




Cognitive Biases Influence Clinical Practice of Selective Removal of Carious Tissue by Dentists and Students: An Exploratory Study

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ABSTRACT

Objective: To determine whether there is a lack of diffusion in the knowledge of selective removal of carious tissue (SRCT) and to examine whether cognitive biases influence professionals in their decision to implement SRCT. Additionally, this study seeks to identify whether the lack of knowledge diffusion and cognitive biases act as barriers to the adoption of SRCT in practice. **Material and Methods:** A series of questions was administered to dental professionals aiming to assess their knowledge of SRCT, their opinions on its use, and whether they incorporated this technique. Some questions were designed to identify potential factors influencing their decision-making process. The data was presented in terms of frequency percentages and analyzed using association tests ($p > 0.05$). **Results:** Out of 568 respondents, fifty-four individuals (9.5%) were not in favor of SRCT, while eighty-nine did not implement it in their practice. Professionals who were less inclined to use SRCT included those who had not studied it, endodontists, specialists unrelated to dentistry/pediatric/dental clinic, and dentists who had completed their degrees more than four years ago. Cognitive biases, such as outcome bias, overconfidence bias, and bias against new beneficial therapies, were found to be influenced by SRCT knowledge, specialized fields, postgraduate education, and the duration of professional training. Regarding the removal of carious tissue at pulp walls in very deep cavities, 158 respondents answered correctly, while 410 respondents provided incorrect responses. **Conclusion:** A deficiency in the dissemination of SRCT knowledge was identified. Cognitive biases exerted a significant influence on decision-making concerning the removal of carious tissue. These two findings contribute to the limitation in translating SRCT into clinical practice.

Keywords: Dental Caries; Heuristics; Education, Professional; Evidence-Based Dentistry.

Introduction

The quality of care in dentistry is impacted by both diagnostic and therapeutic decision-making [1]. Achieving sound decision-making in dentistry should be guided by the principles of evidence-based dentistry (EBD) [2]. As per the American Dental Association (ADA), evidence-based dentistry (EBD) encompasses the assessment of clinically pertinent evidence, patient requirements, and dentist experiences [3,4]. Consequently, EBD can be influenced by factors such as training, professional experiences, scientific evidence, clinical practice guidelines, and cognitive biases [2]. There exists a gap between scientific knowledge and its application in professional practice [1-3,5]. Afrashtehfar and Assery (2017) [1] indicated an adherence to evidence of less than 15% and a delay of up to 20 years for the implementation of scientific findings. The lack of time to search for information and insufficient training are commonly highlighted as contributors to this gap [6-8]. However, these factors mainly limit the search for adequate evidence and tend to undervalue the impact of professionals' experience [3].

Cognitive biases, also known as heuristics, are unconscious cognitive shortcuts that humans employ when making judgments to expedite the decision-making process [9,10]. These heuristics, as a result of their preference for certain viewpoints, tend to reduce impartiality and rationality, potentially leading to harmful outcomes [9,11,12]. Despite their significant influence on clinical decisions in healthcare [2,3,10,12-15], where heuristics are responsible for roughly 70% of medical errors [10,16], in-depth investigations into them are not typically conducted [2].

The decision to address decayed tissue becomes necessary in situations where a caries lesion requires restoration [17]. The recommended approach for managing the remaining tissue is selective removal [18-24]. Selective removal minimizes the risk of pulp exposure and the need for endodontic treatment, while maintaining restorative success [20,22,24]. However, an invasive approach has been advocated for almost a century, shaping generations of professionals under this philosophy [25]. Despite substantial evidence supporting selective removal, there's a significant gap in translating this evidence into practice [Banerjee et al., 2017], resulting in many dentists unnecessarily removing tissue [26]. Several contributing factors to this gap have been previously discussed, including inadequate diagnostic tools, inconsistencies in clinical guidelines, national health policies, payment systems, the age of professionals, variations in dental training, and individual moderating factors for each professional [18,26].

