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Knowledge and Practice of Iranian Dentists on Oral Management of Patients Undergoing Head and Neck Cancer Treatments

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Abstract

Objective(s): Various treatment modalities, such as chemotherapy, radiotherapy, and surgery, are employed for managing malignant oral tumors. This study aimed to assess dentists' knowledge and practice regarding considerations for patients undergoing radiotherapy and chemotherapy. **Methods:** A cross-sectional study was conducted using a valid and reliable questionnaire completed by 250 general dentists at an annual national dental congress in 2019. Besides background questions, the questionnaire included items assessing dentists' knowledge on managing patients undergoing radiotherapy (10 questions) and chemotherapy (12 questions), and whether they admit such patients. **Results:** Of 250 dentists (50% male; mean age: 45.1 ± 12 years), 126 (50%) reported experience treating patients undergoing radiotherapy/chemotherapy; 68% accepted such patients, 16% did not, and 8% referred them. Knowledge about radiotherapy considerations varied, with 77% correctly identifying poor-prognosis lesions, but only 34% aware of implant placement timing post-radiotherapy. Older dentists showed lower knowledge ($p<0.001$), while female dentists ($p=0.005$) and those with relevant experience exhibited higher knowledge ($p<0.001$). Similar trends occurred for chemotherapy-related knowledge: older dentists had lower knowledge ($p<0.001$), female dentists ($p=0.002$), and experienced dentists had higher knowledge ($p<0.001$). **Conclusion:** These findings underscore the need for targeted educational programs to bridge knowledge gaps and ensure optimal dental care for patients undergoing radiotherapy/chemotherapy. Enhancing dental school training and continuous professional development can empower dentists to confidently treat these vulnerable patients. Addressing these gaps is crucial for improving outcomes, equitable access, and proactive management of oncology-related oral health challenges.

Keywords: Radiotherapy; Chemotherapy; Health Knowledge, Attitudes, Practice; Dentists; Patient Care; Head and Neck Neoplasms

Introduction

Cancer incidence is steadily increasing worldwide and is now recognized as the first or second leading cause of death in most of countries [1]. In 2018, over 100,000 newly diagnosed cancer cases were reported in Iran, nearly half of which resulted in death [2]. Oral cancers accounted for approximately 4% of all cancer cases and cancer-related deaths globally in the year 2020, which translates to approximately 380,000 new cases and 180,000 deaths [3]. In 2019, the burden of lip and oral cavity cancer in Iran, as documented by the Global Burden of Disease (GBD) study, comprised an incidence rate of 1.26 per 100,000 (approximately 1-2 new cases annually per 100,000 people), and a prevalence rate of 4.58 per 100,000 (approximately 4-5 individuals living with the disease per 100,000 people) [4]. Chemotherapy and radiotherapy are primary treatment modalities for malignant oral tumors, each associated with distinct adverse effects [5].

Chemotherapy drugs are employed locally or systemically to destroy, suppress, or prevent the spread of malignant cells, with some tumors controlled through chemotherapy alone or in combination with radiotherapy or surgery. However, chemotherapy has notable side effects, particularly on hematopoietic cells, skin, gastrointestinal tract, and the oral cavity. Soft tissues in the mouth are especially prone to physical, chemical, thermal, and microbial damage, often becoming a focal point for complications. Common side effects include xerostomia, dysphagia, altered taste perception, and a high risk of mucositis, which can be severe, emerging within a week of chemotherapy and lasting for several weeks [6].

Radiotherapy uses high-energy ionizing radiation to destroy cancer cells and prevent their spread. Radiotherapy, despite its effectiveness in targeting and eliminating cancer cells, also damages normal tissues. In cases involving the oral cavity and salivary glands, complications such as taste bud destruction, reduced salivary gland function, oral mucositis, and peripheral neuropathy are common. Consequently, patients frequently experience xerostomia, altered taste perception, limited mouth opening, and swallowing difficulties [7].

Management of oral health in patients undergoing cancer treatment, particularly for head and neck cancers, is a critical

yet often underemphasized aspect of comprehensive cancer care. Treatments such as radiotherapy, chemotherapy, and surgery can result in a range of debilitating oral complications, including mucositis, xerostomia, osteoradionecrosis, dysphagia, and radiation-induced caries which diminish patients' quality of life [8]. Despite the established importance of addressing these issues, the knowledge and preparedness of dental professionals to manage such complications vary significantly across regions, professional specialties, and levels of experience [9].

