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Evaluation of anxiety-producing factors in the context of dental care using Delphi-AHP neutrosophic methods

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Abstract. The present study addresses a crucial problem in the field of dental care: the anxiety that patients experience during dental procedures. This worry is crucial considering that anxiety may impair both the patient experience and the efficacy of therapy. Despite the extensive literature on techniques for managing anxiety in medical contexts, there is a notable gap in the integration of systematic approaches that consider both technical and psychological factors. This paper addresses that gap by employing the neutrosophic Delphi-AHP technique, a novel methodology that allows for full evaluation and prioritization of treatments to decrease anxiety. Using a technique that combines rounds of questionnaires and neutrosophic analysis, the research highlights the key elements that lead to anxiety during dental treatment, such as invasive procedures and pain management. The results highlight that improving pain control, simplifying procedures, creating a more comfortable clinical environment, and improving patient communication are effective strategies to mitigate anxiety. The implications of the study are important both theoretically and practically, as it provides new perspective and tools to address a common problem in dentistry, offering concrete recommendations to improve the patient experience and optimize clinical practices.

Keywords: Anxiety, Dental Procedures, Pain Management, Delphi-AHP Neutrosophic Method.

1. Introduction

Anxiety during dental care is an issue of increasing relevance in the field of dental health, as it can significantly influence the patient's experience and the effectiveness of treatments . Research in this field seeks to better understand the factors that contribute to anxiety and develop strategies to mitigate them, in order to improve the quality of care and patient well-being. Existing research reveals that dental anxiety is a frequent condition that affects a large proportion of the population [1]. Accurate identification of causal factors and implementation of effective solutions are crucial to advancing dental practice and providing more humane and less stressful care [2]. Historically, dental care has been marked by invasive procedures that often generate an anxious response in patients. Since the early days of modern dentistry, practitioners have attempted to address this problem through various techniques and approaches, such as the development of anesthetics and distraction methods [3]. However, traditional approaches have had limitations in their ability to comprehensively address anxiety. Over time, there has been a growing awareness of the importance of communication and the clinical environment in the patient experience [4]. These developments have led to a more comprehensive approach to controlling anxiety during dental treatment.

The central problem addressed by this study is the lack of a systematic and comprehensive analysis of the factors that contribute to anxiety during dental care. Despite attempts to enhance patient experience, there is still a need for a systematic approach that includes both technical and emotional components to identify and prioritize anxiety causes [5]. The key question this article seeks to answer is: How can neutrosophic methods such as Delphi-AHP help identify and mitigate anxiety-provoking factors in dental care? The major purpose of this research is to investigate the elements that create anxiety during dental treatment utilizing Delphi-AHP neutrosophic methodologies. Firstly, the purpose is to identify the most relevant elements that contribute to the patient's worry. Secondly, we seek to prioritize strategies to address these factors effectively. The implementation of neutrosophic methodologies will allow for more accurate evaluation and proper prioritization of therapies, consequently offering practical suggestions to enhance the patient experience in the dental setting [6].

The research is based on a technique that combines rounds of questionnaires with neutrosophic analysis to capture the complexity of the issue and select mitigation solutions. This technique provides a new and thorough viewpoint that has not been properly explored in prior studies on dental anxiety. By integrating expert assessments and patient perceptions, the study aims to offer a more complete understanding of the factors that affect anxiety and the best ways to address them [7]. In summary, the importance of this study lies in its novel approach and its potential to transform dental practice. By tackling anxiety from a complete viewpoint, the research not only gives a full evaluation of the variables that create it, but also offers practical solutions to enhance patient treatment. This method may greatly contribute to enhancing the patient experience and the efficacy of dental treatments. The study's results have the potential to affect clinical procedures and the training of dental professionals, stressing the need of a patient-centered approach. With suggestions based on substantial data and novel methodological analysis, this study strives to give important direction for clinical practice and for future research in the area of dentistry.

