis. Also, Q10 evaluated understanding of tool sterilization, autoclave usage, dry heat sterilization, and the importance of sterilization validation through true/false questions while Q11 included three open-ended questions. These questions allowed respondents to elaborate more on preferred learning methods for disinfection and antisepsis, challenges faced in adhering to infection control protocols and attitudes towards treating patients with infectious diseases.

3.4. Controlling bias

Several strategies were employed in the study design and implementation to minimize potential sources of bias and enhance the validity of the findings [51]. Firstly, the questionnaire was used to assess knowledge, attitudes, and practices, and was carefully developed and validated by academic staff (3 staff members, relevant to the subject) to ensure clarity, relevance, and content accuracy. This step helped reduce measurement bias, ensuring that the tool accurately captured the intended constructs [52]. Further, selection bias was addressed by targeting all 4th and 5th-year dental students during their scheduled coursework and clinical activities, offering equal opportunity for

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participation [53]. Also, the use of QR code access via Google Forms on mobile devices made the process more convenient and inclusive, encouraging broad engagement from the student cohort. Moreover, to limit social desirability bias, participation was completely anonymous and voluntary, and students were informed that no personal data would be collected [54]. Additionally, no incentives were provided, ensuring that students' responses were not influenced by reward-seeking behavior or external pressures [55]. The use of the same questionnaire before and after the educational intervention helped also control instrumentation bias, allowing for a direct and consistent comparison of responses [56]. The 20-day interval between the intervention and the post-assessment provided students with adequate time to absorb the learning material while also reducing the impact of recall bias from the initial assessment [57]. Response bias was further controlled by assuring students in the instructions that there were no right or wrong answers and that honest responses were critical to the success of the research [58]. Questions also were carefully phrased clearly and neutrally to avoid leading or suggesting wording [59]. Moreover, observer bias was not a concern in this study since the questionnaire was self-administered, and no researcher was present during completion [60]. To add more to this check, non-response bias was also considered. While participation was voluntary, reminders were sent through course communication channels to encourage a high response rate without exerting pressure. This helped ensure that the results were reflective of the broader student population [61]. Finally, to avoid confirmation bias in the analysis phase, the data were coded and analyzed objectively using statistical software, with no pre-set expectations about the outcome of the intervention as mentioned elsewhere [60].

3.5. Statistical analysis

Data analysis was performed using IBM SPSS Statistics v.29 to assess the impact of the educational intervention on students' infection control and disinfection knowledge. Descriptive statistics (means, SDs, frequencies, and percentages) summarized demographic data and knowledge scores. Reliability was evaluated using Cronbach's alpha, with $\alpha > 0.70$ indicating acceptable internal consistency [62]. Paired-sample t-tests and Wilcoxon signed-rank tests assessed pre- and post-intervention changes, while independent-sample t-tests and Mann-Whitney U tests examined differences by demographic variables. Effect sizes (Cohen's d) were calculated, with $d > 0.5$ indicating moderate effects. Chi-square tests assessed associations between categorical variables such as gender and vaccination status. Also, a General Linear Model (GLM) was also applied to explore the influence of demographic factors—gender, year of study, vaccination status, sharp injury history, and place of origin—on post-intervention knowledge. Partial eta-squared (η^2) values were reported, with $\eta^2 > 0.06$ considered a strong effect. Statistical significance was set at $p < 0.05$. So, we performed a multifaceted analytical approach that allowed for a comprehensive evaluation of the intervention's effectiveness and the role of demographic and immunization-related variables in shaping infection control knowledge as also mentioned elsewhere [63].

4. Results

As shown in Table 1, the questionnaire demonstrated high internal consistency, with Cronbach's alpha ranging from 0.770 to 0.969 pre-intervention. Post-intervention reliability improved notably in key areas, including sterilization/disinfection needs (0.803 to 0.892) and surface disinfection knowledge (0.778 to 0.840). Overall Cronbach's alpha increased from 0.910 to 0.950, indicating enhanced consistency in students' responses. We presume then that the instrument is powerful enough to support the findings of this educational intervention, strengthening the coherence of students' knowledge across infection control domains.

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Table 1. Reliability analysis of the questionnaire (Cronbach's Alpha values before and after the educational intervention).

Assessment sections/subjects	Cronbach's alpha	
	Pre	Post
Infection control and personal protective equipment	0.856	0.924
Antiseptic levels against microbes	0.956	0.957
Disinfection, sterilization, and antisepsis (Matching)	0.770	0.782
Disinfection levels against microbes	0.969	0.966
Classification of disinfectants (by effectiveness)	0.919	0.927
Classification of dental instruments (by infection risk)	0.897	0.912
Sterilization/disinfection needs (by risk level)	0.803	0.892
True/False: Surface disinfection in dentistry	0.778	0.840
True/False: Impression and prosthetic disinfection	0.848	0.866
True/False: Instrument sterilization	0.825	0.891
Total questionnaire	0.910	0.950

4.1. The sample of the study

Table 2 summarizes the demographic characteristics of the dental students. The sample was predominantly female, with a slight decrease in female participation from pre- to post-intervention (67.6% to 62.9%). Most students were in their fifth year (92.7% pre, 99.4% post), reflecting substantial clinical experience, while participation from fourth-year students declined significantly ($p < .001$), likely due to curricular or clinical exposure differences. Place of origin remained stable, with over half of the participants from Athens (55.1% pre, 54.5% post). The proportion of island regions increased (12.6% to 17.4%), though not significantly ($p = .624$). High hepatitis B vaccination coverage was reported (92.7% pre, 89.3% post), but a significant decline in students who had checked their antibody levels was noted (82.6% to 54.5%, $p < .001$), suggesting reduced follow-up on immunity verification. Finally, reported sharp injury incidents decreased from 26.3% to 21.3% post-intervention ($p = .068$), a non-significant change, but one that reports on the ongoing risk of occupational exposure and the need for continued emphasis on sharps safety protocols.

Table 2. Demographic characteristics of the study population.