The critical role of dentists in managing oral health conditions during and after cancer treatment has been well recognized. They play a key role in preventing, diagnosing, and treating oral complications, thereby contributing to improved systemic outcomes and oral health related quality of life [9]. However, evidence suggests that knowledge gaps, limited training, and variable confidence levels hinder many dentists from providing optimal care to cancer patients [10]. Furthermore, a systematic review highlighted that while many dentists recognize their role in cancer care, they frequently report low confidence in managing complex cases, resulting in suboptimal practices and missed opportunities for preventive interventions [9].

Studies conducted in various regions of Iran, including Yazd [11], Ardabil [12], and Rasht [13], highlight a concerning lack of awareness regarding the specific dental needs of cancer patients among dentists. Despite recognizing the importance of preventive and therapeutic interventions for conditions such as mucositis, xerostomia, and osteoradionecrosis, many dentists report insufficient training and confidence in managing these complications [9]. Furthermore, variability in attitudes and practices underscores the urgent need for standardized educational initiatives and continuing professional development programs to equip dental practitioners with the skills required to optimize oral health outcomes in this vulnerable population. The objective of this study was to evaluate the knowledge and practices of Iranian dentists regarding oral and dental considerations for patients treated with radiotherapy or chemotherapy, and whether they admit such patients.

Methods

This study employed a cross-sectional design to meet the research objectives. Target population included general dentists who participated in the 59th Exhibition & Congress of Iranian Dental Association (EXCIDA) in May 2019. Assuming that 50% of dentists (p) have a moderate level of knowledge regarding dental considerations for patients undergoing radiotherapy and chemotherapy, with a margin of error of 15% (d), and a confidence level of 95% (Z), the required sample size for this study was calculated using the standard sample size calculation formula for prevalence studies [14]:

$n=Z^2p(1-p)/d^2= (1.96)^2\times0.5\times0.5/ (0.15\times0.5)^2\approx 171$

After adding an approximate 45% adjustment to account for the potential non-responses, the final sample size was determined to be 250.

The data collection tool for the present study was a questionnaire that was developed and validated as follows: The initial questionnaire consisted of 45 questions extracted from a reference book on oral diseases [15]. To assess the face validity of the questionnaire, 13 dentists who did not participate in the main research evaluated it both qualitatively and quantitatively. For the qualitative assessment, the clarity of the questions, potential ambiguities, and the time required for responses were examined, leading to corrective suggestions. The quantitative face validity was evaluated using the item impact method, where the dentists rated the importance of each item on a 5-point Likert scale (5 for "totally important", and 1 for "unimportant"). The impact score for each item was calculated using the following formula: "Impact Score = Frequency (%) × Importance". Only questions with an impact score greater than 1.5 were deemed acceptable in terms of face validity.

In the subsequent stage, an expert panel consisting of three university professors experienced in education and questionnaire design, five specialists from the department of oral medicine and maxillofacial pathology, and two experts from the department of oral public health evaluated each item in the questionnaire by choosing one option from a range of "necessary, useful but not necessary, and not necessary". The Content Validity Ratio (CVR) was then calculated for each item using the formula: $CVR=(n_e-N/2)/(N/2)$ in which "n_e" is the number of panel members who deemed the item "necessary", and "N" is the total number of panel members. As the panel included 10 experts, a minimum CVR value of 0.62 was required for an item to be retained, based on Lawshe's table [16].

In the next step, the Waltz & Bausell method [17] was used to assess the content validity index (CVI). Questionnaires were distributed to 15 dentists, who evaluated the "relevance," "clarity," and "simplicity" of each item using a 4-point Likert scale. The CVI for each item was calculated by dividing the number of respondents who selected scores of 3 or 4 by the total number of respondents. The three scores (for each of the relevance, clarity, and simplicity) obtained for each question were summed and then divided by three to calculate the average. The minimum acceptable value for the CVI is 0.79, and any questions with a CVI below this threshold were excluded. As a result of three evaluation criteria (impact score, CVR, and CVI), 24 questions were finally selected.

In the next stage of questionnaire construction, a pilot test was conducted with 25 dentists. The aim was to identify any issues with implementation and determine how to address them. Additionally, to assess the reliability of the questionnaire, the test-retest method was employed. After two weeks, the same 25 dentists completed the questionnaire again, allowing for the calculation of Intra-class Correlation Coefficient (ICC). The resulting ICC was 0.76, indicating good reliability for the questionnaire.