Various cognitive biases have been cited, such as confirmation bias, overconfidence bias, attention bias, and availability bias [3,4,10,13,14,27,28]. Dental surgeons often face difficulty in adopting new approaches [1], displaying limitations when they exhibit a lack of trust in these new practices [1]. Heuristics such as biases against new therapies and resistance to change [2] heavily influence professionals' choices and might be associated with the disparity between scientific knowledge and practical application [2,3]. The adherence of dental schools to updated therapeutic protocols can serve as an ally [13], but when these institutions resist change, they become a significant barrier to implementing these advancements [1,29].

Efforts to bridge the gap between science and clinical practice are imperative for Evidence-Based Dentistry (EBD) to truly benefit society [25]. Recognizing the existence of cognitive biases in healthcare is the first crucial step in mitigating their harmful effects [2,3,10,12,15,27,30]. Thus, this research aims to determine whether there is a lack of diffusion in the knowledge of SRCT and to examine whether cognitive biases influence professionals in their decision to implement SRCT. Additionally, this study seeks to identify whether the lack of knowledge diffusion and cognitive biases act as barriers to the adoption of SRCT in practical applications.

Material and Methods

Ethical Clearance and Study Design

The study received approval from the local Institutional Review Board under protocol # 4.658.605. Additionally, an informed consent form was obtained from each subject before their participation in the study. This is not an epidemiological study; rather, it is an exploratory investigation aimed at understanding the landscape of knowledge on the subject, without focusing on epidemiological distribution.

Experimental Design

Volunteers responded to a series of questions prepared by the authors. A pilot test was conducted to assess the adequacy of the questions. This preliminary stage involved voluntary contributions from 13 professionals, including clinical dentists and postgraduates. The series of questions (Table 1) was administered to both dentists and senior dental students. Along with identifying their professional profiles, the questionnaire aimed to assess their knowledge about selective removal, their preferences for the technique, and whether they were incorporating it into their practice. Additionally, the survey explored potential factors influencing their decision-making regarding the choice of technique for removing carious tissue.

Table 1 provides a summarized version of the series of questions. The complete series of questions is accessible through the following link:

https://drive.google.com/drive/folders/1mrwDXocr4zhFkvIwsMpQFhQuFAcj7yiv?usp=share_link

Table 1. Series of questions summarized.

Identification	Selective Removal Knowledge	Searching Cognitive Biases	Others
Gender?	Did you study any regular discipline related to cariology during your professional training?	Are you in favor for selective removal? (If yes) Why yes? (If not) Why not?	Do you believe in Evidence-based Dentistry? (If not, why?) (If yes, why?)
Region of Brazil?	Did you already hear or study about selective removal of carious tissue technique? (If not → What protocol do you use to remove the carious tissue?)	Do you perform this technique on your clinical daily? (If yes) Why yes? (If not) Why not? (If not) → Do you think you may cause an injury to your patient (e.g.: Pulp exposure) while performing the complete removal?	
Age?	Where did you hear or study about selective removal of carious tissue?	Imagine the next clinical case: "A 26 years old patient has a fistula in the periapical region of tooth 16. The information of a selective removal performed on that tooth a month ago can be found on his medical record." Which of the following hypotheses do you think is most likely to be the cause of the pulp necrosis of tooth 16?	
Graduation time?	What is the main clinical parameter you use to decide how much remove the carious tissue?		
Graduation Institute (University)?	To next questions section you must consider that the mentioned tooth has vital pulp or reversible pulpitis (short time of painful symptomatology, only under painful stimulation).		
Do you have any master or doctor degree, or any finished specialization?	According to selective removal technique, how must be performed the carious tissue removal on pulp walls of shallow to moderate cavities?		

According to selective removal technique, how must be performed the carious tissue removal on peripheral walls of shallow to moderated cavities?
According to selective removal technique, how must be performed the carious tissue removal on pulp walls of very deep cavities?
According to selective removal technique, how must be performed the carious tissue removal on peripheral walls of very deep cavities?
What is the most used restorative treatment that you use after you perform selective removal?
Do you feel insecure about your selective removal technique knowledge?