2. Neutrosophic Delphi method

2.1. Dental Care

Dental treatment, at its foundation, is much more than merely treating teeth. It is a highly human contact that is interwoven with the emotional, psychological and social wellness of patients. This facet is often underestimated compared to the technical aspects of the practice, but is critical to providing comprehensive and effective care. As we delve deeper into dental care, it is crucial to understand that the impact of dental procedures is not only limited to oral health, but also encompasses the overall patient experience.

The history of dentistry reveals a significant evolution from the times when treatments were rudimentary and often painful. Today, technological developments and innovative treatments have radically revolutionized the way dental care is addressed. However, despite these developments, patient experience remains a significant issue. Studies reveal that dental anxiety continues to be a frequent condition, affecting a broad range of the population [8]. The absence of a holistic strategy that incorporates both the technical and emotional components of treatment is one of the key gaps in the present research. The key difficulty arises in the gap between the advancement of dental methods and the patient's subjective experience. While current technology have made operations more accurate and less intrusive, pain perception and fear still remain key impediments. The issue that emerges, therefore, is: how can we more successfully incorporate the emotional component into dental practice to enhance the patient experience? This problem is not just significant for oral health professionals, but also for patients seeking less stressful and more complete treatment.

The aims of the research on dental care center on understanding how emotional and psychological aspects impact the patient's experience. Firstly, we strive to determine the primary variables that lead

to anxiety during dental treatment. Second, the research intends to identify and suggest techniques based on these results to alleviate anxiety and enhance the overall patient experience. This holistic approach will not only handle the technical elements of treatment, but also create a more personal and compassionate environment. The relevance of this method resides in its capacity to convert dental treatment from a basic mechanical intervention to a more human and individualized experience. While procedures and equipment have evolved substantially, the true innovation is in how they are applied in the patient's setting. By incorporating treatments that address both physical pain and mental anxiety, dental practitioners may dramatically increase the quality of care delivered [8]. One of the most essential features of this study is the use of approaches such as the Delphi-AHP neutrosophic analysis to identify and prioritize anxiety variables. This methodological approach not only gives a more complete and organized picture of the aspects that impact the patient experience, but also provides a strong platform for making practical and useful suggestions [5][6]. By integrating both professional ratings and patient impressions, the study places itself at the forefront of dental care research.

Despite tremendous improvement, major problems persist. The heterogeneity in patients' emotional reaction and the intrinsic subjectivity of pain perception provide obstacles in establishing uniform remedies. Each patient is unique, and their experiences and responses might vary greatly. This heterogeneity underscores the necessity for individualized and adaptable techniques that may be adjusted to individual requirements [9]. The potential significance of this work is substantial. By establishing a greater knowledge of the variables that lead to dental anxiety and providing techniques to treat them, it opens the door to more patient-centered dental care. This transformation not only has the potential to increase patient happiness, but also to maximize clinical results and create more cooperation between patients and oral health professionals [9]. Dental care is a profession that, while extremely technical, cannot be properly comprehended without understanding the emotional and psychological components of the patient's experience. Research in this field gives a chance to bridge the gap between technique and human experience, creating a more holistic and sympathetic approach to dental treatment. This method not only enhances the quality of service, but also affects the way patients view and experience dental care. Therefore, it is crucial that dental practice continues to grow to thoroughly address all areas of the patient experience. Combining scientific developments with a profound awareness of patients' emotional and psychological needs may lead to more effective and humanized dental treatment, thereby giving a role model for the future of health care.

2.2. Delphi technique.

The Delphi approach is employed in numerous disciplines, such as program planning, resource utilization, policy judgment, and requirements assessment. A Delphi approach provides the following advantages:

- Tackle complicated challenges successfully.Able to define and change a vast variety of possibilities.
- Create diverse judgments on the same issue and utilize comments on others' assessments to enable them to modify their perspectives.
- Achieve a high degree of unanimity.