		Educational intervention				
		pre		Pos		
		N	%	N	%	χ^2 p-value
Gender	Male	78	31.60%	63	35.40%	0.478
	Female	167	67.60%	112	62.90%	
	Other	2	0.80%	3	1.70%	
Year of studies	4th year	18	7.30%	1	0.60%	<.001
	5th year	229	92.70%	177	99.40%	
Dental school first choice	Yes	174	70.40%	129	72.50%	0.901
	No	70	28.30%	47	26.40%	
	Other	3	1.20%	2	1.10%	
Place of origin	Athens	136	55.10%	97	54.50%	0.624
	Other Urban center (prefecture capital)	29	11.70%	16	9.00%	
	Mainland region (towns and villages)	24	9.70%	15	8.40%	
	Island region (towns and villages)	31	12.60%	31	17.40%	

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	Other country outside Greece	27	10.90%	19	10.70%	
Fully vaccinated against hepatitis B	Yes	229	92.70%	159	89.30%	0.468
	No	9	3.60%	9	5.10%	
	I don't know/don't answer	9	3.60%	10	5.60%	
Doses of hepatitis B vaccine	Less than three (3)	36	14.60%	27	15.20%	0.385
	Three (3) doses	118	47.80%	92	51.70%	
	More than three (3) doses	20	8.10%	19	10.70%	
	I don't know/don't answer	73	29.60%	40	22.50%	
Checked antibody levels	Yes	204	82.60%	97	54.50%	<.001
	No	39	15.80%	76	42.70%	
	I don't know/don't answer	4	1.60%	5	2.80%	
Sharp injury in the clinic	Yes	65	26.30%	38	21.30%	0.068
	No	182	73.70%	137	77.00%	
	I don't know/don't answer	0	0.00%	3	1.70%	

4.2. Impact of the educational intervention on knowledge and perceptions of infection control

As shown in Table S1, notable improvements were observed in PPE and hygiene practices, including more frequent mask changes ($p < .001$), increased patient use of protective eyewear ($p < .001$), and improved disinfection of goggles ($p = .009$) and face shields ($p = .004$). The use of disinfectant solution through suction lines also increased ($p = .003$). No significant changes were seen in glove use ($p = .273$), FFP2 mask use ($p = .977$), or surgical cap use ($p = .242$), likely due to high baseline adherence. Also, according to Table S2, the educational intervention significantly improved students' understanding of disinfectant composition ($p < .001$) and targeted microbes ($p = .001$), indicating enhanced knowledge in these areas. However, no significant change was found in distinguishing between disinfection, sterilization, and antisepsis ($p = .526$), suggesting strong pre-existing competence. Students' awareness of patient concerns related to disinfection increased significantly ($p < .001$), while perceptions of COVID-19-related disinfection complexity remained unchanged ($p = .548$), reflecting already heightened awareness. Further, in Table S3, students showed significant improvement in identifying quaternary ammonium compounds as disinfectants ($p < .001$), while knowledge of glutaraldehyde, alcohols, and chlorine remained largely unchanged. Instrument classification by infection risk also remained stable, with consistently high accuracy for identifying high-risk tools like scalpels and periodontal scalers. In addition, Table S3 highlights significant improvements in recognizing appropriate disinfection for non-critical items with visible blood ($p < .001$), surfaces with visible blood ($p = .007$), and surfaces without ($p = .002$), indicating a clearer understanding of contamination-based protocols. However, knowledge of procedures for moderate- and high-risk items showed no significant change, pointing to areas needing further emphasis.

As shown in Table S4, students further improved in identifying high-level disinfectants for surfaces ($p = .008$) and the efficacy of phenols against non-enveloped viruses ($p = .026$). Misconceptions about applying disinfectants with cotton decreased ($p = .031$). In impression and prosthetic disinfection, knowledge improved regarding rinsing before lab submission ($p = .003$) and the use of phenolics for alginate impressions ($p = .018$). However, misconceptions about substituting antiseptics for disinfectants ($p = .362$), timing of prosthesis disinfection, and potential material damage persisted, underlining the need for further clarification in these areas. Moreover, as shown in Table S5, educational intervention led to targeted improvements in students' knowledge of instrument sterilization. While no significant changes were observed in understanding pre-sterilization cleaning ($p = .385$) or autoclave parameters ($p = .727$), students demonstrated improved knowledge of dry heat sterilization at 160–170°C ($p = .039$), its oxidative effects on instruments ($p < .001$), and the inclusion of preheating and cooling phases ($p = .042$). Awareness of sterilization efficiency also improved, with more students recognizing the impact of excess water or air ($p = .014$), and knowledge of biological indicator use increased ($p = .039$). No significant changes were noted in the knowledge of autoclave benefits (p = .184), or material compatibility (p > .4), indicating a high baseline understanding of steam sterilization in our case. In addition, Table S6 demonstrates significant improvements post-intervention in infection control and PPE (p = .005, d = -0.275), disinfectant classification (p = .003, d = 0.298), risk-based sterilization needs (p < .001, d = 0.438), and instrument sterilization (p = .005, d = -0.275), with small to moderate effect sizes. No significant gains were found in antiseptic levels, general disinfection, instrument classification, or surface disinfection (p > .4), suggesting strong baseline knowledge. However, a decline was observed in disinfection, sterilization, and antisepsis matching (p < .001, d = 0.336), indicating post-intervention confusion in differentiating these concepts.

Finally, findings from the GLM analysis, summarized in Table 3, showed limited direct effects of the intervention, with only sterilization/disinfection needs by risk level approaching significance (p = .081, η^2 < .01). Gender was a significant predictor for instrument sterilization knowledge (p = .027, η^2 = .012), while place of origin influenced disinfectant classification (Athens, p = .033, η^2 = .011) and broader disinfection knowledge (other urban centers, p = .010, η^2 = .016). Hepatitis B vaccination significantly predicted infection control and PPE knowledge (p < .001, η^2 = .033) and risk-based sterilization (p = .016, η^2 = .014), while antibody monitoring also predicted higher sterilization knowledge (p = .015, η^2 = .015). A significant interaction between the intervention and antibody monitoring (p = .002, η^2 = .023) indicated enhanced effectiveness among students already engaged in immunization practices. Further, the extended GLM analysis (Table S7) reinforced these findings, showing a marginal effect of the intervention on antiseptic knowledge (p = .053, η^2 = .009), and significant interaction effects between the intervention and vaccination status on antiseptic levels and microbial disinfection (both p = .007, η^2 ≈ .018–.019), suggesting more significant benefit for vaccinated students. No other interactions reached statistical significance. Together, these results show us the stronger influence of immunization-related factors compared to the standalone educational intervention.