Target Audience

The study focused on both the public and private sectors. In terms of inclusion criteria, the study population comprised dentists currently or previously working in clinical settings, as well as senior dental students. For non-inclusion criteria, the study excluded students who were not in their senior year. As for exclusion criteria, respondents who did not complete the entire series of questions were excluded from the analysis.

Data Collection

The series of questions used in this study was made available online through Google Forms from May 6, 2021, to December 4, 2021.

Data Analysis

Data were extracted from Google Forms into Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Duplicate responses were removed by identifying and excluding entries with identical email addresses. The answers were tabulated for statistical analysis. The data were summarized using frequency percentages and subjected to association tests (chi-square or fisher), with a significance level established at 5%. For the statistical analysis, the Social Science Statistics (<https://www.socscistatistics.com>) was used.

Results

The respondents' characteristics are outlined in Table 2. In this study, 568 participants completed all the questions.

Table 2. Characteristics of the respondents.

Variables	N	%
Gender		
Women	411	72.4
Men	156	27.5
Non-binary	01	0.2
Region of Brazil		
North	14	2.5
Northeast	123	21.7
Midwest	45	7.9
Southeast	337	59.3

South	49	8.6
Age (years old)		
20-29	269	47.2
30-39	121	21.1
40-49	85	15.1
50-59	63	11.2
60-69	26	4.7
≥ 70	04	0.7
Time from graduation		
Not graduated	39	6.9
< 1 year	62	10.9
1-3 years	152	26.7
4-10 years	117	20.6
> 10 years	198	34.9
Specialties [#]		
Dentistry/Pediatric/Dental clinic	81	12.8
Endodontics	42	6.7
Other specialties	230	36.5
Non-specialist	278	44.0

[#]For this question, more than one option could be selected.

Among the participants, 514 respondents (90.5%) expressed being in favor of selective removal, while 54 participants (9.5%) stated they were not in favor. Statistical analysis revealed no significant difference between these responses concerning the region of Brazil ($p=0.7286$) or the training time ($p=0.7286$). A significant difference was observed (Figure 1) when comparing the responses of participants with and without a postgraduate degree. However, among dentists with postgraduate qualifications, no differences were found in terms of their expertise in dentistry/pediatrics/dental clinic, endodontics, or other specialties ($p=0.2849$). Dentists and dental students who were less in favor of the technique were those respondents who did not study it (Figure 1).

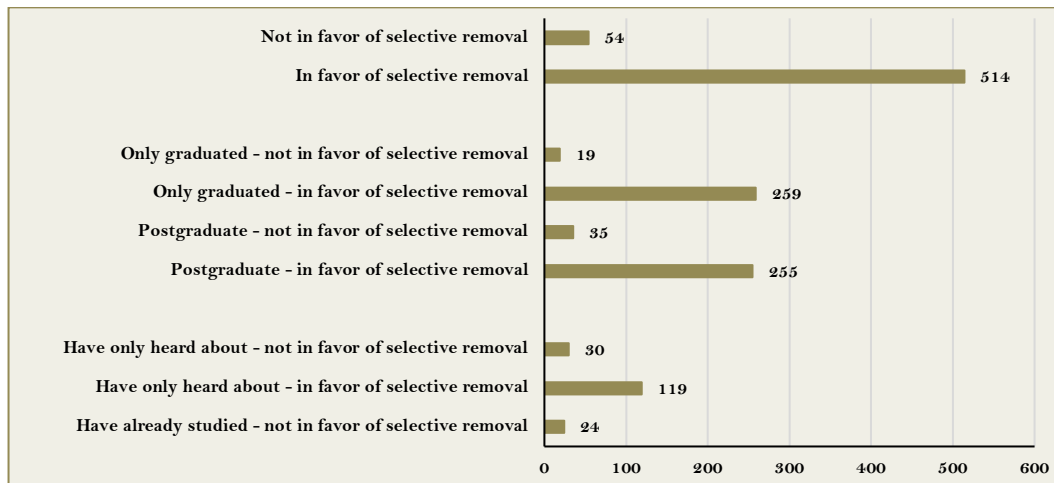


Figure 1. Dentists with postgraduate degrees ($p=0.0335$) and dentists who did not study selective removal ($p<0.00001$) exhibit less support for the technique.

