Submitted: 05 March, 2024 Accepted: 15 August, 2024 Published: 03 March, 2025 DOI:10.22514/jocpd.2025.027

ORIGINAL RESEARCH

Journal of Clinical Pediatric Dentistry

Exploring the role of a thematic approach in dental anxiety and physiological stress: an investigation into dental radiology

Gilman Yucel[1], Burcu Demir[2,*], Ferruh Semir Smail[2], Sureyya Sahinoglu[3], Ulku Noyan[1]

[1]Bahcesehir Orthodontics Clinic, 34538 Istanbul, Turkey
[2]Bahcesehir University, 34349 Istanbul, Turkey
[3]Biruni Laboratory, 34538 Istanbul, Turkey

***Correspondence**
burcu.demir@es.bau.edu.tr
(Burcu Demir)

Abstract

Background: Dental anxiety in pediatric patients can lead to avoidance of care and increased stress. While previous research has explored various anxiety-reduction interventions, the role of environmental modifications, such as thematic design, remains underexplored. This study examines the impact of a thematic approach in dental radiology on anxiety and physiological stress markers. **Methods**: A comparative observational study was conducted with 42 children (6–14 years) undergoing panoramic radiographic imaging in a private dental clinic in Istanbul, Turkey. Participants were assigned to a standard imaging environment or a thematically designed environment. Anxiety levels and physiological markers, including salivary cortisol, pulse rate, oxygen levels, and body temperature, were measured before and after the procedure. **Results**: No significant differences were observed in pulse rate, oxygen levels, or body temperature between groups. However, post-procedure salivary cortisol levels were significantly lower in the thematically designed environment group (p = 0.005), indicating reduced physiological stress. **Conclusions**: Thematic modifications in dental radiology may help lower stress responses, particularly in cortisol regulation. While broader physiological effects were not observed, the findings highlight the potential of environmental interventions in pediatric dental care.

Keywords

Dental anxiety; Thematic approach; Physiological stress

1. Introduction

Dental anxiety and physiological stress are prevalent issues in dental offices, affecting individuals of all ages. While multiple factors can contribute to children's experiences of a procedure, including how children's choices are listened to and considered [1, 2], the negative emotions during a procedure can have far-reaching consequences, including compromised oral health, and even the deterioration of overall well-being [3, 4]. Moreover, dental anxiety is recognized as a barrier to seeking necessary care, causing some children to completely avoid treatment [5], with that being a potential predictor of dental caries incidence [6]. Studies have indicated that 43% of children exhibited "low to moderate" general dental fear, with 10% experiencing high dental fear [7, 8]. Stimuli such as the sight and sensation of the anaesthetic needle, as well as the sound and sensation of the drill, were identified particularly fear-inducing [7]. However, within the realm of dental procedures, radiological imaging has also emerged as a specific source of anxiety for many patients, necessitating effective interventions to alleviate their distress [9], and it should not be underestimated although dental radiology does not make use of potentially anxiogenic objects and instruments, such as needles for local anesthesia, burs, and dental handpieces [10, 11]. Research indicates that radiological imaging procedures, such as intraoral periapical (IOPA) and panoramic radiographic imaging (PRI), can contribute to heightened anxiety in patients, not due to the procedures themselves, but rather due to negative experiences during their execution. The unfamiliarity of the equipment and potential exposure to radiation, combined with how the procedure is carried out, may lead to discomfort and fear [12]. These negative experiences can result in distorted images, necessitating repeated exposures and increasing radiation exposure for patients [13]. Additionally, such experiences may contribute to post-traumatic stress syndrome in some cases [14, 15].

Various intervention methods have been explored by dentists to address dental anxiety [16, 17] ranging from sedation and general anesthesia to positive reinforcement and distraction (*i.e.*, augmented reality) [18–20]. Recently, alternative approaches focusing specifically on the psychosomatic aspect of pain have emerged due to its ability to mitigate the respon-

siveness focused on the noxious stimulus [21]. One example is a novel intervention by Yucel *et al.* [20] that integrates Augmented Reality applications as a positive environment distraction into the waiting room, including virtual cartoon-like characters as video animations projected on walls/ceilings. Before the treatment, a pre-determined augmented reality (AR) application is provided through tablets in the waiting room, alleviating the fear of unknown and promoting distraction. This intervention aggregated the effects of anxiety-reducing mechanisms before any treatment among 6–14 years old of kids. In a similar sense, we present a novel approach known as dental theming that has gained attention for its potential to alleviate anxiety and enhance the dental experience. By creating a dental environment that incorporates supportive design, conscious choices in office décor and positive distractions, dental theming may counteract anxiety on a broader scale and provide both physically and emotionally supportive environment for patients undergoing radiological imaging. Research also indicates that the design of the environment influences children's understanding of and navigation within their surroundings, achieving a positive healthcare experience, particularly during extended hospital stays [22] and lead to increased pain tolerance and reduced anxiety [23–25]. In fact, according to National Health Service (NHS) Estates (2004b) the design of the environment is a key element that contributes to children's "understanding" of, and ability to "navigate" within their surroundings, and a high-quality environment can "raise the morale of patients, their parents and families, but also the morale of staff who work in the hospital" (Alder Hey Children's NHS Foundation Trust 2012, p.20). The development of a child-centric environment can benefit from the values and opinions of children themselves; obtained through surveys or in-person interviews that help to guide the medical design process. For example, making environments "less scary" and as a result more child-friendly, is cited as a priority by children when asked about their experience of healthcare [26].