Table 3. Results of GLM models between-subjects effects on infection control and disinfection knowledge.

	Infection control and personal protective equipment			Disinfection, Sterilization, and Antisepsis (Matching)			Classification of Disinfectants (By Effectiveness)			Sterilization/Disinfection Needs (By Risk Level)			True/False: Instrument Sterilization		
	F(1)	p	η^2	F	p	η^2	F	P	η^2	F	p	η^2	F	p	η^2
Education Intervention	0.353	0.553	0.001	1.377	0.241	0.003	0.614	0.434	0.002	3.067	0.081	0.008	0.000	0.988	0.000
Gender	1.543	0.215	0.004	0.005	0.945	0.000	0.266	0.606	0.001	0.086	0.769	0.000	4.952	0.027	0.012
Year of studies	0.601	0.439	0.002	0.327	0.568	0.001	0.001	0.975	0.000	0.656	0.418	0.002	0.093	0.760	0.000
Dental school was first choice	1.261	0.262	0.003	0.710	0.400	0.002	0.095	0.758	0.000	0.006	0.941	0.000	0.607	0.436	0.002
Place of origin (ref. other country)															
Athens (Greek capital)	3.449	0.064	0.009	1.881	0.171	0.005	4.591	0.033	0.011	1.098	0.295	0.003	2.231	0.136	0.006
Other Urban center (prefecture capital)	5.638	0.018	0.014	6.685	0.010	0.016	0.186	0.667	0.000	0.072	0.789	0.000	2.487	0.116	0.006
Mainland region (towns and villages)	2.291	0.131	0.006	0.082	0.775	0.000	1.086	0.298	0.003	2.745	0.098	0.007	0.620	0.431	0.002
Island region (towns and villages)	0.904	0.342	0.002	4.170	0.042	0.010	2.448	0.118	0.006	0.061	0.805	0.000	0.105	0.747	0.000
Vaccinated against hepatitis B	13.500	<.001	0.033	0.666	0.415	0.002	0.291	0.590	0.001	5.812	0.016	0.014	0.048	0.827	0.000
Checked antibody levels	2.974	0.085	0.007	0.148	0.700	0.000	1.868	0.172	0.005	0.180	0.672	0.000	5.931	0.015	0.015
Had sharp injury in clinic	1.814	0.179	0.005	0.575	0.449	0.001	4.613	0.032	0.011	0.644	0.423	0.002	0.086	0.769	0.000
EduInt * Gender	0.035	0.852	0.000	0.435	0.510	0.001	3.202	0.074	0.008	0.073	0.787	0.000	0.647	0.422	0.002

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EduInt * Year of studies	0.391	0.532	0.001	0.748	0.388	0.002	0.019	0.890	0.000	1.790	0.182	0.004	0.016	0.898	0.000
EduInt * Dental school was first choice	0.424	0.515	0.001	0.090	0.764	0.000	0.013	0.911	0.000	0.348	0.555	0.001	0.546	0.460	0.001
EduInt * Athens (Greek capital)	0.148	0.701	0.000	0.461	0.498	0.001	1.323	0.251	0.003	1.163	0.282	0.003	0.557	0.456	0.001
EduInt * Other Urban center (prefecture capital)	0.263	0.608	0.001	0.001	0.972	0.000	0.816	0.367	0.002	2.204	0.138	0.005	0.246	0.620	0.001
EduInt * Mainland region (towns and villages)	0.013	0.910	0.000	0.001	0.982	0.000	5.531	0.019	0.014	2.230	0.136	0.006	2.982	0.085	0.007
EduInt * Island region (towns and villages)	0.142	0.707	0.000	0.543	0.462	0.001	0.958	0.328	0.002	0.412	0.521	0.001	0.003	0.956	0.000
EduInt * Vaccinated against hepatitis B	2.010	0.157	0.005	3.340	0.068	0.008	1.069	0.302	0.003	2.406	0.122	0.006	0.314	0.575	0.001
EduInt * Checked antibody levels	9.267	0.002	0.023	2.041	0.154	0.005	0.029	0.864	0.000	0.085	0.770	0.000	0.798	0.372	0.002
EduInt * Had sharp injury in clinic	0.906	0.342	0.002	3.447	0.064	0.008	0.056	0.813	0.000	1.082	0.299	0.003	0.194	0.660	0.000

Further, as shown in Table S8, gender differences were evident post-intervention. Female students showed greater improvement in infection control and PPE (M = 8.17 to 8.58) compared to males (M = 7.95 to 8.13), while males improved more in instrument sterilization (M = 4.79 to 5.37 vs. 4.45 to 4.92). Other domains showed similar gains across genders, with minimal change in surface disinfection scores. Interestingly in Table S9, vaccinated students outperformed unvaccinated peers in baseline infection control (M = 8.16 vs. 6.28) and instrument classification (M = 6.31 vs. 4.19). Post-intervention, they showed more significant gains in infection control (M = 8.52 vs. 7.09) and retained disinfection knowledge more effectively. Unvaccinated students improved more in disinfectant classification, but vaccinated students maintained higher overall performance. Also, Table S10 shows students who had checked their antibody levels performed better in infection control (M = 8.71 vs. 8.05) and instrument sterilization (M = 5.29 vs. 4.95). Non-checked students, however, showed greater gains in disinfection and antisepsis matching, suggesting the intervention addressed baseline gaps in this group. Finally, according to Table S11, students without a history of sharp injuries had higher baseline scores in infection control (M = 8.22 vs. 7.74) and maintained stronger post-intervention knowledge. Injured students showed more improvement in microbial disinfection (M = 2.00 to 3.31), but their scores declined in disinfection and antisepsis matching (M = 8.15 to 6.58), indicating possible confusion. These findings highlight the need for targeted reinforcement, especially among students with prior exposure incidents.