The data from completed final questionnaires was entered into SPSS statistical software version 21, where descriptive statistical methods and related tests were used to investigate the relationship between the dentists' knowledge and performance with variables such as age, gender, time passed from graduation, and history of dealing with patients undergoing radiotherapy and chemotherapy. The dentists' knowledge regarding radiotherapy considerations was evaluated by 10 questions. Each correct answer was awarded 1 point, while incorrect answers received no points. Total scores were categorized as follows: scores <4 indicated low, scores 4-7 indicated moderate, and scores >7 indicated high level of knowledge regarding consideration of patients undergoing radiotherapy. Similarly, the dentists' knowledge regarding chemotherapy considerations was assessed by 12 questions. Again, each correct answer received 1 point, and incorrect answers received no points. Total scores were categorized as follows: scores <5 indicated low, scores 5-8 indicated medium, and scores >8 indicated high level of knowledge. Two separate questions with yes/no options assessed respondents' practice regarding management of patients undergoing radiotherapy or chemotherapy as follows: Do you admit patients undergoing radiotherapy/ chemotherapy?

Associations between dentists' knowledge levels (categorized as low, medium, high) and background factors were evaluated using appropriate inferential statistics. For continuous independent variables (age and years since graduation), the Kruskal-Wallis test was employed to compare distributions across the three ordinal knowledge categories. For categorical independent variables (gender, history of dealing with patients undergoing treatment, and admission of such patients), the Chi-square test assessed the associations. These analyses were conducted separately for radiotherapy- and chemotherapy-related knowledge. All statistical tests were performed at $p<0.05$.

Ehical considerations of this study were carefully addressed to ensure participants' rights and confidentiality. The questionnaires were designed to be anonymous, and participation in the study was entirely voluntary. The act of completing the questionnaire was considered as implied informed consent to participate in the research. Participants were assured that their responses would remain confidential. Furthermore, the study received formal approval from the Ethics Committee of Shahid Beheshti School of dentistry, under the code IR.SBMU.DRC.REC.1398.004, ensuring compliance with ethical research standards.

Results

In this cross sectional study, half of the participated dentists were men with mean (SD) age of 45.1 (12) years, ranging from 26 to 69 years. On average, they had graduated 17.7 years ago (SD: 11.2), with a range of 1 to 40 years. Of the dentists, 126 (50.4%) reported having experience dealing with patients undergoing radiotherapy or chemotherapy. When asked about their approach to treating these patients, 171 dentists (68.4%) indicated that they accept and treat these patients, 40 dentists (16%) said they do not accept these patients, 20 dentists (8%) would refer them to a specialist or to a school of dentistry.

Table 1 shows how the dentists responded to 10 questions regarding dental considerations for patients undergoing head and neck radiotherapy. The question with the highest percentage of correct answers was, "Which lesion created after radiotherapy has a lower prognosis?"—192 respondents (77%) answered correctly. Conversely, the question that received the lowest percentage of correct responses was, "How many months after radiotherapy can a dental implant be placed?" with only 85 respondents (34%) answering correctly.

Table 1- Percentages of the dentists' (N=250) correct answers regarding dental considerations in patients undergoing radiotherapy.

	Correct Answer	Number (%)
Which lesion that occurs after radiotherapy has the poorest prognosis?	Osteoradionecrosis	192 (77)
In which area of the jaw is osteoradionecrosis most commonly observed?	Posterior mandible	177 (71)
Which treatment is NOT recommended for a patient with osteoradionecrosis?	Complete prophylactic removal of the lesion	151 (60)
What is the minimum stability period required for a bone lesion to be diagnosed as osteoradionecrosis?	6 months	125 (50)
Which medication is used to treat dry mouth following radiotherapy?	Pilocarpine	110 (44)
How long after completing radiotherapy can a patient begin using a dental prosthesis?	6 months	105 (42)
How many days before starting radiotherapy can a decayed tooth in the upper jaw be extracted?	5 days	100 (40)
How do osteoradionecrosis lesions appear on radiographs?	Radiolucency	96 (38)
Which mouthwash is recommended to reduce dental sensitivity after radiotherapy?	Mouthwash containing oxalate	94 (38)
How many months after radiotherapy can an implant be placed in the affected area?	12 to 18 months	85 (34)

Table 2 presents the level of dentists' knowledge about dental considerations for patients undergoing radiotherapy, along with relevant background factors. Specifically, older dentists and those with more work experience demonstrated lower levels of knowledge (p<0.001). Additionally, female dentists exhibited significantly higher level of knowledge than their male counterparts (p = 0.005). Dentists who accepted patients undergoing radiotherapy and had experience treating such patints also showed significantly greater knowledge compared to those without this experience (p<0.001).