Concerning the use of selective removal in clinical practice, 479 respondents chose 'yes', while 89 selected 'no'. Statistical analysis showed no significant difference concerning the region of Brazil ($p=0.4346$). Non-use of the technique was significantly more prevalent among professionals who had completed their dentistry degree four years or more ago (Figure 2). Non-use of selective removal was also bigger in postgraduate dentists (Figure 2).

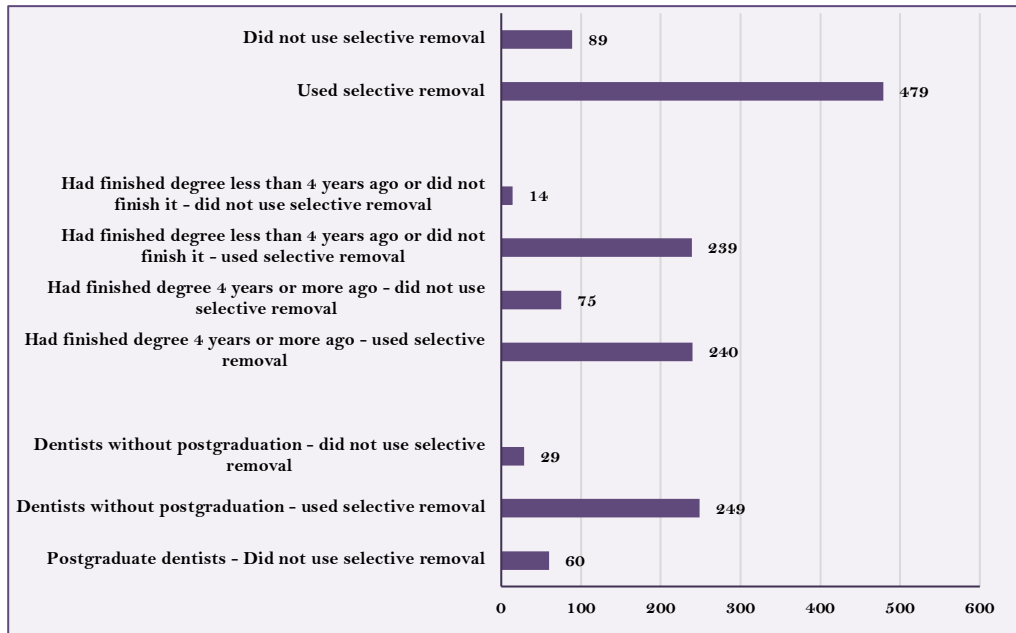


Figure 2. Dentists with postgraduate degrees ($p=0.0008$) and those who completed their degree four years or more ago ($p<0.00001$) tend to use selective removal less in clinical practice.

Endodontists employed the technique less frequently compared to all other groups, whereas professionals in other specialties used selective removal less than dentists specialized in dentistry/pediatric dentistry/dental clinic (Figure 3). Furthermore, a reduced utilization of the technique was observed among professionals who did not study selective removal (Figure 3).