Increase coherence by minimizing the noise that occurs from focusing on group and/or individual interests instead of focused on resolving the issue. It is a structured communication strategy, developed mainly to gather and aggregate expert perspectives on certain themes via a series of iterative questions with controlled feedback. Developed in the 1950s by the RAND Corporation, this strategy is used to establish agreement on anticipating future trends, addressing complicated issues, strategic planning, and risk assessment, among others. The procedure starts with the selection of a panel of experts who

have specialized expertise in the area of interest. These experts submit to an initial questionnaire, the responses to which are anonymized and summarized by a coordinator or coordinating team. The summary findings are then given with the group, along with a new questionnaire based on the prior replies. This questionnaire-answer-feedback procedure is repeated in numerous rounds, to minimize the range of replies and move the group toward agreement. A significant component of the Delphi method is the anonymity of the participants, which helps reduce the impact of influence or dominance of some individuals over others, thereby promoting more objective replies and lowering conformity bias. At the conclusion of the process, the convergence of viewpoints is supposed to disclose a consensus or greater knowledge of the subject at hand, offering useful information for decision-making [5,14] . To establish knowledge of the subject investigated and object of study, it is established by a self-assessment procedure on a scale (see Table 1). This so-called neutrosophic knowledge coefficient is determined by the information that the expert himself gives on the topic of study.

Table 1: Linguistic terms used to determine K _(aN ,) K and evaluate the proposed criteria. Source: own elaboration.

linguistic term	**SVNN**
Full knowledge of the study topic (FK)	(1,0,0)
Very very good in the subject of study (VVGK)	(0.9, 0.1, 0.1)
Very good in the study topic (VGK)	(0.8,0.15,0.20)
Good at study topic (GK)	(0.70,0.25,0.30)
Moderately good in the subject of study (MGK)	(0.60,0.35,0.40)
Know the study topic (K)	(0.50,0.50,0.50)
Knows the topic of study moderately poorly (MPK)	(0.40,0.65,0.60)
Poor knowledge of the subject of study (PK)	(0.30,0.75,0.70)
Knows the subject of study very poorly (VPK)	(0.20,0.85,0.80)
Very, very poor knowledge of the subject of study (VVPK)	(0.10,0.90,0.90)
Without knowledge of the study topic (NK)	(0,1,1)

For the evaluation and validation of questionnaires using the Delphi method, the scale was used (see Table 2) to achieve greater objectivity in the management of the information. This allows us to evaluate the criteria argued by the judges of the panel of experts for each of the items individually. Through linguistic terms with Single Value Neutrosophic Numbers (SVNN) for consensus on the basis of the expert's opinion, criteria are evaluated using the neutrosophic argumentation coefficient.

Table 2: Linguistic terms used. Source: own elaboration.

Linguistic term I	**SVNN**	**Linguistic term II**
Very Suitable (VA)	(0.9,0.1,0.1)	Essential (E)
Fairly adequate (FA)	(0.75,0.25,0.20)	Very useful (VU)
Adequate (A)	(0.50,0.55,0.5)	Useful (U)
Not suitable (PA)	(0.3,0.75,0.80)	Not useful (LU)
Not suitable (NA)	(0.10,0.90,0.90)	Not useful (NU)

To determine the consensus among the participants of the expert panel, the agreement coefficient was used, determined through the expression:

$$Cc = \left(1 - \frac{V_n}{V_t}\right) 100 \quad (1)$$

Where: V_n is the number of negative votes cast by the judges, and $V_t$is the total number of votes cast by the judges. Therefore, a level of consensus must be reached when the agreement coefficient Cc obtains a value greater than 75%, and the process must be concluded; If this value is not reached, a new round must be established.

2.3. Neutrosophic AHP method

The Analytical Hierarchy Process (AHP) is a theory oriented to the decision maker and serves to identify the best alternative according to the assigned resources. This method can be applied to situations that involve technical, economic, political, social and cultural factors. That is, it aims to be a scientific tool to address aspects that are difficult to quantify but that sometimes require a unit of measurement. The methodology in its original version can be seen in [11, 15] . However, for this work the need for uncertainty is recognized, and for this purpose its neutrosophic version is adopted. Which uses triangular numbers for its execution, whose definition is as follows:

Definition 1: Let X be a space of points and $x \in$ of belonging to falsehood $F_A(x)$. U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$, $F_A(x) \subseteq]-0, 1+[$ and $-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup T_A(x) \leq 3+$. Note that , by definition , $T_A(x)$, $I_{A(A}(x)$ and $F_A(x)$ can be subintervals of [0, 1] [6,16] .