Table 2 - The knowledge level of dentists (N=250) regarding dental considerations for patients undergoing radiotherapy, in relation to their background factors.

		Knowledge level[1]			p-value
		Low N(%) 63 (25)	Medium N(%) 137 (55)	High N(%) 50 (20)	
Mean (±SD) age (by year)		45.3 (9.49)	47.5 (12.5)	38.3 (11.2)	0.0001[2]
Mean (±SD) years past from graduation		16.5 (9.67)	20.7 (11.5)	11.3 (9.24)	0.0001[2]
Gender	Male	37 (30)	70 (56)	18 (14)	0.005[3]
	Female	26 (21)	67 (54)	32 (26)	
History of dealing with patients undergoing radiotherapy	Yes	17 (14)	71(57)	38 (30)	0.0001[3]
	No	46 (37)	66 (53)	12 (10)	
Do you admit patients undergoing radiotherapy?	Yes	29 (23)	102 (82)	40 (32)	0.0001[3]
	No	34 (27)	35 (28)	10 (8)	

1. Knowledge scores: theoretical range: 0-10, low: <4, medium: 4-7, high: >7.
2. Statistical evaluation by the Kruskal-Wallis test.
3. Statistical evaluation by the Chi-square test.

Dentists' answers to 12 questions regarding considerations for patients undergoing chemotherapy are presented in Table 3. The question with the highest percentage of correct answers was, "For how many weeks after chemotherapy treatment should antibiotic prophylaxis be administered to a neutropenic patient with cancer?"—173 respondents (69%) answered correctly. On the other hand, the question with the lowest percentage of correct responses was, "How many months should a patient be examined after oral cancer treatment during the first year?" with only 85 respondents (34%) answering correctly.

Table 3- Percentages of the dentists' (N=250) correct answers regarding dental considerations in patients undergoing chemotherapy.

	Correct Answer	Number (%)
For how many weeks after chemotherapy treatment should antibiotic prophylaxis be administered to a neutropenic patient with cancer?	One week	173 (69)
In a patient undergoing chemotherapy, the reduction of granulocytes to less than which level necessitates antibiotic prophylaxis?	2000	168 (67)
In a patient undergoing chemotherapy, the reduction of platelets to less than which level requires a hematology consultation?	50,000	150 (60)
Which complication is more prevalent in chemotherapy patients compared to those receiving radiotherapy?	Mucositis	145 (58)
If prophylaxis is required for a chemotherapy patient with a history of penicillin allergy, what is the standard medication prescribed?	Clindamycin	135 (54)
All indications for tooth extraction in a patient should occur before chemotherapy, except for..?	Caries without root involvement	116 (46)
Which medication is used to treat taste disorders in individuals undergoing chemotherapy?	Zinc	134 (54)
What change occurs during the first week of chemotherapy and typically improves one week after treatment ends?	Mucositis	130 (52)
What local and non-emergency procedure can be performed for a chemotherapy patient who experiences bleeding due to tooth extraction?	Use of aminocaproic acid syrup	129 (52)
At least how many days before the start of chemotherapy can the patient's lower jaw teeth be extracted?	Seven days	104 (42)
At least how many days before chemotherapy can a root canal treatment be conducted for a patient?	Seven days	96 (38)
How many months should a patient be examined after oral cancer treatment during the first year?	Three months	85 (34)

Table 4 illustrates the extent of dentists' knowledge regarding considerations for patients receiving chemotherapy, based on their background information. Notably, older dentists showed a lower level of knowledge, with a P-value of 0.002. Furthermore, female dentists displayed a significantly higher level of knowledge compared to their male colleagues (p<0.001). Additionally, dentists who had experience in treating chemotherapy patients, as well as those who were open

to accepting such patients, demonstrated a significantly greater level of knowledge than those lacking this experience (p<0.001).

