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Evaluating Patients' Preferences for Dental Clinic Waiting Area Design and the Impact on Perceived Stress

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Abstract: The waiting area in dental clinics is a known source of stress for patients. However, positive distractions and comfortable design elements might reduce stress levels and provide mental stimulation while awaiting treatment. While ambient elements might play an important role in patient well-being, few studies have directly explored the impact of various design attributes of dental clinic waiting areas on patients' perceived stress. This study intended to bridge that gap and employed a discrete choice experiment method where 250 participants randomly selected a block and evaluated six pairs of computer-generated images of dental clinic waiting areas created based on eight interior design attributes with various levels: ambient lighting, false ceiling, window size, window view, indoor plants, wall shape, wall material, and seating options. Each visitor chose their preferred option in relation to its presumed effect on stress mitigation. The results suggest that the presence of ambient lighting, a false ceiling with a nature design, large window dimensions, a nature window view, green indoor plants, a curved wall shape, natural wall materials, and mixed seating options all can contribute to mitigating patients' perceived stress. Additionally, our findings indicate that age, gender, and education might influence choices across some levels of these variables. Overall, these results might assist architects and designers in shaping clinic environments mitigating patient stress during visits. Further studies would be needed to validate our findings and should also consider additional design attributes, more immersive stimuli presentation technologies, as well as potential differences across cultural contexts.

Keywords: stress; dental clinic; health; healthcare; discrete choice model

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1. Introduction

Stress is a significant issue in dental settings, especially for individuals who visit oral surgery clinics [1]. Dental fear, stemming from previous negative encounters, apprehension about pain, and concerns about losing control during treatment, frequently causes patients to refrain from seeking dental care [2,3]. This avoidance can lead to unfavorable oral health results [4]. Additionally, dental anxiety can hinder treatment, as patients may involuntarily move or flinch during procedures, which can complicate the dentist's efforts [5]. Furthermore, this anxiety can considerably affect quality of life. Stress is a reaction that affects an individual psychologically, physiologically, and often behaviorally as they respond to situations that can either enhance or impair well-being [6].

In the past few decades, there has been a change in the focus of healthcare environment design research. Instead of just reducing the negative aspects of the physical environment, the emphasis is now on creating and improving positive experiences. Ulrich's supportive design theory [7] demonstrates this shift by emphasizing three key elements that should be considered in the physical environment of any healthcare facility: empowering a sense of control, fostering social support, and providing access to positive environmental stimuli

while minimizing exposure to negative factors. Understanding the impact of the physical environment on patient well-being allows healthcare facilities to establish healing effects for patients and a pleasant working atmosphere for medical staff. This approach has the potential to lower staff stress levels and enhance patient safety and overall wellness [7].

The waiting area in dental clinics, where patients typically spend time before treatment, is a well-known source of stress [8]. These spaces are important in healthcare environments as they can either help alleviate or worsen the stress experienced by users [9], impacting patient anxiety levels, comfort, treatment outcomes, and their overall perception of care [9]. When patients perceive the waiting room as comfortable and containing positive distractions, it can lead to not only reduced stress levels but also increased mental stimulation [10]. Apart from the typical architectural features found in healthcare settings, various ambient elements also contribute to the well-being of patients in the waiting room. However, there have been few studies focusing on how the interior design of waiting areas in dental clinics influences patients' perceived stress. By examining influential environmental factors and significant components of interior architecture, this research aims to understand the extent to which waiting area attributes might impact perceived stress.

1.1. Interior Design Attributes Related to Perceived Stress

1.1.1. Ambient Lighting

Nowadays, a common method used for treating individuals with depression and mood disorders is light therapy. It can be said that light therapy is one of the best treatments for improving sleep disorders, depression, and reducing stress and anxiety levels [11]. Past studies have focused on the influence of interior lighting on the perceived stress from the environment and indicate that light perception affects patients and improves their physical and mental issues [12]. Other researchers [13] in their study aiming to investigate the impact of daylight and interior lighting on circadian rhythm, length of stay, and pain levels of hospitalized patients concluded that daylight is positively associated with the reduction of length of stay and pain levels in hospital patients. Interior lighting should be accompanied by daylight, and when the hospital building is properly combined with daylight and lighting, it will be beneficial for the patients' health and the hospital's well-being [14]. Additionally, eastern and southern patient rooms are better for patients and contribute to their improvement [14]. Therefore, interior lighting is one of the therapeutic environmental factors and has a tremendous impact on individuals' mental state and stress [15]. Bright and cool light during the day supports the suppression of melatonin, while dim and warm light in the evening can help minimize melatonin suppression before sleep [16].