Definition 2: Let X be a universe of discourse. A single-valued neutrosophic set A over X is an object that takes the form $A = \{<x; T_A(x), I_A(x), F_A(x)>: x \in U\}$, where $T_A: U \rightarrow [0, 1]$, $I_A: U \rightarrow [0, 1]$, and $F_A: U \rightarrow [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$ for all $x \in X$. The intervals $T_A(x)$, $I_A(x)$ and $F_A(x)$ represent the degree of belonging to the truth, the degree of belonging to the indeterminacy and the degree of belonging to the falsity of x to A, respectively. For convenience, an SVN number is represented by A = (a, b, c), where a, b, c ∈ [0, 1] and a+b+c≤3.

Definition 3: Suppose that ã, ã, ã ∈ [0, 1] and $a_1, a_2, a_3, a_4 \in R$ where $a_1 \leq a_2 \leq a_3 \leq a_4$. Then, a single-valued trapezoidal neutrosophic number $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$is a special neutrosophic set on the set of real lines $\mathbb{R}$, whose functions of belonging to truth, belonging to indeterminacy and belonging to falsity are defined as see revised methodology [7, 8] .

Definition 4: given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$single-valued $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$trapezoidal neutrosophic numbers and λany non-zero number on the real line. Then, the following operations are defined :

Addition:$\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Subtraction : $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$(2)

Investment :, $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$where $a_1, a_2, a_3, a_4 \neq 0$.

Multiplication by a scalar number: [9]

This technique models the problem leading to the formation of a hierarchy representative of the associated decision-making scheme. The comparison is made using a scale, according to Table 3 [10] . To verify the neutrosophic methodology see [6-10].

Table 3: Saaty scale translated into a neutrosophic triangular scale. Source: [11]

saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\langle (1, 1, 1); 0.50, 0.50, 0.50 \rangle$
3	Slightly influential	$\langle (2, 3, 4); 0.30, 0.75, 0.70 \rangle$
5	Strongly influential	$\langle (4, 5, 6); 0.80, 0.15, 0.20 \rangle$
7	Very influential	$\langle (6, 7, 8); 0.90, 0.10, 0.10 \rangle$
9	Absolutely influential	$\langle (9, 9, 9); 1.00, 1.00, 1.00 \rangle$

saaty scale	Definition	Neutrosophic Triangular Scale
2, 4, 6, 8	Sporadic values between two close scales	$\langle(1,2,3);0.40,0.65,0.60\rangle$ $\langle(3,4,5);0.60,0.35,0.40\rangle$ $\langle(5,6,7);0.70,0.25,0.30\rangle$ $\langle(7,8,9);0.85,0.10,0.15\rangle$

3. Results.

The Delphi approach is based on an iterative process of rounds of questions issued to a panel of experts. The aim is that, via multiple rounds, a closer agreement is formed on the problem at hand.

For the study of variables that create anxiety during dental treatment using Delphi-AHP neutrosophic methodologies, the purpose is to identify the primary elements that generate anxiety in patients during dental appointments and analyze how these factors interrelate and impact the degree of anxiety.

Round 1: Determination of Factors

Six elements are identified that interfere in anxiety during dental care:

1. Clinical Environment : The quality of the physical environment of the dental office, including comfort, cleanliness, and overall attractiveness.
2. Dentist Communication : The manner the dentist interacts with the patient, includes clarity, empathy, and tone.
3. Dental operations : The kind and complexity of the operations conducted during the consultation.
4. Patient's past Experience : The patient's past experiences with dental care, which may impact their anxiety levels.
5. Patient Expectations : The patient's expectations and perceptions of the therapy and anticipated outcomes.
6. Pain Management : The patient's impression of pain control and management of discomfort during and after the process.