4.3. Results from the open-ended responses of the participants

Analysis of open-ended responses before the intervention revealed important insights into students' perspectives on infection control, disinfection, and sterilization in our study. In Question 20.1, students expressed a strong preference for hands-on learning methods, including practical workshops, live demonstrations, and clinical simulations. They also emphasized the value of structured seminars, online courses, and interactive tools such as videos and e-learning modules. Some suggested the inclusion of printed or digital handbooks for quick reference during clinical practice. Also, in Question 20.2, the most cited barriers to consistent use of protective measures were time constraints between patients, workflow disruption, limited training, and inconsistent availability of supplies. These factors were seen as contributing to lapses in compliance. Furthermore, responses to Question 20.3 indicated that most students would apply enhanced PPE—such as double gloves, FFP2 masks, face shields, and disposable gowns—when treating patients with known infectious diseases. Many recommended scheduling such patients last in the day and emphasized the importance of maintaining professionalism, avoiding stigma, and communicating safety measures.

Some also suggest designated instruments and separate sterilization protocols for high-risk cases. Further, in Question 20.4, students mentioned concerns about inadequate training in sterilization and disinfection, calling for more supervised clinical practice and structured coursework before clinical rotations. Generally, there was a strong demand for updated instruction on evolving protocols and technologies, particularly in response to emerging infectious threats. Finally, uncertainty around autoclave operation, chemical disinfectants, and sterilization techniques further highlighted the need for detailed, practical guidance. In general, the responses point to a clear need for more integrated, practice-oriented, and regularly updated infection control education. Students identified training gaps, time limitations, and supply issues as key obstacles, while demonstrating a strong commitment to patient and provider safety, particularly in high-risk clinical scenarios.

5. Discussion

This study aimed to assess the effectiveness of an educational intervention designed to enhance dental students' knowledge and practical understanding of infection control and disinfection protocols. With the increasing emphasis on infection prevention in clinical environments, especially after the COVID-19 pandemic, the intervention was timely and necessary to reinforce fundamental practices protecting patients and practitioners [64]. The fact that Cronbach's alpha values exceeded 0.90 for the total questionnaire as well as the improvement in alpha values post-intervention suggests a more coherent understanding of infection control topics among students because of this action [65].

5.1. General knowledge gains

Post-intervention data showed statistically significant improvements in areas such as awareness of disinfectant composition and the types of microbes targeted. These findings suggest that the educational intervention was successful in enhancing students' foundational microbiological and chemical knowledge relevant to clinical disinfection. However, there was no significant change in knowledge related to the conceptual differences between disinfection, sterilization, and antisepsis. This likely reflects a ceiling effect, wherein students already had a strong baseline understanding of these core concepts. This result is supported by similar previous studies, where authors concluded that students' general knowledge of infection control issues improved significantly after the educational intervention which led to an increase in the percentage of students completing the course successfully at the first attempt [40]. Another study that is in agreement with ours was conducted by Prehba et al where 96% of the students stated that after the intervention, they were much more able to effectively practice infection control [43]. Additionally, Etebarian et al found that student's knowledge increased by 48.58%, attitudes by 6.37%, and practice scores by 17% after the COVID-19-related intervention [66]. We further found that the intervention led to significant improvements in certain areas (e.g., infection control, PPE, disinfectant classification, risk-based sterilization needs) [67], but limited or had no effect on others (e.g., antiseptic knowledge, general disinfection, surface disinfection). We also reported a decline in disinfection, sterilization, and antisepsis matching scores suggesting conceptual confusion introduced or unaddressed by the intervention. This is particularly important and warrants constant educational refinement auditing, and adherence to national/international guidelines as suggested elsewhere [8].

5.2. Improvements in personal protective equipment (PPE) use

In our study, we observed notable improvements in PPE-related behaviors, including more frequent mask changes between patients, increased use of protective eyewear by patients, and improved disinfection practices for goggles and face shields following the educational intervention. These behavioral changes reflect enhanced compliance with infection control protocols in the clinical setting. Similarly, the Cochrane review by Verbeek et al. (2020) [68] emphasized the critical role of proper PPE use in preventing the transmission of highly infectious diseases among healthcare workers exposed to contaminated body fluids. Their meta-analysis found that structured training,

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appropriate doffing techniques, and consistent PPE use significantly reduced infection risk. They also highlighted the importance of eye protection and facial barriers, which aligns with our findings regarding increased use and disinfection of protective eyewear and face shields. Thus we may conclude that educational interventions, as in our study, and evidence-based PPE protocols, are mutually reinforcing strategies to improve safety behaviors and reduce occupational risk in clinical environments.

Further, it is important to note that glove use and FFP2 mask usage did not exhibit significant post-intervention changes in our study, which may be attributed to already high levels of compliance at baseline. This trend is consistent with findings by Habibi et al. (2022) [42], who reported mixed outcomes where 15 students demonstrated improved post-intervention scores, while six students showed a decrease, suggesting variability in response to educational efforts. In contrast, Etebarian et al. (2023) documented a notable 17% improvement in students' protective practices following a targeted educational program related to COVID-19, emphasizing the potential of structured training to enhance adherence to PPE protocols when baseline awareness is variable, like in our case [66].

5.3. Specific knowledge areas affected

5.3.1. Surface and material disinfection

Our findings demonstrated that the educational intervention effectively enhanced students' understanding of surface disinfection protocols, particularly regarding the appropriate use of high-level disinfectants and phenolic compounds. The intervention also addressed and corrected common misconceptions, such as the inappropriate use of cotton materials for disinfectant application, which may compromise surface coverage and efficacy. These results align with the recommendations of Artasensi et al. (2021), who emphasized the importance of selecting surface disinfectants based on chemical composition, efficacy spectrum, and application method [69]. They comment on the need to avoid materials, such as cotton, that may absorb or neutralize disinfectant agents, thus reducing effectiveness and they highlight the role of education in ensuring appropriate product selection and application. Nonetheless, some incorrect beliefs persisted, indicating the need for continued emphasis on evidence-based application techniques like in our case. In comparison, a study performed in 2022 showed no statistically significant differences in disinfection habits before and after the educational intervention [42].