In healthcare settings, anxiety may lead to a set of physiological, psychological and behavioral responses (*e.g.*, high blood pressure, sleeplessness) and cause disorders, diseases and negative outcomes [27–30]. And, various measures have been used in the literature to evaluate this phenomenon. These methods include psychological measures such as questionnaires (*i.e.*, the modified child dental anxiety scale, MCDAS) and physiological measures, such as blood oxygen levels and pulse rate. Although psychological measures are commonly used to detect and monitor anxiety levels, they are criticized due to their reliability depending on the self-perception and honesty of the respondents [9]. To obtain a more objective assessment, blood pressure, pulse rate, the activity of salivary cortisol, an enzyme released in higher quantities during stressful situations [31], can be measured [9]. Studies have also validated the utility of salivary cortisol as a biological marker for detecting dental anxiety [32–34]. Thus, the objective of this study is to investigate the impact of a thematic approach in dental radiology on children's dental anxiety and physiological stress. Specifically, the study will explore how the design of the radiological environment influences children's anxiety levels and stress responses during dental procedures. By gaining deeper insights into the effectiveness of this approach and by combining multiple markers, we hope to inform future interventions and improve the dental experience for children.

2. Materials and methods

This study was conducted at a private dental clinic in Bahcesehir, Istanbul, Turkey. The study duration was two months, from April 2023 to June 2023. The study included 42 paediatric dentistry patients (53.4% girls and 46.6% boys) aged between 6–14 years. Participants were allocated to either group in an alternating manner based on appointment order. The sample size of 42 pediatric patients was determined to ensure manageability within the given timeframe and resources, while still providing a sufficient number of participants to observe meaningful trends and effects. Additionally, this sample size aligns with previous studies in the field that have used similar numbers of participants to study dental anxiety and stress responses in pediatric patients [35, 36]. Besides, given the limited sample size, this study is framed as a preliminary investigation to explore the potential effects of a thematic approach in dental radiology, with plans to continue and expand the study in the future.

2.1 Study design

This study was conducted as a comparative observational study to assess the effect of a thematic approach used in radiological techniques on dental anxiety and physiological indicators. The study includes two groups: one group underwent radiological imaging in a thematically designed environment, while the other underwent imaging in a standard environment.

2.1.1 Inclusion criteria

Children aged 6 to 14 years.

Children scheduled for radiological imaging procedures (*e.g.*, panoramic radiographic imaging).

2.1.2 Exclusion criteria

Children with cognitive or physical disabilities that may interfere with their ability to participate in the study.

Children with a history of dental or medical conditions that may affect anxiety levels or physiological responses.

2.2 Study procedures

2.2.1 Group allocation

Participants were assigned to either a standard imaging environment or a thematically designed environment based on their appointment schedule at the dental clinic. The thematically designed environment group received radiological imaging with the thematic approach, while the standard imaging environment group received radiological imaging without any thematic elements. Children scheduled for radiological imaging procedures including panoramic radiographic imaging (PRI) and intraoral periapical (IOPA) imaging. Both groups were selected from the same population base.

2.2.2 Thematic approach

The thematic approach involved creating an imaging room that incorporated supportive design, conscious choices in of-

fice décor, and positive distractions. Specifically, it included space-themed wall murals, child-friendly artwork, interactive displays and the use of space characters, designed and manufactured by Imagination Design Studios (Figs. 1,2). In addition to the thematic approach, the following behavior management techniques were used consistently across both groups:

Tell-Show-Do: Child specialists and dental assistants explained the imaging procedure to the children using age-appropriate language, demonstrated the procedure on models or themselves, and then performed the actual procedure. We did not systematically include these approaches; it is the natural way of interacting with pediatric patients in our clinic and was consistent across both groups.

Positive Reinforcement: Verbal praise and small rewards (*e.g.*, stickers or small toys) were given to encourage cooperative behavior and reduce anxiety.

2.3 Data collection

The primary variables measured were salivary cortisol levels, pulse rate, blood oxygen level, and body temperature. We measured each variable using specific instruments and processes as described:

2.3.1 Panoramic x-ray and intraoral periapical imaging

All participants received panoramic x-rays using the Dentsply Sirona Axeos CBCT Machine.

2.3.2 Physiological indicators

The physiological indicators included salivary cortisol levels, pulse rate, blood oxygen level, and body temperature. The following instruments and processes were used:

Salivary Cortisol Levels: Salivary samples were collected using specialized sterile kits (Salivette®). Participants were instructed to avoid food intake for at least 30 minutes before sample collection. Saliva was collected using the passive drool method (Putnam 2012), where participants allowed saliva to accumulate in their mouths and then drooled into the provided tubes. The collected samples were stored in a −60 °C freezer and later transported to the lab for analysis. Salivary cortisol was measured using the second-generation electrochemiluminescence immunoassay (ECLIA) on a Cobas e411 analyzer, which is a fully automated analyzer that uses a patented ElectroChemiLuminescence (ECL) technology for immunoassay analysis. The test principle is a 1-step competitive assay conducted at 37 °C for 18 minutes (Cobas e411 analyzer, Roche Diagnostics GmbH, Mannheim, BW, Germany).