Round 2: Identification of Key Factors and Initial Assessments

Questions :

What do you perceive to be the influence of the clinical atmosphere on patient anxiety during dental care?

To examine the impact of the dentist's conversation on the patient's anxiety.

How does the kind and complexity of dental treatments effect patient anxiety?

To examine the influence of the patient's past experience with dental procedures on their anxiety.

What is the impact of the patient's expectations regarding the therapy on his or her anxiety level?

To examine the influence of pain treatment on patient anxiety during dental care.

Answers :

Experts share their judgments based on their expertise and experiences. Responses are gathered and examined to find areas of consensus and disagreement.

Table 4: Criteria Validation Level

Expert	Clinical Environment	Dentist Communication	Dental Procedures	Previous Experience	Patient Expectations	Pain Management
E1	(0.7;0.2;0.1)	(0.8;0.1;0.1)	(0.6;0.3;0.1)	(0.5;0.4;0.1)	(0.4;0.4;0.2)	(0.7;0.2;0.1)
E2	(0.8;0.1;0.1)	(0.7;0.2;0.1)	(0.5;0.4;0.1)	(0.6;0.3;0.1)	(0.5;0.3;0.2)	(0.6;0.3;0.1)
E3	(0.6;0.3;0.1)	(0.7;0.2;0.1)	(0.7;0.2;0.1)	(0.5;0.4;0.1)	(0.4;0.4;0.2)	(0.7;0.2;0.1)
E4	(0.7;0.2;0.1)	(0.6;0.3;0.1)	(0.6;0.3;0.1)	(0.4;0.5;0.1)	(0.5;0.3;0.2)	(0.6;0.3;0.1)
E5	(0.8;0.1;0.1)	(0.8;0.1;0.1)	(0.5;0.4;0.1)	(0.5;0.4;0.1)	(0.6;0.3;0.1)	(0.7;0.2;0.1)

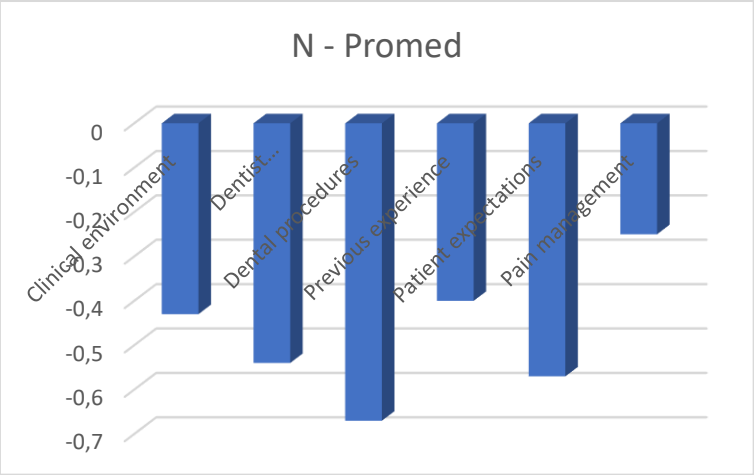
Table 5: Neutrosophic Relative Frequency

Indicators	(0.9;0.1;0.1)	(0.8;0.2;0.1)	(0.6;0.3;0.1)	(0.5;0.4;0.1)	(0.4;0.4;0.2)	(0.7;0.2;0.1)
Clinical Environment	0.2500	0.3750	0.2000	0.1500	0.0750	0.2000
Dentist Communication	0.2500	0.3000	0.2000	0.1500	0.1500	0.2000
Dental Procedures	0.2000	0.2000	0.3500	0.1500	0.1000	0.2000
Previous Experience	0.1500	0.1750	0.2000	0.2000	0.1500	0.1500
Patient Expectations	0.1500	0.1250	0.1500	0.1750	0.1750	0.2000
Pain Management	0.2000	0.2000	0.2000	0.1500	0.1000	0.2500

Table 6: Cut-Off Points and Criteria Scale

Indicators	N - Average	SVNN
Clinical Environment	-0.43	Very useful
Dentist Communication	-0.54	Appropriate
Dental Procedures	-0.67	Not very useful
Previous Experience	-0.40	Appropriate
Patient Expectations	-0.57	Appropriate
Pain Management	-0.25	Very useful

Round 3: Refinement of Assessments



Graph 1: Cut-Off Points and Scale of Criteria

Questions :

Considering the range of replies on the influence of the clinical setting, would you wish to revise your assessment?