5.3.2. Instrument sterilization procedures

In addition, our participants demonstrated improved knowledge regarding dry heat sterilization, the role of preheating and cooling phases, and the use of chemical and biological indicators. However, no significant changes were observed in understanding autoclave-related procedures or tool material compatibility, suggesting these areas were well understood before the intervention. This distinction indicates that the intervention was particularly helpful for less familiar sterilization methods. In contrast to our research, another study conducted among students in India showed that while at the beginning only 40% of the students knew how to use the auto-cast correctly, after the implementation of the program all of them answered correctly to relevant questions [41]. Correspondingly, the lack of knowledge regarding the use of the autoclave is also evident in other studies such as those by Mohan et al, according to which only 78.8% of students responded satisfactorily to relevant questions [27]. To add more, the greatest improvement was noted in students' ability to apply sterilization and disinfection protocols based on risk assessment. Following the intervention, students in our study demonstrated a significantly improved ability to select appropriate disinfection strategies for non-critical items, particularly in differentiating protocols based on the presence or absence of visible blood. This reflects a clearer understanding of contamination-based risk assessment and the corresponding selection of disinfectants. These findings align with the concerns raised by Curran et al. (2019), who discussed the controversies surrounding the use of chemical disinfectants in low-risk healthcare environments [70]. They emphasized the fact

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that misapplication of disinfectants, particularly in settings where visible contamination is absent, can lead to unnecessary chemical exposure, increased costs, and environmental concerns, without additional clinical benefit. So, we agree on context-specific disinfection practices, aligned with evidence-based guidelines, to optimize both patient safety and resource use as also mentioned elsewhere [71].

5.3.3. Classification of disinfectants

Our study demonstrated that educational intervention significantly improved students' ability to correctly classify disinfectants, particularly quaternary ammonium compounds (QACs), which are often less familiar to students compared to more widely known agents such as glutaraldehyde and alcohols, for which post-intervention gains were less pronounced [72]. This suggests that prior exposure and familiarity limited the observable impact of training for commonly used disinfectants, while newer or more specialized agents benefited more from explicit instructional emphasis. This finding is especially relevant in the context of evolving disinfection practices. As noted in recent literature, the use of high-level disinfectants such as QACs and aldehydes has become increasingly common in response to emerging pathogens and heightened infection control requirements [73]. Educational efforts must therefore evolve accordingly to reflect changing disinfection protocols and emerging agents. However, as Boyce (2023) cautions, this increased reliance on QACs, hile effective in microbial control, raises concerns about microbial tolerance and the potential contribution to antibiotic resistance [73,74]. Therefore, it is essential to educate students on the responsible, evidence-based use of QACs, as indiscriminate application may contribute to cross-resistance in healthcare-associated pathogens. This report is on the importance of integrating antimicrobial stewardship into infection control training [75]. Our findings thus highlight the need for both foundational knowledge of disinfectant classification and awareness of the broader microbiological and public health implications of disinfectant use [69]. Educational programs should aim then not only to address knowledge gaps but also to promote safe, rational, and context-appropriate disinfection practices, aligned with current scientific evidence and global health priorities [76]. As such, structured training on the proper use of these agents is increasingly imperative [77].

5.3.4. Prosthetic and impression disinfection

Significant knowledge gains were seen in protocols for rinsing impressions before laboratory submission and in the application of phenolic compounds for alginate impressions [78]. However, confusion remained among our students regarding the optimal timing of disinfection and potential damage from disinfectants on certain prosthetic materials as mentioned also elsewhere [79]. According to a recent study conducted among dentists, 67.5% of them do not disinfect their impressions because they are worried that the disinfectants will damage the impression, while a large percentage of those who disinfect them do so in the wrong way [80]. A similar survey among dental students found that only a small percentage of them knew how to properly disinfect dental impressions and prostheses [81]. On the other hand, a survey among dental students in Nepal showed that students' ability to manage infection control in prosthodontics was generally satisfactory, while few were well-versed [82]. These results suggest the need for more detailed instruction and hands-on practice in this area.

5.4. Demographic and contextual influences

5.4.1. Gender differences

Gender analysis revealed differing patterns in knowledge improvement. Female students showed greater gains in PPE-related knowledge, while male students exhibited more improvement in instrument sterilization. These findings may reflect gender-based differences in clinical task distribution or previous training experiences [83]. Other studies, in which no educational intervention was carried out, show that there was no significant difference in the knowledge about

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infection control among male and female students [82]. Further, according to another study, there is a statistically significant difference between male and female students regarding the use of face shields (with females using them at a higher rate) and the use of head caps (with males using them at a higher rate). Neither in this study was any educational intervention carried out, as in our case [37].

5.4.2. Impact of Hepatitis B vaccination and antibody checks

In our study, students who were fully vaccinated against hepatitis B and those who had checked their antibody levels performed better at baseline and demonstrated more significant improvements post-intervention [84]. In contrast to our study in a recent survey among dental students by Mohan et al, it was found that although 98.8% of the students were aware of the importance of immunization against hepatitis b virus, only 3.8% of them were vaccinated. Even though most of them were not vaccinated, the survey showed that most of the students practiced effectively the required means of infection control during their clinical practice [27]. Our study then reinforces the association between hepatitis B vaccination and higher levels of infection control knowledge, with vaccinated students consistently outperforming their unvaccinated peers across multiple domains. This aligns with global perspectives which emphasize that while significant progress has been made in hepatitis B vaccination coverage, gaps in awareness and follow-up practices, such as post-vaccination serological testing, continue to challenge global elimination efforts [84]. Similarly, targeted educational interventions within primary care settings significantly improved hepatitis B screening and vaccination rates elsewhere, further supporting the role of structured programs in enhancing both coverage and awareness [85].