Pulse Rate: Pulse rate was measured using a Braun YK-81CEU Pulse Oximeter. The oximeter was placed on the participant's fingertip, and the pulse rate was recorded before and after the radiological imaging procedure. The pulse rate values were recorded in beats per minute (bpm) and analyzed for pre- and post-procedure differences.

Blood Oxygen Level: Blood oxygen levels were also measured using the Braun YK-81CEU Pulse Oximeter. The oximeter was used to measure the oxygen saturation (SpO_2) in the blood before and after the imaging procedure. Blood oxygen levels were recorded as a percentage and analyzed for changes pre- and post-procedure.

Body Temperature: Body temperature was measured using an Omron Gentle Temp 720 Infrared Ear Thermometer. The thermometer was placed in the participant's ear to record body temperature before and after the imaging procedure. Temperature readings were recorded in degrees Celsius and analyzed for pre- and post-procedure differences.

3. Results

Statistical analyses were conducted using IBM SPSS V23 (IBM Corporation, Armonk, NY, USA). Changes in physiological indicators before and after the radiological imaging procedures were assessed using paired *t*-tests for normally distributed data and Wilcoxon signed-rank tests for non-normally

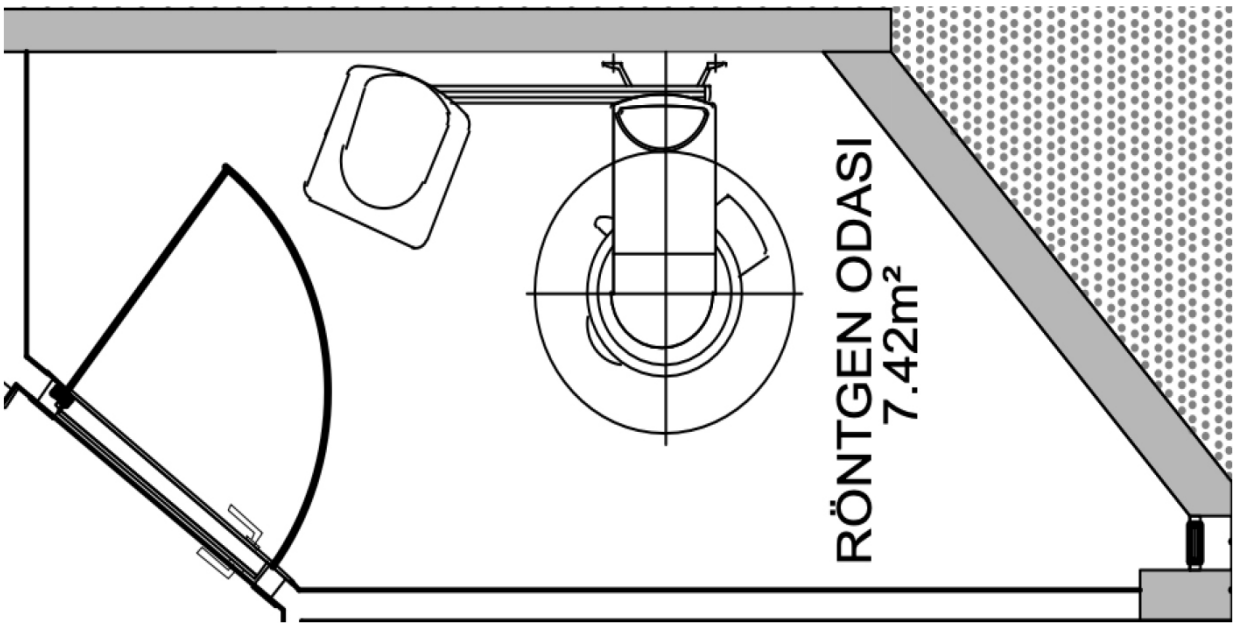

FIGURE 1. Radiography room layout.