Are there any additional thoughts you would want to add about dental communication?

Given the range of viewpoints on dental operations, do you believe it is important to change your assessment?

How would you rethink the value of the patient's past experience after viewing other experts' responses?

Based on the comments obtained, would you adjust your perspective of the patient's expectations?

Is there any reason that would cause you to rethink your judgment of pain management?

Answers :

The experts examine their earlier evaluations, changing them depending on the debates and arguments offered by other participants.

Round 4: Consensus

If there are still major disagreements, another round is done focused on the issues of dispute. Answers are received and experts give a consensus.

Conclusion of the Delphi Process

A final report is generated that highlights the agreement achieved, stressing the aspects that cause the greatest anxiety during dental treatment, along with their interrelationships and implications. The paper may serve as a foundation for enhancing dental practices and lowering patient concern.

Conclusion of the Neutrosophic Evaluation

The elements that most lead to anxiety during dental treatment are:

1. Dental Procedures : Due to the intrusive nature and the related discomfort.
2. Pain Management : The sense of pain control and management throughout the operation.

Recommendations to minimize anxiety in dental care :

1. Improve Pain Management : Implement more sophisticated pain control procedures and provide appropriate anesthetic.
2. Simplify treatments : Opt for less intrusive treatments wherever feasible and clearly clarify the stages to follow.
3. Create a Comfortable Clinical Environment : Ensure that the office is clean, contemporary and pleasant for the patient.
4. Improve Communication : Train dentists to use clear, sympathetic language and offer full information regarding treatment.

To prioritize improvement measures, the AHP Process is employed, integrating expert assessments and views to decide which strategies have the most effect on anxiety reduction.

The implementation of the Delphi-AHP neutrosophic method helps you to successfully identify and prioritize elements that produce anxiety during dental treatment and build ways to effectively minimize these issues.

4. Conclusion

In the investigation of the anxiety experienced during dental treatment, this research has shown critical variables that greatly impact the patient's well-being. The data reveal that invasive procedures and pain management are the key variables leading to anxiety in these circumstances. Through the application of the Delphi-AHP neutrosophic method, it has been possible to identify and prioritize effective strategies to reduce this anxiety, such as improving pain management, simplifying procedures, creating a more comfortable clinical environment and optimization of communication between dentist and patient. The practical value of these findings is enormous, as it gives clear instructions for the adoption of tactics that might improve the patient experience in the dental setting. Adopting improved pain management strategies and efficient communication not only promises to minimize anxiety but also increase patient happiness and participation throughout treatments. These innovations have the potential to increase standards of care in dentistry, leading to a more pleasant and less stressful experience for patients. Among the contributions of this research, the integration of the Delphi-AHP neutrosophic technique stands out, which gives a systematic strategy to solve complicated challenges in dental treatment. This unique technique not only enhances the knowledge of variables impacting patient anxiety, but also offers a formal framework for generating and prioritizing effective remedies. This addition to the field may influence future research and practice in dental care management.

However, the research had certain drawbacks. The application of the results may be modified by the subjectivity inherent in expert judgments and by the unique circumstances of the dental treatment reviewed. Generalization of the findings to other dental settings or specializations should be treated with care. For future study, it is proposed to examine the introduction of other approaches that complement the neutrosophic approach, such as research on pain management strategies based on new technology. Furthermore, it would be good to undertake research in diverse circumstances and with different patient groups to verify and expand the existing results. Continued review and refinement of ways to minimize anxiety in dental treatment are vital to delivering high-quality dental care and a more pleasant experience for all patients.

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