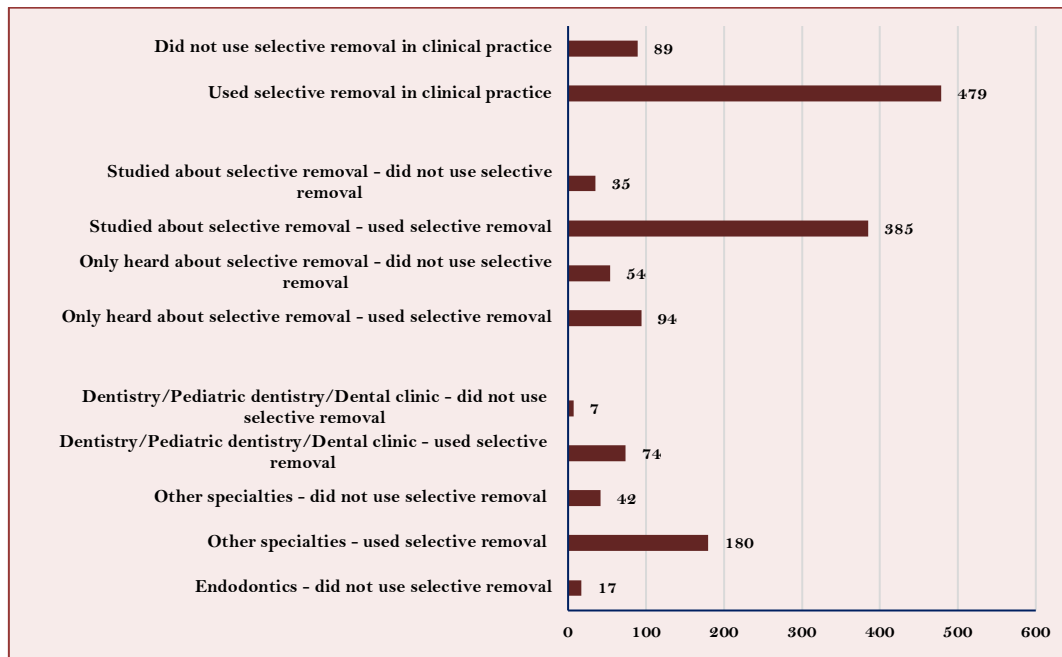


Figure 3. Endodontists ($p=0.0001$) and dentists who did not study selective removal ($p<0.00001$) tend to use selective removal less frequently in their clinical practice.

When participants were asked why they did not use selective removal, no statistically significant differences were found concerning the characteristics of the respondents. However, certain reasons were more commonly selected: "I do not feel secure about how to perform it" (42 responses), "I prefer not to change the

technique I currently use, which I find effective" (31 responses), and "I believe pulpal problems are caused by selective removal" (26 responses). Additionally, participants were asked whether they believed they could cause harm to patients by employing complete removal. Once more, no significant differences were observed among the dentists' characteristics.

In the clinical case presented in the series of questions, the most appropriate alternative (describing a "tooth that did not display pulp vitality before restoration") was chosen by 420 respondents, while the less appropriate alternative (indicating that the "carious lesion continued to progress after restorative treatment and reached the pulp") was selected by 133 professionals. There were no discernible differences when comparing the responses of dentists who graduated between 1 to 3 years ago with those of any other graduation period. The less appropriate alternative was more frequently chosen by individuals who had not completed their degree yet compared to dentists who had graduated more than 10 years ago. Similarly, the less suitable choice was selected more by dentists who had finished their degree within a year, as opposed to those who graduated between 4-10 years ago or more than 10 years ago. Dentists who completed their degree between 4-10 years ago selected the less appropriate alternative less often than those who finished their education 10 years ago. Additionally, a significant difference was observed between postgraduates and non-postgraduates, with the latter opting more for the alternative that contained a potential bias (Figure 4). No differences were found concerning specialties ($p=0.4118$), region of Brazil ($p=0.3253$), and whether they had studied the technique ($p=0.0949$).