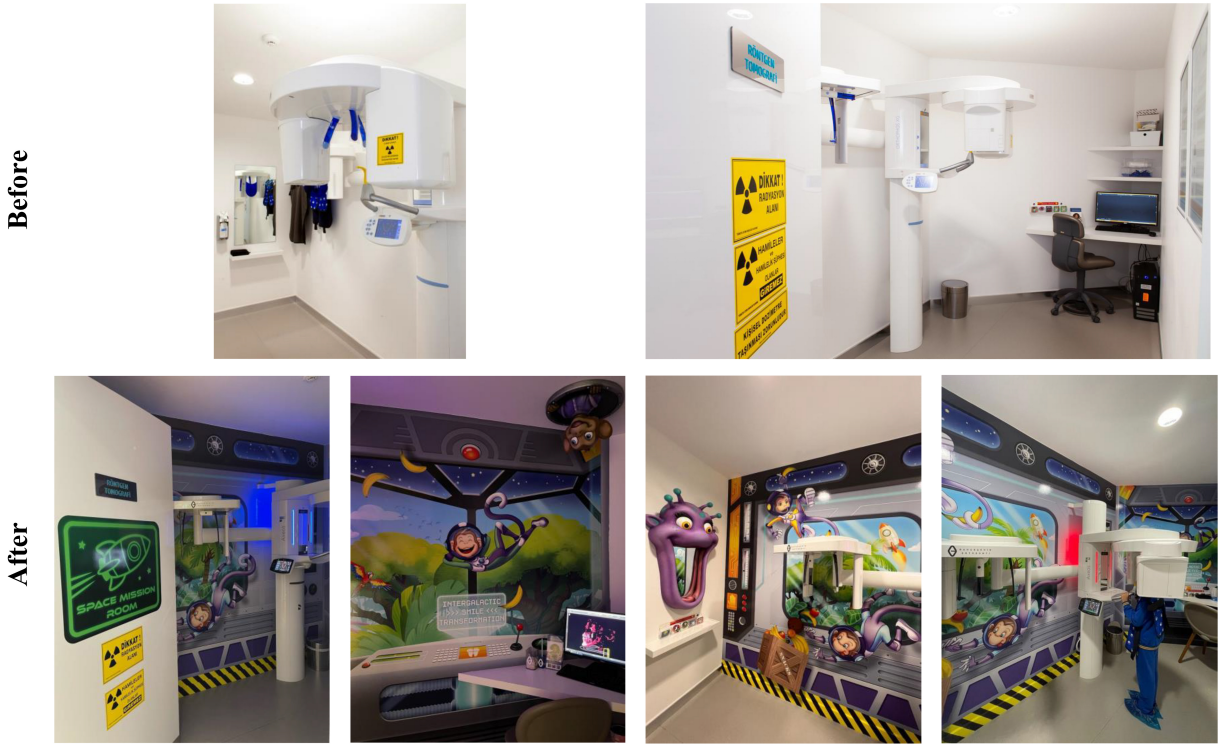

FIGURE 2. Before & after photos for thematic design.

distributed data within each group. Independent *t*-tests and Mann-Whitney U tests were used to compare differences between the standard imaging environment and thematically designed environment groups. Normality was assessed using the Shapiro-Wilk test, and homogeneity of variances was tested using Levene's test (Table 1).

There is no significant difference between the groups regarding the pre-fever scores (p = 0.458). Similarly, there is no difference between post-fever measurements, with a median value of 37.2 in the standard imaging environment group and 36.9 in the thematically designed environment group (p = 0.572). The changes in the pre and post scores do not differ between groups (p = 0.841). According to within-group comparisons, there is also no difference in pre and post measurements for both the standard imaging environment and thematically designed environment groups (with the p-values of 0.266 and 0.070, respectively).

There is no significant difference between the groups regarding the pre-pulse rates (p = 0.442). Similarly, there is no difference between post-pulse rate measurements, with a mean value of 94.73 in the standard imaging environment group and 97.64 in the thematically designed environment group (p = 0.387). The changes in the pre and post scores do not differ between groups (p = 0.751). According to within-group comparisons, there is also no difference in pre and post measurements for both the standard imaging environment and thematically designed environment groups (with the p-values of 0.565 and 0.248, respectively).

There is no significant difference between the groups regarding the pre-oxygen levels (p = 0.438). Similarly, there is no difference between post-oxygen measurements, with a mean value of 94.5 in the standard imaging environment group and 94 in the thematically designed environment group (p = 0.609). The changes in the pre and post scores do not differ between groups (p = 0.376). According to within-group comparisons, there is also no difference in pre and post measurements for both the standard imaging environment and thematically designed environment groups (with the p-values of 0.261 and 0.248, respectively).

There was no significant difference between the groups in pre-cortisol levels (Mann-Whitney U = 212, p = 0.481). Post-cortisol levels also showed no significant difference between the standard imaging environment group (median = 0.2) and the thematically designed environment group (median = 0.1) (Mann-Whitney U = 171, p = 0.096).

The results suggest that the thematic approach may have potential benefits in reducing salivary cortisol levels, indicating a reduction in physiological stress. However, no significant differences were observed in other physiological measures such as body temperature, pulse rate and blood oxygen levels. These findings highlight the need for further research to explore the broader impact of the thematic approach on patient stress and anxiety, as well as its potential application in other clinical settings.

4. Discussion

Anxiety, characterized by anticipatory fear and physiological changes, notably in blood pressure, heart rate and salivary cortisol levels [38, 39], has significance for assessing stress and anxiety during dental procedures. However, pediatric patients undergoing tomographic x-rays may exhibit distinct stress responses compared to patients in other clinical contexts, as evidenced by previous research [40, 41]. Thus, investigating

TABLE 1. Changes found in physiological indicators before and after the radiological imaging procedures.