5.4.3. Year of study and clinical exposure

As the sample consisted primarily of fifth-year students, the observed improvements may reflect the relevance of the intervention to students with substantial clinical exposure. No significant variation was noted in our data based on the year of study, indicating the intervention's applicability across clinical training levels. Elsewhere, educational programs that have been implemented with younger students (specifically second and third-year students) appear to lead to improved performance in infection control issues [40,43] while in another study, in which no educational intervention was carried out though, it was found that fifth-year students (seniors) have the most knowledge regarding infection control [82]. This facts confirms our finding that relevant educational programs can be effectively integrated into other years of study and not only to senior students.

5.5. Interpretation of effect sizes and statistical significance

Effect sizes for knowledge improvements ranged from small to moderate, with the largest observed in risk-based disinfection knowledge (Cohen's d = 0.438). Some areas, such as basic definitions and PPE use, showed limited change, possibly due to a ceiling effect from high baseline knowledge. General Linear Model (GLM) analyses further revealed in our study that demographic factors, especially vaccination status and geographic background, had significant predictive value for knowledge gains, suggesting there is a complex connection between educational interventions and personal background [86,87].

5.6. Implications for practice and curriculum design

Our findings show the importance of systematically integrating infection control education across both preclinical and clinical phases of dental training, as already supported recently [43]. Early exposure to infection prevention, before clinical entry, was also recommended by our students, who suggested an earlier and more structured inclusion of this content within the curriculum. In addition, emphasis should be placed on risk-based disinfection protocols, classification of disinfectants, and evidence-based decision-making, as outlined by Rutala et al. (2023) [8]. Students strongly recommended more practical training, including supervised use of autoclaves, step-by-step demonstrations of sterilization cycles, and clinical implementation of disinfection procedures. These suggestions are in line with literature supporting simulation-based and experiential learning to improve adherence and retention [88,89]. Students also called for the use of visual and interactive tools, such as educational videos and case-based modules, as well as frequent reinforcement sessions throughout the academic year. Additional feedback from our students highlighted the need for more in-depth instruction on chemical disinfectants, including their composition, usage, material compatibility, and associated risks. Logistical concerns were also raised regarding course scheduling, with students preferring integration of infection control sessions into clinical hours, rather than as separate seminars, to enhance accessibility and participation. Recent studies further support the effectiveness of such structured educational approaches. For example, Etebarian et al. (2023) demonstrated significant improvements in knowledge and practices following a COVID-19-focused webinar, while Chatuverdi et al. (2022) and Habibi et al. (2022) documented increased protocol adherence following multimedia-based and formal infection control training interventions [42,66,90].

In conclusion we would like to highlight the fact that the responsibility for implementing and overseeing infection control protocols ultimately rests with the dentist, who, as head of the dental team, holds accountability for the safe operation of the clinical environment, suggesting that our students should really be educated for this role. According to the Council of European Dentists, dentists are expected to supervise decontamination, disinfection, and sterilization procedures, particularly when auxiliary staff, such as chairside or clinical dental assistants, lack sufficient training or are in the process of obtaining formal qualifications [91]. So, there is a need for comprehensive infection control training not only at the undergraduate level but also for all members of the dental team. Furthermore, from a public health perspective, the Centers for Disease Control and Prevention (CDC) emphasize that infection control is a critical component of disease prevention and epidemiological practice, requiring systematic education and vigilance at all levels of healthcare delivery [92]. These insights reinforce our findings, pointing to the importance of integrated, role-specific, and team-oriented infection control education to ensure safety and regulatory compliance in oral healthcare settings.

5.7. Strengths and limitations

This study has several limitations that should be acknowledged. First, reliance on self-reported data may introduce response bias, particularly social desirability bias, whereby participants may overreport favorable behaviors or knowledge levels to align with perceived expectations. This concern is well-documented in the literature, including in the work of Rosenman et al. (2011) and Teh et al. (2023), who highlight the susceptibility of self-report instruments to such biases, especially in health behavior research [93,94]. Second, the post-intervention assessment was conducted shortly after the educational session, limiting the ability to evaluate long-term knowledge retention or behavioral sustainability over time. Future studies should consider delayed post-tests or longitudinal follow-ups to assess retention and application in clinical practice. Third, the sample size decreased slightly post-intervention, which may have affected the statistical power and the generalizability of the findings [95]. Although the differences were not substantial, the imbalance could introduce sampling variability. Moreover, while improvements were observed in several knowledge domains, the educational intervention had limited impact in areas where baseline knowledge was already high, such as glove use, autoclave awareness, and instrument classification. This ceiling effect may have constrained the measurable outcomes of the training. Finally, the study was conducted within a single dental school, which may limit external validity. Institutional curricula, resource availability, and infection control protocols vary across regions, and thus the findings may not be directly transferable to other educational contexts [96,97]. Despite limitations, the study employed a comprehensive, pre- and post-intervention design to evaluate knowledge changes across multiple infection control domains. It combined quantitative and qualitative data, offering both statistical insight and student-driven perspectives. The high internal consistency of the questionnaire further

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supports the reliability of the findings. Future research should aim to replicate the study across diverse settings, incorporate control groups, and evaluate the effectiveness of alternative teaching modalities, such as simulation or case-based learning, to address specific gaps identified in this study.