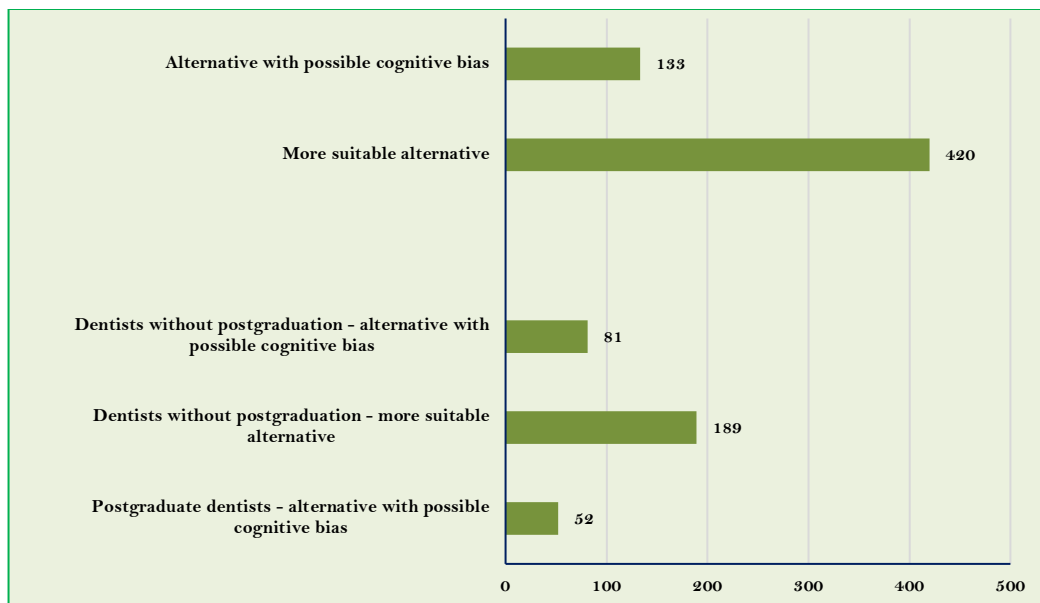


Figure 4. Dentists without postgraduate qualifications were more likely to select the alternative associated with cognitive biases in the clinical case ($p=0.0014$).

A total of 319 participants displayed insecurity about their knowledge of selective removal, while 249 professionals showed no insecurity. Specialties related to dentistry/pediatric/dental clinic exhibited less uncertainty compared to endodontics ($p=0.0029$) and other specialties ($p<0.0001$) (Figure 5). Additionally, less insecurity was observed in professionals who had studied selective removal (Figure 5). No significant differences were found in terms of the characteristics of the region of Brazil ($p=0.9934$), training time ($p=0.1382$), and whether they held postgraduate degrees or not ($p=0.2452$).