Measure	Time	Standard Imaging Environment		Thematically Designed Environment		Test Statistics	*p*
		Mean ± s.d.	Median (min:max)	Mean ± s.d.	Median (min:max)		
Body Temp							
	Pre	36.98 ± 0.62	37.1 (35.8:38.11)	36.85 ± 0.56	36.9 (35.8:38.11)	210.5[a]	0.458
	Post	36.63 ± 2.27	37.2 (26.9:38.11)	36.94 ± 0.53	36.9 (35.7:38.1)	218.5[a]	0.572
	Dif (Post–Pre)	−0.35 ± 2.23	0.1 (−10.1:0.7)	0.09 ± 0.25	0.1 (−0.6:0.5)	233.5[a]	0.841
	Test Statistics	−1.112[d]		−1.813[d]			
	p	0.266		0.070			
Pulse Rate							
	Pre	94.41 ± 10.68	94.41 (78:114)	97.09 ± 12.18	99.17 (77:116)	−0.777[b]	0.442
	Post	94.73 ± 9.74	92.53 (80:112)	97.64 ± 12.24	100.36 (80:118)	−0.874[b]	0.387
	Dif (Post–Pre)	0.32 ± 2.55	0.5 (−5:5)	0.55 ± 2.15	0.5 (−5:4)	−0.319[b]	0.751
	Test Statistics	−0.585[c]		−1.188[c]			
	p	0.565		0.248			
Oxygen							
	Pre	94.73 ± 3.06	95 (89:99)	94 ± 3.16	94 (89:100)	0.783[b]	0.438
	Post	94.52 ± 3.28	95 (89:99)	94 ± 3.16	94 (89:101)	0.515[b]	0.609
	Dif (Post–Pre)	−0.23 ± 0.92	0 (−2:2)	0 ± 0.76	0 (−1:2)	−0.894[b]	0.376
	Test Statistics	1.156[c]		0.000[c]			
	p	0.261		1.000			
Cortizol							
	Pre	0.27 ± 0.16	0.3 (0:0.5)	0.24 ± 0.17	0.2 (0:0.5)	212[a]	0.481
	Post	0.22 ± 0.17	0.2 (0:0.7)	0.14 ± 0.13	0.1 (0:0.4)	171[a]	0.096
	Dif (Post–Pre)	−0.05 ± 0.15	0 (−0.4:0.2)	−0.13 ± 0.15	−0.1 (−0.5:0.1)	195[a]	0.275
	Test Statistics	−1.542[d]		−2.825[d]			
	p	0.123		0.005			

[a]*Mann-Whitney U;* [b]*Independent Samples t-test;* [c]*Paired samples t-test;* [d]*Wilcoxon.*
s.d.: standard deviation; Dif: difference.

the specific stress response profiles of pediatric patients in various clinical settings and their intricate connections with environmental and procedural stressors, as well as stress-related outcomes, is important for future research and practices. The current study's findings provide valuable insights into the effectiveness of the thematic approach in managing dental anxiety and its associated physiological manifestations. The study demonstrated that while pulse rate and body temperature differences between groups were not significant, post-procedure salivary cortisol levels showed a notable distinction, suggesting the thematic approach's potential influence on cortisol release and stress modulation. However, it is important to note that we did not systematically categorize children's behavior, such as crying, pain or success rates in image acquisition, during the radiographic exams. This limitation highlights the need for future studies to include comprehensive behavioral assessments to fully understand the impact of the thematic approach on pediatric dental experiences. Despite this, the reduction in cortisol levels is a promising indicator of the thematic environment's potential benefits in reducing physiological stress in children.

As of heart rate, it has been a subject of interest in previous studies which present inconsistent insights with the current study's findings. For example, Tucker *et al.* [42] and Goldstein *et al.* [43] found increased heart rates during dental-related stimuli and emphasized the role of anxiety in influencing heart rate responses. Additionally, Wannemüller *et al.* [44] noted significant heart rate variations in anxious patients even before entering the dental chair. In terms of body temperature, our finding is against the evidence that human body temperature changes in response to stress [45, 46]. Already in 1930, a case report described the presence of psychogenic fever [47]. However, human thermoregulation is a complex process under the control of the central nervous system so it is also

consistent with research indicating that anxiety is related to body temperature and interventions targeting stress improve participants' stress levels and body temperature [48].

When it comes to salivary cortisol levels, it has been the first choice of several researchers in the last years since it is relatively easily attainable and it is not an invasive method. Our findings showed that patients undergoing both tomographic x-rays and panoramic radiographic imaging (PRI) in a thematic environment have significantly lower cortisol levels compared to the standard imaging environment group, underscoring the role of environmental cues in shaping physiological responses, which, in turn, influence patients' comfort and well-being. This finding from tomography rooms is consistent with previous studies in other pediatric settings that reported significant benefits (*e.g.*, lower stress and anxiety, calming effects) associated with the provision of nature images, artworks, music and other audio-visual environmental distractions [49–52] as well as the provision of non-environmental distractions (*e.g.*, pet, hypnosis, pre-procedural preparation) [14, 53]. Similarly, other previous studies involving dental procedures with associated distress and pain, such as third molar extraction, showed slight alterations in Hypothalamic-Pituitary-Adrenal (HPA) biomarkers like cortisol [54]. For instance, in [55], the cortisol levels of thematically designed environment group were higher than those of the standard imaging environment group at both the beginning and end of the study. However, this finding is inconsistent with the study by [56], who did not observe significant differences in cortisol levels in adults undergoing routine dental procedures. Similarly [57], found no significant difference in salivary cortisol levels between the two groups at the beginning and end of the study.

This reduction in salivary cortisol levels is an important outcome, suggesting that the thematic approach may effectively reduce physiological stress markers. However, we did not observe significant changes in other physiological indicators such as pulse rate and body temperature. This may indicate that while the thematic approach can influence cortisol levels, its impact on other physiological stress responses might be less pronounced or requires further investigation with larger sample sizes and more detailed behavioral assessments. The thematic approach's ability to modulate post-procedure cortisol levels within the thematically designed environment group highlights its potential to influence stress responses, even though such effects might not be immediately apparent in other physiological markers. This observation could imply that the thematic approach's effect might be more nuanced and selective, particularly concerning the neuroendocrine response linked to stress. The neurohormonal system releases certain cytokines during stressful situations, which can activate the immune system, and hormones like cortisol can have both inhibitory and stimulatory effects on the Locus Coeruleus and Raphe Magnus [58], which are areas in the brain involved in regulating body temperature and heart rate. In this sense, the release of that cortisol may have played a regulatory role in this particular situation and blocked the increase in other physical indicators. However, the thematic approach has definitely an untapped potential to improve radiography environment pleasantness, increasing the sense of environmental control, reducing patient stress responses, making pediatric patients happier and increasing parent willingness to recommend and return to the facility. However, its effects on stress responses need further evaluation, both in radiography settings and other settings where longer and more stressful procedures are performed.