Table 4 - The knowledge level of dentists (N=250) regarding dental considerations for patients undergoing chemotherapy, in relation to their background factors.

		Knowledge level[1]			
		Low N(%) 86 (34)	Medium N(%) 110 (44)	High N(%) 54 (22)	p-value
Mean (±SD) age (by year)		49.6 (10.8)	44.2 (12)	39.2 (11.3)	0.002[2]
Mean (±SD) years past from graduation		20.9 (10.7)	18 (11.3)	12.1 (9.6)	0.065[2]
Gender	Male	60 (48)	44 (35)	21 (17)	0.0001[3]
	Female	26 (21)	66 (53)	33 (26)	
History of dealing with patients undergoing radiotherapy	Yes	21 (17)	63(50)	42 (34)	0.0001[3]
	No	65 (52)	47 (38)	12 (10)	
Do you admit patients undergoing chemotherapy?	Yes	43 (34)	84 (67)	44 (35)	0.0001[3]
	No	43 (34)	26 (21)	10 (8)	

1. Knowledge scores: theoretical range: 0-12, low: <5, medium: 5-8, high: >8.
2. Statistical evaluation by the Kruskal-Wallis test.
3. Statistical evaluation by the Chi-square test.

Discussion

The findings of this study indicated that the participating dentists had a good understanding of certain dental considerations for patients undergoing radiotherapy or chemotherapy. However, one- to two-thirds of these dentists lacked knowledge about some other considerations. Additionally, younger and female dentists who had experience treating these patients or were willing to accept them demonstrated a higher level of knowledge.

The findings highlighted varying levels of knowledge among dentists regarding the management of dental considerations in patients undergoing radiotherapy. While a prevalent understanding was evident in identifying osteoradionecrosis as the lesion with the poorest prognosis and recognizing its common occurrence in the posterior mandible, knowledge about other critical aspects of care was less consistent. For instance, fewer than half of the respondents demonstrated accurate knowledge about treating dry mouth with pilocarpine or the timeline for introducing dental prostheses after radiotherapy. Similarly, knowledge about radiographic characteristics of osteoradionecrosis and the appropriate timing for tooth extractions and implant placement was notably limited. Similar trends were reported in studies focusing on practicing dentists. For example, Alqahtani et al. found that a significant proportion of Saudi dental practitioners lacked comprehensive knowledge of radiotherapy-induced oral complications, such as mucositis, xerostomia, and osteoradionecrosis [18]. Martins et al., also observed limited awareness among dentists regarding radiation-related caries [19]. These gaps underscore the need for enhanced education and training in specific areas, such as the management of radiation-related complications and post-radiotherapy dental care. Emphasizing these topics in dental curricula and continuing education programs could help ensure that dentists are better equipped to provide optimal care for patients undergoing radiotherapy, reducing the risk of complications and improving long-term oral health outcomes.

In the current study, the dentists' knowledge regarding dental care for chemotherapy patients was also evidenced by the varied percentages of correct answers. While most participants demonstrated an understanding of antibiotic prophylaxis protocols for neutropenic patients and critical granulocyte and platelet thresholds, other essential aspects of care, such as managing dental procedures before chemotherapy or addressing chemotherapy-related complications, showed lower levels of accuracy. For example, less than half of the respondents correctly identified the timing for tooth extractions or root canal treatments before chemotherapy, indicating potential risks for patients due to delayed or improperly timed interventions. Similarly, knowledge of alternative medications for patients with penicillin allergies and the use of aminocaproic acid syrup for post-extraction bleeding management was limited. The relatively low percentage of correct responses for post-treatment monitoring intervals suggests a need for greater emphasis on long-term follow-up care in professional guidelines and training. Overall, the findings underscore the necessity of targeted educational initiatives to improve dentists' understanding of critical protocols and management strategies for patients undergoing chemotherapy. Enhancing this knowledge is crucial for minimizing complications and optimizing patient outcomes in this vulnerable population.

Despite limited knowledge of the dentists in this study regarding some aspects of management of patients undergoing radiotherapy or chemotherapy, approximately two-third reported that they admit such patients. Interestingly, this is against the findings by Low et al. [9] who observed that dentists often lack confidence in managing complex cancer cases, or Hussain et al. [10] who reported limited involvement of Malaysian

dental practitioners in dysphagia management for patients with head and neck cancers. This eagerness to engage directly with cancer-related complications among the dentists in the current study may stem from their positive attitude to help such patients, and on the other hand underscores the need for targeted educational interventions and confidence-building measures, such as simulation-based training and mentorship programs.