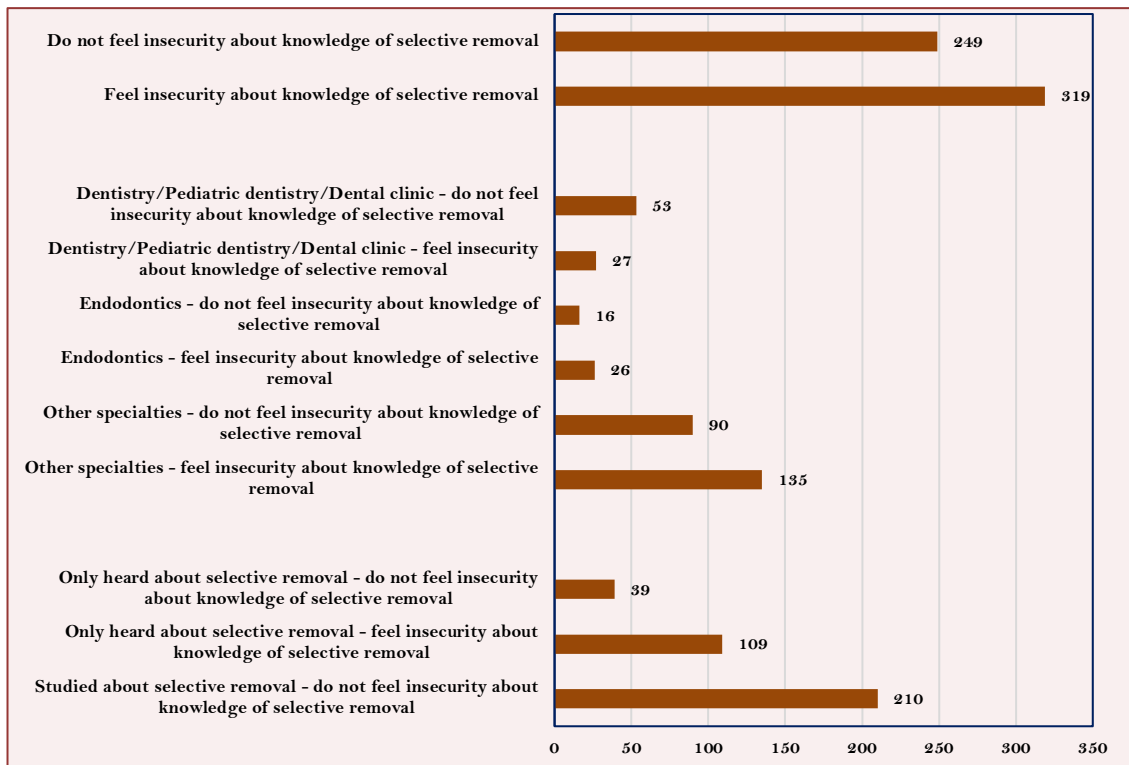


Figure 5. Dentists specializing in dentistry/pediatric dentistry/dental clinic and those who have studied selective removal exhibited lower levels of insecurity regarding their knowledge of the technique ($p < 0.00001$).

Discussion

Specific responses related to selective removal, responses regarding cognitive biases, and participants' characteristics were found to be associated. However, no studies were identified that directly compared these results. Among the participants' characteristics, the regions of Brazil did not appear to influence the responses.

The high proportion of professionals in favor of the selective removal technique, with 514 out of 568 respondents, differs from the findings of Li et al. [19] and Innes and Schwendicke [26], where many professionals preferred invasive techniques. It's worth noting that the respondents in this study voluntarily chose to participate, which could explain the significant adherence to the technique. This self-selection may have led to a higher representation of individuals favorable to selective removal, as the technique's name was mentioned in the invitation to participate. Additionally, it's essential to acknowledge that this study was exclusively conducted with Brazilian professionals. Furthermore, Kakudate et al. [31] suggested a greater acceptance of scientific information via the web by female dentists. In our study, 72% of the participants were women, which may have contributed to the high level of support for the selective removal technique.

Despite claiming to be in favor of the technique, a substantial number of participants reported not using it in their clinical practice. While 54 individuals initially expressed not being in favor, this number rose to 89 among those who did not apply selective removal (Refer to Figure 4). Factors such as the time of graduation, possession of a postgraduate degree, specialty, and knowledge about the technique appeared to influence the decision regarding the practice of selective removal (Refer to Figures 2 and 3).

As highlighted in the results section, 319 participants showed insecurity about their knowledge of the selective removal technique, whereas 249 professionals demonstrated confidence. Notably, when asked about the procedure for removing carious tissue from pulpal walls using the selective removal technique, when facing a

very deep cavity, 410 respondents answered incorrectly. Only 158 dentists provided the correct answer. These findings indicate a significant knowledge deficit concerning the selective removal of carious tissue.

Apart from the lack of knowledge dissemination regarding selective removal, it appears that cognitive biases are influencing the decreased adherence to the technique. Non-use of selective removal was more prevalent among post-graduates in specialties not related to cariology, suggesting a potential influence of overconfidence bias. This bias is characterized by professionals' excessive confidence in their intuition, often surpassing the accuracy of their judgments or knowledge, leading to mistakes [10,13,32]. A continued sense of confidence might stem from ongoing education, even in fields unrelated to the undergraduate course. Overconfidence has been identified by several authors as a type of heuristic [10,13,32]. Renner and Renner [33] in 2001 investigated two strategies to reduce overconfidence, finding that students who employed these strategies exhibited greater diagnostic accuracy. Therefore, it becomes evident that further research into biases in dentistry is crucial, as their reduction is directly linked to improved practice.

Another crucial aspect to consider regarding specialties is the potential influence of opinions from specialty professional trainers on students' critical perspectives. Endodontists frequently encounter teeth requiring root canals due to caries, even after restorative treatments. It seems plausible that the cognitive bias of outcome might influence endodontists' decisions to use selective removal less frequently (Figure 5). In this bias, clinicians tend to judge treatments as inadequate due to poor clinical outcomes, rather than basing their judgment on logical or evidence-based factors [13,32].