While our study highlights the potential of the thematic approach to reduce cortisol levels, the clinical impact of this finding should be interpreted with caution. The observed reduction in cortisol suggests a stress-reducing effect, but additional research is needed to confirm whether this translates into improved clinical outcomes, such as enhanced patient cooperation during procedures and overall dental experience. Future studies should include comprehensive behavioral assessments and larger sample sizes to further elucidate the clinical significance of these findings and provide a more robust theoretical foundation. Besides, regarding temperature, it is important to consider the environmental climate control, as physiological adaptation occurs concurrently with the stressful stimulus. The controlled climate conditions of the clinic likely played a role in maintaining stable body temperature, potentially masking any subtle changes that might occur due to stress.

Despite the promising findings, this study has several limitations. Firstly, the study was conducted in a single dental clinic, which may not represent broader clinical settings. Secondly, the short duration of the study might not capture long-term effects of the thematic approach on dental anxiety and physiological stress. Future research should involve larger, more diverse populations and extended follow-up periods to validate and expand upon these findings.

5. Conclusions

Our study aimed to evaluate the impact of a thematic approach on reducing dental anxiety and physiological stress indicators in pediatric patients undergoing radiographic imaging. The results demonstrated that the thematic environment led to a significant reduction in salivary cortisol levels, indicating a decrease in stress. However, no significant changes were observed in other physiological measures such as heart rate, blood oxygen levels, and body temperature. This suggests that while the thematic approach may effectively reduce cortisol levels, its impact on other stress markers might be limited or require further investigation.

Given these findings, the thematic approach shows promise as a method to alleviate stress in pediatric dental settings. However, the clinical significance of reduced cortisol levels needs further exploration to determine if it translates into improved overall dental experiences and patient cooperation. Future research should incorporate larger sample sizes, comprehensive behavioral assessments, and controlled environmental factors to fully understand the broader impact of the thematic approach.

AVAILABILITY OF DATA AND MATERIALS

Data of this study is available upon request from the corresponding author.

AUTHOR CONTRIBUTIONS

GY—conceptualization, methodology, data curation, writing-original draft. BD—formal analysis, visualization. FSS—supervision, conceptualization, methodology, writing & editing. UN—supervision, writing & editing. SS—supervision, writing & editing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol and all procedures were approved by the Ethics Committee of Bahçesehir University, Istanbul, Turkey before the start of the study (letter no E-20021704-604.02.02-50236). Informed consent for the participation of pediatric patients was obtained from their parents or legal guardians. The consent forms detailed the collection of demographic data, heart rate, body temperature, and saliva samples, and the research process was also explained verbally by the authors to both the children and their parents or guardians.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Tates K, Meeuwesen L. Doctor–parent–child communication. A (re)view of the literature. Social Science & Medicine. 2001; 52: 839–851.

[2] Davies H. Trust and distrust: listening to children about their relationships with professionals. Social Sciences. 2019; 8: 251.

[3] Kritsidima M, Newton T, Asimakopoulou K. The effects of lavender scent on dental patient anxiety levels: a cluster randomized-controlled trial. Community Dentistry and Oral Epidemiology. 2010; 38: 83–87.

[4] Shapiro M, Melmed RN, Sgan-Cohen HD, Eli I, Parush S. Behavioural and physiological effect of dental environment sensory adaptation on children's dental anxiety. European Journal of Oral Sciences. 2007; 115: 479–483.

[5] Gurunathan D, Kothari S. Factors influencing anxiety levels in children undergoing dental treatment in an undergraduate clinic. Journal of Family Medicine and Primary Care. 2019; 8: 2036–2041.

[6] Alvesalo I, Murtomaa H, Milgrom P, Honkanen A, Karjalainen M, Tay KM. The dental fear survey schedule: a study with finnish children. International Journal of Paediatric Dentistry. 1993; 3: 193–198.

[7] Milgrom P, Vignehsa H, Weinstein P. Adolescent dental fear and control: prevalence and theoretical implications. Behaviour Research and Therapy. 1992; 30: 367–373.

[8] Taani DQ, El-Qaderi SS, Abu Alhaija ES. Dental anxiety in children and its relationship to dental caries and gingival condition. International Journal of Dental Hygiene. 2005; 3: 83–87.

[9] Costa ED, Martins LAC, Chaves-Junior SC, Sousa ET, Gavião MBD, de Fátima Possobon R, *et al*. Patients anxiety related to dental radiographic examinations: levels perception and management. International Journal of Odontostomatology. 2021; 15: 971–979.

[10] Doebling S, Rowe MM. Negative perceptions of dental stimuli and their effects on dental fear. Journal of Dental Hygiene. 2000; 74: 110–116.

[11] Oosterink FMD, De Jongh A, Hoogstraten J. Prevalence of dental fear and phobia relative to other fear and phobia subtypes. European Journal of Oral Sciences. 2009; 117: 135–143.