1.1.2. False Ceiling

Designing the ceiling as well as designing walls and using boards in healthcare spaces can be equally effective. This is because the ceiling, like walls, can play a crucial role in reducing stress and anxiety and creating calmness, especially during treatment when a patient is lying down and facing upwards, such as in a dental unit. Ulrich showed in a study that one of the factors that can have a positive impact on patient recovery through distraction is the use of natural landscape images on boards, wall panels, and ceilings in healthcare spaces [17]. Images of water, plants, animals, and other elements of nature can influence individual preferences [18]. Dutro et al. [15] believe that natural images on operating room ceilings can alleviate patients' pain and stress, and false ceilings with flower and leaf patterns and tree designs with accent lighting are suggested on embossed patterns. They state that adding small lights on the ceiling that gently turn on and off during long night hours simulates stars and creates a positive distraction. Additionally, exposure to water and sky images, similar to green landscapes, might be beneficial for the well-being of patients [19].

1.1.3. Window Size

Window dimensions not only impact lighting conditions but also influence users' perception of space [20,21]. A study by [20] found that medium and large windows demonstrate how small changes in their size can affect spatial perception. Their research, which examined three different window sizes, showed that both the window size and the type of space significantly affect participants' spatial perception and their satisfaction with the outside view, with larger windows contributing to better spaces. The study also revealed a significant interaction between window size and space type regarding satisfaction with the view, suggesting that the window size preference depends on the type of space where the windows are situated. Additionally, when it comes to assessing visibility levels, windows in smaller spaces received higher ratings than those in larger spaces. The researchers concluded that window size influences individuals' perception of a space, and the type of space influences size preferences. Specifically, medium to large window sizes are preferred for creating more enjoyable, interesting, stimulating, well-lit, spacious, and satisfying spaces. Moreover, individuals generally prefer brighter spaces with larger windows or minimal furniture [22].

1.1.4. Window View

In a now classical study, Ulrich reported how a view with visible trees significantly improved patients' well-being and recovery after surgery compared with a view facing buildings [23]. Since then, the significance of the quality of the window view has attracted considerable attention in fields such as architecture, urban health, and property valuation. Since spaces lacking a view from the window are generally less preferred by people [24,25], a well-designed architectural plan typically considers both interior design and outdoor views holistically [22,23]. Natural landscapes and scenic views might serve as favorable environmental cues that contribute to positive sensory experiences and notably reduce stress levels [17]. Such landscapes might inspire positive thoughts and mitigate negative emotions like fear and anger, ultimately alleviating individuals' stress [26]. Hartig and his team [27] further assert that when individuals are under high stress, exposure to nature elicits positive feelings and diminishes negative thoughts and emotions, while also reducing psychophysiological activity, helping in coping with stress and agitation. Multiple studies indicate a positive link between views of natural landscapes from windows and mental health enhancements and overall well-being [18], with researchers believing that nature has the potential to positively impact a wide array of mental health outcomes [28]. Conversely, a study on individuals' blood pressure revealed that natural landscapes are less stressful compared to urban landscapes [26]. Consequently, images of natural landscapes, as opposed to urban landscapes, promote greater tranquility [29] and improved mental health [18], suggesting that urban nature can be used as a "nature-based solution" to enhance public health [30].

1.1.5. Indoor Plants

It is well established that exposure to natural scenes might reduce physiological stress and increase positive emotions. Especially, trees and greenery seem beneficial in this regard [31]. It is therefore interesting to consider enriching indoor spaces with greenery to induce stress-reducing responses in visitors. Additionally, colorful flowers used for room decoration and artificial flower pots might also have a positive effect on individuals' mood states [32], and combinations of colorful flowers are often preferred [33]. However, it has been suggested that people who are stressed often have a lower tolerance for high-diversity environments, rich in such things as, e.g., colorful flowers [34]. Depending on patient stress levels, different preferences might thus be expressed regarding indoor plants and whether diversity and color or a more cohesive and uniform green indoor vegetation is preferred.

1.1.6. Wall Shape

The link between interior design—particularly wall shapes—and perceived stress in healthcare settings has been extensively researched. Studies indicate that curvilinear environments are more effective for stress recovery than linear ones. For instance, Li et al. [35] found that participants in curvilinear spaces experienced better stress recovery, as evidenced by physiological measures such as salivary cortisol and heart rate variability, along with subjective stress assessments. Likewise, Shemesh et al. [36] showed that minimal wall curvature correlates with heightened physiological stress responses, implying that excessive linearity may increase stress levels. Aesthetic preferences also influence perceptions, with research suggesting that curved environments are seen as more calming and less stressful, in line with the biophilia hypothesis [37]. Overall, incorporating curvilinear designs in healthcare environments can improve patient comfort and alleviate stress, underscoring the significance of thoughtful architectural design for enhanced mental health outcomes.