Dentists who graduated more than four years ago may not have been taught selective removal as the gold standard technique for addressing carious tissues [25]. The significantly higher rate of non-use of selective removal in this group appears to be associated with another cognitive bias, known as the bias against new beneficial therapies. This bias occurs when a professional's decision is founded on maintaining a therapy with which they are already familiar, instead of considering research that demonstrates the benefits of a new and advantageous therapy [2]. The bias against new beneficial therapies has been noted in various medical studies, including one conducted by Aberegg et al. [34]. In this particular research [34], when a therapy was identified as harmful by two randomized clinical trials, 85% of the individuals surveyed stated they would discontinue the use of such therapy. However, when a new therapy was demonstrated as beneficial by two randomized clinical trials, only 35% of those surveyed indicated they would opt to use the new therapy. This discrepancy underscores the reluctance among individuals to adopt new therapies, even when supported by robust clinical evidence of their effectiveness.

Although there were no significant differences between responses regarding why not to use selective removal, it's plausible that the most frequently selected alternative ("I do not feel secure about how to perform it") was due to a lack of knowledge. Greater insecurity in how to perform the technique may indeed be linked to this knowledge deficit. On the other hand, the second most frequently chosen alternative ("I prefer not to change the technique I am currently using, which I find effective") appears to be connected to the bias against new beneficial therapies [2]. This alternative's description closely aligns with the characteristics of the bias against new beneficial therapies, as it reflects a reluctance to change from a familiar technique, even when a more beneficial option may exist.




It's also probable that the third most chosen alternative was related to a lack of updated information. This is because one of the primary advantages of selective removal is better preservation of pulp vitality, and this third option stated the opposite, suggesting a lack of awareness of the technique's benefits [18,23]. Furthermore, when participants believed they could cause harm by using complete removal, the most frequently

selected alternative ("No, I think how I perform is the best, and if a pulp exposure occurs, it was caused by the carious lesion evolution") essentially disregarded the possibility of professional error. This response reflects a bias of overconfidence, as it implies that the professional's judgment and technique are infallible, and any negative outcome must be attributed solely to the carious lesion's progression.

The gap between evidence-based healthcare protocols and their application in clinical practice negatively impacts patients by denying them the benefits of procedures such as selective removal. This disparity between scientific evidence and actual practice has long been observed in the field [18,25,26]. In dentistry, similar discrepancies have been noted in various approaches [35-38]. For instance, patients might be advised to limit the consumption of staining beverages during dental bleaching, despite evidence showing no influence of these beverages on the final bleaching effectiveness [39,40]. Despite the significance of new discoveries and technologies, the current major challenge lies in translating and implementing what is already known into everyday clinical practice [18,25,26].

Given that certain questions and answers indicated the presence of biases such as overconfidence, outcome bias, and bias against new beneficial therapies, it's evident that heuristics strongly influence dentists' decision-making regarding the use of the selective removal technique. Additionally, this work identified a lack of knowledge about this technique. Therefore, studies focusing on developing strategies to increase the adoption of scientific evidence and further research on heuristics related to selective removal and other health approaches are imperative. It is recommended that research should not only focus on identifying cognitive biases but also on developing methods to mitigate their impact. Strategies to reduce these biases among dental professionals would be highly beneficial for improving the adoption of evidence-based techniques in clinical practice.

Authors' Contributions

JCM	 https://orcid.org/0000-0003-4276-4810	Conceptualization, Methodology, Software, Investigation, Writing - Original Draft and Writing - Review and Editing.
TMFC	 https://orcid.org/0000-0003-0521-7922	Conceptualization, Methodology and Writing - Review and Editing.
EB	 https://orcid.org/0000-0001-9299-8792	Conceptualization, Methodology, Writing - Original Draft, Writing - Review and Editing, Visualization and Supervision.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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