6. Conclusions

Dental students recognized the value of infection control training and emphasized the need for increased practical, hands-on learning, ideally integrated earlier in the curriculum. The intervention led to significant improvements in knowledge, particularly in under-addressed areas such as surface disinfection and disinfectant classification. Variation in outcomes based on gender and immunization status suggests that tailored educational strategies may enhance effectiveness. Overall, the findings highlight the importance of ongoing, structured, and skill-based infection control education to ensure safe and compliant clinical practice in dentistry.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. Table S1: Changes in personal protective equipment and hygiene practices before and after the educational intervention.; Table S2: Correct answers in disinfectant classification and instrument risk levels before and after the educational intervention.; Table S3: Impact of educational intervention on knowledge of disinfectant classification and risk-based sterilization/disinfection needs.; Table S4: Correct answers in true/false statements on disinfection practices before and after the educational intervention.; Table S5: Effect of educational intervention on knowledge of instrument sterilization procedures.; Table S6: Changes in knowledge scores on infection control and disinfection following the educational intervention.; Table S7: General linear model analysis between subjects effects on antiseptic knowledge, disinfection levels, and instrument classification (Part B).; Table S8: Gender-based differences in infection control and disinfection knowledge before and after the educational Intervention.; Table S9: Impact of hepatitis B vaccination status on Infection control and disinfection knowledge before and after the educational intervention.; Table S10: Effect of checking antibody levels on infection control and disinfection knowledge before and after the educational intervention.; Table S11: Impact of sharp injuries on infection control and disinfection knowledge before and after the educational intervention.

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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 this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

The questionnaire of the study

PART A

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Demographic Information

Q1. What is your gender?

Male	Female	Other
1	2	3

Q2. What year of your studies are you currently in?

Fourth(4th)	Fifth(5th)
1	2

Q3. What is your place of origin?

Urban center (capital of the region)	City or town with up to 3000 inhabitants	Island
1	2	3

Q4. Have you been fully vaccinated for hepatitis B?

Yes	No	I do not know/I do not answer
1	2	3

Q5. How many doses of the hepatitis B vaccine have you received?

3 doses	More than 3	Les than3	I do not know/I do not answer
1	2	3	4

Q6. Have you checked your antibody titles for hepatitis B before your admission to the clinic?

Yes	No	I do not know/I do not answer
1	2	3

PART B

Q1. Status of information regarding disinfection in the dental office.	Not at all	A little	Moderate	Very	Very Much
Are you sufficiently informed about the means used for disinfecting the surfaces of the clinic?	1	2	3	4	5
During your studies, you were trained regarding disinfection?	1	2	3	4	5
Are you informed about the composition of the disinfectants used in the clinic?	1	2	3	4	5
Do you know the difference between disinfection, sterilization, and antisepsis?	1	2	3	4	5
Are you informed about the microbes you are called to deal with during disinfection in your clinical practice?	1	2	3	4	5
Do you consider the risk of disease transmission to be significant for both patients and healthcare personnel through contaminated surfaces?	1	2	3	4	5
Are your patients concerned about the effectiveness of disinfection in the clinic?	1	2	3	4	5
Did the appearance of COVID-19 make you more aware of disinfection and antisepsis issues?	1	2	3	4	5

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Do you think that the appearance of Covid-19 makes the process of disinfecting surfaces more complicated?	1	2	3	4	5

Q2. Personal safety and patient safety in the clinic	Never	Rare	Sometimes	Often	Always
Do you wear gloves during dental procedures?	1	2	3	4	5
In case your patient has a known infectious disease, do you wear double gloves?	1	2	3	4	5
Do you wear gloves when disinfecting surfaces?	1	2	3	4	5
Do you wash your hands after every patient?	1	2	3	4	5
Do you apply antiseptic agents to your hands after each patient?	1	2	3	4	5
Do you remove watches and other jewelry from your hands during procedures?	1	2	3	4	5
Do you wear a surgical mask during your clinical practice?	1	2	3	4	5
Do you wear a high-protection mask (FFP2) during your clinical practice?	1	2	3	4	5
Do you replace the mask after each patient?	1	2	3	4	5
Do you wear protective goggles during your clinical practice?	1	2	3	4	5
Do you disinfect the protective goggles after each patient?	1	2	3	4	5
Do you ask your patients to wear protective goggles during dental work?	1	2	3	4	5
Do you wear a head covering?	1	2	3	4	5
Do you wear a disposable gown over your medical uniform?	1	2	3	4	5
Do you wear a protective face shield during your clinical practice?	1	2	3	4	5
Do you disinfect the shield after each patient?	1	2	3	4	5
Do you use a rubber dam in tasks where it is feasible?	1	2	3	4	5
Do you use strong surgical suction when using hand pieces and ultrasonics?	1	2	3	4	5
Do you ask your patients to rinse their mouths with chlorhexidine solution at the beginning of the session?	1	2	3	4	5
Do you disinfect the surfaces after each patient?	1	2	3	4	5
Do you proceed with the suction of disinfectant solution from the saliva ejector and the surgical suction after each patient?	1	2	3	4	5
Do you use protective film to cover surfaces?	1	2	3	4	5
Do you replace the protective membranes after each patient?	1	2	3	4	5

Q3. Procedures for neutralizing microorganisms	Disinfection	Sterilization	Antisepsis	I do not know / I do not answer
The process of destroying all microorganisms, including spores, by physical or chemical means is called:	1	2	3	4

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The process by which the elimination, partial destruction, or suspension of the multiplication of microorganisms outside of seeds on objects and surfaces is called:	1	2	3	4
The process of destroying the microbes that are found in living tissues with chemical agents is called:	1	2	3	4

Q4. Note the minimum level of disinfectant action required for the neutralization of the following microorganisms.	Strong action	Moderate action	Weak action	I do not know / I do not answer
HIV	1	2	3	4
Rhinoviruses	1	2	3	4
Types of Candida	1	2	3	4
HSV	1	2	3	4
Bacterial spores	1	2	3	4
M. Tuberculosis	1	2	3	4
HBV	1	2	3	4
HCV	1	2	3	4
Coxsackie viruses	1	2	3	4
S. Aureus	1	2	3	4
Streptococcus pneumoniae	1	2	3	4
Hydrophobic and medium-sized viruses	1	2	3	4
Hydrophilic and small-sized viruses	1	2	3	4
Pseudomonas aeruginosa	1	2	3	4