The present study revealed that 68% of Iranian dentists accept patients undergoing radiotherapy or chemotherapy and 16% decline treatment. This acceptance rate aligns closely with findings of a study on Italian dentists in which about 65% reported preparedness for oral cancer screening practices [20], but exceeds the rates in Sudan where 54% of dentists abstain from special examinations for oncology patients [21]. Critically, in the present study, dentists belonging to the medium and high knowledge levels were more likely to admit patients, reinforcing findings from Australia where dentists' knowledge confidence directly increased screening adherence [22], and another study on Italian dentists where those attended continuing education courses were more likely to perform cancer examinations [20]. On the other hand, 67% of Sudanese dentists cited "lack of training" as the primary barrier for accepting oncology patients [21]. These findings underscore the need for targeted educational interventions to improve dentists' clinical competence which in turn increase their confidence for admitting such patients.

The findings of the present research indicate that older dentists and those who graduated a long time ago possess less knowledge about the dental considerations for patients undergoing radiotherapy or chemotherapy. Supporting this result, a research from Brazil identified difference in knowledge levels between older and newer dentists, with new dentists demonstrating knowledge levels twice as high as those of their older counterparts [23]. Similarly, findings of a study on dentists from Kerman, Iran concluded that older dentists exhibit a lower level of knowledge in this area [24]. This highlights the pressing need for continuous professional education, specialized training, and updated guidelines to help dentists maintain their knowledge to an optimum level.

Female dentists in the present study showed a greater awareness of dental considerations for patients undergoing radiotherapy and chemotherapy than their male counterparts. This finding is consistent with the research conducted by Alqahtani et al. which may be attributed to female dentists being more careful or more sympathetic towards their patients [18]. However, it is important to note that the results of various studies on this topic exhibit considerable variability. A recent systematic review revealed that while some studies found women to have better knowledge about cancer patients than men, others found no significant difference [9].

The present research also revealed that dentists dealing with cancer patients in their daily practice possess a higher level of awareness compared to their peers. This finding aligns with a study conducted in Kerman which indicated that dentists with experience in caring for cancer patients demonstrated significantly greater awareness and performance than those without such experience [24]. This suggests that increased exposure to cancer patients during a dentist's education and practice enhances their skills and understanding, ultimately leading to improved performance in patient care.

This study had several strengths; including a well-defined target population that fairly represents dental practitioners from all around the country as EXCIDA is the most important annual meeting of dental practitioners in Iran. The comprehensive process of questionnaire development, encompassing face validity, content validity, and pilot testing, contributed to the reliability and validity of the data collection tool. Additionally, the use of established statistical methods for data analysis added to the robustness of the study. However, certain limitations should be acknowledged. The conference setting, despite efforts to minimize distractions, may have introduced factors that could influence respondents' concentration during questionnaire completion. The study relied on self-reported data, which is subject to response biases and may not fully capture actual knowledge or practices. Furthermore, the cross-sectional design limits the ability to establish causality between dentists' knowledge and demographic or professional variables. Lastly, the study's generalizability may be constrained, as it was conducted within the specific context of a single event and may not reflect the broader population of dentists in other settings.

Conclusion

Dentists in this study demonstrated limited knowledge regarding some considerations for patients undergoing radiotherapy or chemotherapy. Since these patients frequently seek routine dental treatments, improving dentists' understanding in this area could greatly enhance patient care. To mitigate these limitations, relevant continuing education, such as conferences and workshops, should be organized, and appropriate modifications should be made to academic training programs.

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Informed Consent Statement: Questionnaires were distributed only to those who provided their informed consent..

Data Availability Statement: Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Using AI: This manuscript has benefited from the use of Deepseek (version 3) exclusively for language improvement. Deepseek was utilized to enhance the clarity, coherence, and grammatical accuracy of the text while ensuring that the original meaning and scholarly integrity of the content remained unchanged. No part of the research design, data analysis, interpretation of results, or conceptual contributions were generated or influenced by AI. The authors take full responsibility for the intellectual content of this work.

Conflict of Interest: " The authors declare no conflict of interest."

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