[12] Spin-Neto R, Wenzel A. Patient movement and motion artefacts in cone beam computed tomography of the dentomaxillofacial region: a systematic literature review. Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology. 2016; 121: 425–433.

[13] Mhaske R, Kale L, Kadam V, Kale A, Ingle V, Vispute S. Audiovisual modeling: an efficient, time-saving, radiation-specified method of reducing dental anxiety in children undergoing panoramic radiographic imaging and IOPA radiographic imaging. Journal of Indian Academy of Oral Medicine and Radiology. 2019; 31: 147–151.

[14] Alexander M. Managing patient stress in pediatric radiology. Radiologic Technology. 2012; 83: 549–560.

[15] Etzel-Hardman D, Kapsin K, Jones S, Churilla H. Sedation reduction in a pediatric radiology department. Journal for Healthcare Quality. 2009; 31: 34–39.

[16] Appukuttan DP. Strategies to manage patients with dental anxiety and dental phobia: literature review. Clinical, Cosmetic and Investigational Dentistry. 2016; 8: 35–50.

[17] Cianetti S, Lombardo G, Lupatelli E, Pagano S, Abraha I, Montedori A, *et al*. Dental fear/anxiety among children and adolescents. A systematic review. European Journal of Paediatric Dentistry. 2017; 18: 121–130.

[18] Al-Namankany A. Assessing dental anxiety in young girls in KSA. Journal of Taibah University Medical Sciences. 2018; 13: 123–128.

[19] Kadivar M, Seyedfatemi N, Akbari N, Haghani H. The effect of narrative writing on maternal stress in neonatal intensive care settings. Journal of Maternal-Fetal and Neonatal Medicine. 2015; 28: 938–943.

[20] Yucel G, Demir B, Smail FS, Yayim PS. Use of augmented reality in alleviating dental anxiety among paediatric patients: a randomised control study. Journal of Clinical & Diagnostic Research. 2023; 17: 43–46.

[21] Prado IM, Carcavalli L, Abreu LG, Serra-Negra JM, Paiva SM, Martins CC. Use of distraction techniques for the management of anxiety and fear in paediatric dental practice: a systematic review of randomized controlled trials. International Journal of Paediatric Dentistry. 2019; 29: 650–668.

[22] Bishop K. The role of art in a paediatric healthcare environment from children's and young people's perspectives. Procedia—Social and Behavioral Sciences. 2012; 38: 81–88.

[23] Festini F, Occhipinti V, Cocco M, Biermann K, Neri S, Giannini C, *et al*. Use of non-conventional nurses' attire in a paediatric hospital: a quasi-experimental study. Journal of Clinical Nursing. 2009; 18: 1018–1026.

[24] Lambert V, Glacken M, McCarron M. Meeting the information needs of children in hospital. Journal of Child Health Care. 2013; 17: 338–353.

[25] Norton-Westwood D. The health-care environment through the eyes of a child—does it soothe or provoke anxiety? International Journal of Nursing Practice. 2012; 18: 7–11.

[26] NHS England. Improving patient experience for children and young people. 2013. Available at: https://patientexperiencenetwork.org/wp-content/uploads/2019/10/PEN-Improving-PE-for-Children-Young-People-Report-FINAL-Electronic-file.pdf (Accessed: 07 February 2024).

[27] Brannon L, Feist J, Updegraff JA. Health psychology: an introduction to behavior and health. 8th edn. Cengage Learning: Belmont, CA. 2013.

[28] Porhomayon J, Kolesnikov S, Nader ND. The impact of stress hormones on post-traumatic stress disorder symptoms and memory in cardiac surgery patients. Journal of Cardiovascular and Thoracic Research. 2014; 6: 79–84.

[29] Ulrich RS. Effects of health facility interior design on wellness: theory and recent scientific research. Journal of Health Care Design. 1991; 3: 97–109.

[30] Ulrich RS, Zimring C, Quan X, Joseph A. The environment's impact on stress. Improving healthcare with better building design. 2006; 37–61.

[31] Rohleder N, Nater UM. Determinants of salivary α-amylase in humans and methodological considerations. Psychoneuroendocrinology. 2009; 34: 469–485.

[32] Furlan NF, Gavião MBD, Barbosa TS, Nicolau J, Castelo PM. Salivary cortisol, alpha-amylase, and heart rate variation in response to dental

treatment in children. Journal of Clinical Pediatric Dentistry. 2012; 37: 83–87.

[33] Karibe H, Aoyagi-Naka K, Koda A. Correlation between dental anxiety, difficulty of extracting impacted mandibular third molars, and salivary amylase level among Japanese patients. Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology. 2014; 117: e6–e10.

[34] Huamani JRS, de Souza Barbosa T, de Freitas CN, de Sousa KGG, Gavião MBD, Leal SC, *et al*. Assessment of anxiety and stress markers in children submitted to educational strategies and ART-restoration: a randomized clinical trial. Archives of Oral Biology. 2019; 97: 191–197.

[35] Smith AB, Milgrom P. The effects of audiovisual distraction on children's anxiety during dental procedures. Journal of Pediatric Dentistry. 2009; 31: 204–210.

[36] Jones M, Huggins K. Impact of dental environment design on pediatric patients' anxiety and stress levels. Journal of Clinical Pediatric Dentistry. 2011; 36: 185–190.