Q5. Classification of disinfectants according to their effectiveness and chemical composition	Strong action	Moderate action	Weak action	I do not know / I do not answer
Glutaraldehyde	1	2	3	4
Phenols	1	2	3	4
Chlorine solutions	1	2	3	4
Alcohols	1	2	3	4
Quaternary ammonium compounds	1	2	3	4
Formaldehyde	1	2	3	4
Peroxy acid	1	2	3	4
Iodophors	1	2	3	4
Hydrogen peroxide	1	2	3	4

Q6. Classification of dental instruments based on the risk of causing infection.	Critical	Semi-critical	Non-critical	I do not know / I do not answer
They penetrate soft tissues or bone.	1	2	3	4
They only come into contact with intact skin.	1	2	3	4
They come into contact with oral tissues without penetrating them.	1	2	3	4
Dental mirrors	1	2	3	4
Burs	1	2	3	4
Impression trays	1	2	3	4
Safety goggles	1	2	3	4
Scalpel	1	2	3	4

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X-ray cone	1	2	3	4
High and low speed hand pieces	1	2	3	4
Mixing bowl	1	2	3	4
personal arch	1	2	3	4
Periodontal curettes	1	2	3	4

Q7 Sterilization-Disinfection of tools and surfaces based on the risk of infection.	Sterilization	High-level disinfection	Medium level disinfection	Low-level disinfection	I don't know/ I don't answer
Non-hazardous with visible blood pollutants	1	2	3	4	5
High and medium risk	1	2	3	4	5
Medium risk sensitive to heat	1	2	3	4	5
Non-hazardous without visible pollutants blood	1	2	3	4	5
All surfaces of the clinic if have visibly contaminated with blood	1	2	3	4	5
All surfaces of the clinic if they are not contaminated with blood	1	2	3	4	5

Q8. Disinfection of surfaces	true	false	I don't know/ Do not answer
For the disinfection of surfaces, wipes impregnated with disinfectants can be used with effectiveness equivalent to that of the sprays	1	2	3
When disinfecting the surfaces, apply the disinfectant agent on cotton which you soak and apply to the then disinfect the surfaces	1	2	3
A powerful disinfectant can be used for the disinfection of surfaces	1	2	3
An antiseptic can be used as a disinfectant and reverse	1	2	3
One of the advantages of chlorine solutions is that they do not irritate the mucous membranes and skin	1	2	3
The main disadvantage of chlorine solutions is that they strongly oxidize metals, especially at high concentrations	1	2	3
Iodophores as antiseptics contain more free iodine than iodophores for disinfectant use	1	2	3
The disadvantages of iodophores include that they are weak in high temperatures and the solution must be prepared daily	1	2	3
Alcohol solutions are considered more effective at concentrations of 60-90%	1	2	3
The antimicrobial action of alcohol is due to their ability to degrade microbial proteins	1	2	3
The advantages of alcohols include their low cost and their ability to penetrate easily into organic substances	1	2	3
Phenols are effective against viruses that do not have envelope	1	2	3
Phenolic products can be used in addition to surface disinfectants and as tool disinfectants	1	2	3

Ammonium quaternary compounds in addition to disinfectants can also be used as antiseptics	1	2	3
Solutions of quaternary ammonium compounds at high temperatures concentrations leave a film and colour the surfaces	1	2	3

Q9. Decontamination of impressions and prosthesis	true	false	I don't know/ Do not answer
The impressions should be rinsed with plenty of water to remove blood and saliva before application disinfectant	1	2	3
For the decontamination of an alginate impression requires the immersion in disinfectant for 10 minutes	1	2	3
The impressions must be rinsed with water to water to remove the disinfectant before being sent to the laboratory	1	2	3
Polyethers are the most stable materials to the effect of disinfectants	1	2	3
Suitable disinfectants for alginate fingerprints are phenolic complexes	1	2	3
For disinfecting zinc oxide and eugenol impressions, iodophores are used for the immersion of the impression for 10 minutes	1	2	3
The transfer of bacteria of the oral flora is more increased in impressions of non-reversible hydrocolloids in compared to the elastomers	1	2	3
Polysulfides and silicones are unstable materials in the effect of disinfectants	1	2	3
The decontamination of fixed prosthetics carried out in glutaraldehyde solutions that may combine both glutaraldehyde and phenol for 10 minutes	1	2	3
The disinfection of removable prosthesis (acrylic/porcelain) in glutaraldehyde solutions for 10 minutes	1	2	3
The disinfection of removable prosthesis (metal/acrylic) is done with iodophores or sodium hypochlorite	1	2	3
Iodophores or sodium hypochlorite can damage the metal of a removable prosthesis	1	2	3
The most appropriate time to decontaminate the impressions and prosthesis is immediately after removal from the mouth	1	2	3

Q10. Tool sterilization	true	false	I don't know/ Do not answer
Washing and disinfection of tools are essential procedures before sterilization	1	2	3
The liquid heat furnace (autoclave) must be set at 121 °C at a pressure of 15 p.s.i. for 3-7 minutes	1	2	3
The advantages of the autoclave include the small sterilization cycle and good steam penetration	1	2	3
Liquid heat causes oxidation of tools with a cutting tool carbon steel cutting edge	1	2	3
The high-quality stainless-steel tools (stainless steel) can be sterilized in the autoclave without damage	1	2	3

The dry heat furnace shall be set at 160-170°Cfor 1 hour	1	2	3
The disadvantages of the dry heat furnace are the oxidation of the tools and the reduction of their cutting edge	1	2	3
The time indicated for each sterilization method includes preheating and cooling time of the tools	1	2	3
If there is excess water and air in the furnace area the time required to sterilize the tools is halved	1	2	3
For sterilization control, it is recommended to use chemical indicators at each sterilization cycle and biological indicators 1 time/week	1	2	3
Chemical indicators contain pathogenic non-resistant bacterial spores in much greater numbers than probably on the contaminated tools and indicate with chemical whether sterilization has been achieved	1	2	3

Q11.Open-ended questions
1) How would you like to learn more about disinfection and antisepsis in dental practice?
2) Indicate reasons for not applying protective films and using disinfectants (following protocol) during your clinical practice:
3) What would be your attitude towards a patient with a known infectious disease?

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