[37] Schulz KF, Altman DG, Moher D. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. The BMJ. 2010; 340: c332.

[38] Karibe H, Aoyagi-Naka K, Koda A. Assessment of salivary cortisol as a potential stress marker in patients undergoing routine dental procedures. Journal of Oral Science. 2014; 56: 135–139.

[39] Aravena PC, Almonacid C, Mancilla MI. Effect of music at 432 Hz and 440 Hz on dental anxiety and salivary cortisol levels in patients undergoing tooth extraction: a randomized clinical trial. Journal of Applied Oral Science. 2020; 28: e20190601.

[40] Lopez-Yufera E, Lopez-Jornet P, Toralla O, Pons-Fuster López E. Non-pharmacological interventions for reducing anxiety in patients with potentially malignant oral disorders. Journal of Clinical Medicine. 2020; 9: 622.

[41] Chorney JM, Tan ET, Martin SR, Fortier MA, Kain ZN. Children's behavior in the postanesthesia care unit: the development of the Child Behavior Coding System-PACU (CBCS-P). Journal of Pediatric Psychology. 2012; 37: 338–347.

[42] Tucker CL, Slifer KJ, Dahlquist LM. Reliability and validity of the brief behavioral distress scale: a measure of children's distress during invasive medical procedures. Journal of Pediatric Psychology. 2001; 26: 513–523.

[43] Goldstein DS, Dionne RA, Sweet J, Gracely RH, Brewer RP. Circulatory, plasma catecholamine, cortisol, lipid, and psychological responses to a real-life stress (third molar extractions): effects of diazepam sedation and of inclusion of epinephrine with the local anesthetic. 1982. Available at: https://journals.lww.com/psychosomaticmedicine/abstract/1982/07000/circulatory,_plasma_catecholamine,_cortisol,.4.aspx (Accessed: 07 February 2024).

[44] Wannemüller A, Sartory G, Elsesser K, Lohrmann T, Jöhren HP. Modality of fear cues affects acoustic startle potentiation but not heart-rate response in patients with dental phobia. Frontiers in Psychology. 2015; 6: 170.

[45] AlMaummar M, AlThabit HO, Pani S. The impact of dental treatment and age on salivary cortisol and alpha-amylase levels of patients with varying degrees of dental anxiety. BMC Oral Health. 2019; 19: 211.

[46] Oka T, Oka K. Age and gender differences of psychogenic fever: a review of the Japanese literature. BioPsychoSocial Medicine. 2007; 1: 11.

[47] Vinkers CH, Penning R, Hellhammer J, Verster JC, Klaessens JH, Olivier B, *et al*. The effect of stress on core and peripheral body temperature in humans. Stress. 2013; 16: 520–530.

[48] Falcon-Lesses M, Proger SH. Psychogenic fever. New England Journal of Medicine. 1930; 203: 1034–1036.

[49] Lai HL, Chen PW, Chen CJ, Chang HK, Peng TC, Chang FM. Randomized crossover trial studying the effect of music on examination anxiety. Nurse Education Today. 2008; 28: 909–916.

[50] Caprilli S, Anastasi F, Grotto RPL, Abeti MS, Messeri A. Interactive music as a treatment for pain and stress in children during venipuncture: a randomized prospective study. Journal of Developmental and Behavioral Pediatrics. 2007; 28: 399–403.

[51] Hartling L, Newton AS, Liang Y, Jou H, Hewson K, Klassen TP, *et al*. Music to reduce pain and distress in the pediatric emergency department: a randomized clinical trial. JAMA Pediatrics. 2013; 167: 826–835.

[52] Mifflin KA, Hackmann T, Chorney JM. Streamed video clips to reduce anxiety in children during inhaled induction of anesthesia. Anesthesia & Analgesia. 2012; 115: 1162–1167.

[53] Pati D, Nanda U. Influence of positive distractions on children in two clinic waiting areas. Health Environments Research & Design Journal. 2011; 4: 124–140.

[54] Kettwich SC, Sibbitt WL III, Brandt JR, Johnson CR, Wong CS, Bankhurst AD. Needle phobia and stress-reducing medical devices in pediatric and adult chemotherapy patients. Journal of Pediatric Oncology Nursing. 2007; 24: 20–28.

[55] Hill CM, Walker RV. Salivary cortisol determinations and self-rating scales in the assessment of stress in patients undergoing the extraction of wisdom teeth. British Dental Journal. 2001; 191: 513–515.

[56] Kaimal G, Ray K, Muniz J. Reduction of cortisol levels and participants' responses following art making. Art Therapy. 2016; 33: 74–80.

[57] Miller CS, Dembo JB, Falace DA, Kaplan AL. Salivary cortisol response to dental treatment of varying stress. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 1995; 79: 436–441.

[58] Fenzl A, Kiefer FW. Brown adipose tissue and thermogenesis. Hormone Molecular Biology and Clinical Investigation. 2014; 19: 25–37.

How to cite this article: Gilman Yucel, Burcu Demir, Ferruh Semir Smail, Sureyya Sahinoglu, Ulku Noyan. Exploring the role of a thematic approach in dental anxiety and physiological stress: an investigation into dental radiology. Journal of Clinical Pediatric Dentistry. 2025; 49(2): 81-88. doi: 10.22514/jocpd.2025.027.