1.1.7. Wall Materials

Researchers suggested that the least an architect can do to support people's well-being is to use natural elements and materials in the design. Natural elements and materials might create a sense of comfort and relaxation, as evidenced by decreased blood pressure and increased pulse rate, improve mental health, and reduce stress levels [38]. In addition, studies have shown that wood has antimicrobial properties against some pathogens and wooden materials, due to their natural appearance and biophilic effects on humans, present a nature-based topic for construction [39]. Additionally, maintaining cleanliness in indoor spaces and design elements from accumulated bacteria and microbes using antibacterial technology in synthetic materials and incorporating nanotechnology and materials in hospital buildings enhance their efficiency in terms of economics, environmental, health, and beauty. The positive effects include moderating indoor air humidity fluctuations, inducing positive emotions in individuals, inhibiting bacteria, and having positive psychological effects on human health and well-being [40]. Overall, it has been suggested that wood can contribute to healthy buildings and be beneficial for both the environment and people [41]. In addition, natural features are associated with stress-reducing effects, while the view of a brick wall has been associated with worse recovery after surgery compared to a view with visible greenery.

1.1.8. Seating Options

Finally, another potentially influential factor in reducing stress is the furniture and its arrangement. Essentially, the comfort and tranquility of an individual are significantly impacted by the layout of the environment [42]. Studies indicate that individuals with relatively strong social interactions tend to experience better mental and physical health and a greater sense of peace compared to those who are isolated and withdrawn. Social interactions can play a critical role in reducing stress and aiding in the recovery process of patients [26]. Therefore, designing and organizing furniture in waiting areas and other environments where people spend extended periods in a manner that encourages group interactions can be highly effective in achieving this objective. A study by Devlin [43], aimed at exploring individuals' visual preferences for waiting spaces in hospital environments by assessing the priority of five different seating arrangements, suggests that there is no compelling evidence for the primacy of a specific arrangement of chairs in a doctor's office waiting room. However, the seating choices reveal a preference for end seats over middle seats. While a social seating arrangement in a doctor's office may offer a sense of comforting familiarity to individuals, it is important to note that not all individuals visit the doctor with someone else. Therefore, a layout designed to encourage social interaction may not always be suitable [44], especially for psychiatric patients, and may not yield desirable results. This consideration may not apply universally to patients who typically seek primary care from doctors, as social interaction may not always be expected or desired

in such cases. It has been suggested that highly social environments are the least preferred by patients who experience high levels of stress and fatigue [43,44].

In summary, the literature discussed above emphasizes the influence of various interior design factors on people's perception of healthcare environments, particularly in relation to perceived stress. The identified factors include ambient lighting, false ceilings, window size, window view, indoor plants, wall shape, wall materials, and seating options. Figure 1 summarizes the theoretical model that formed the basis for our study.

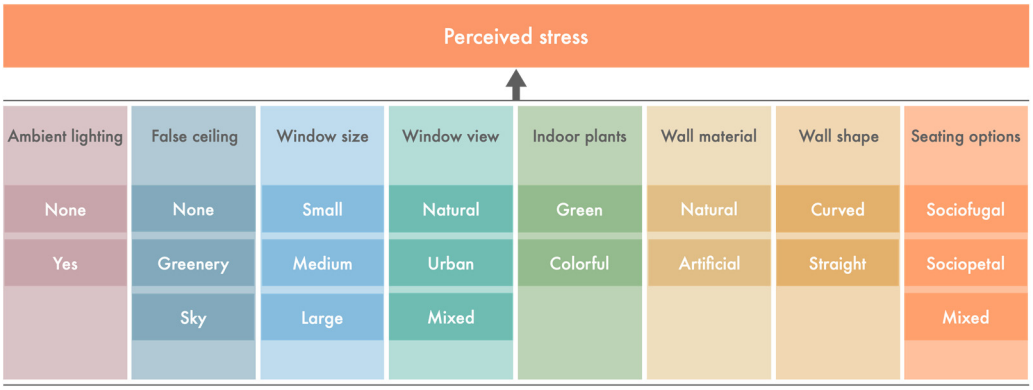

Figure 1. A summary of the theoretical model behind the study, with eight environmental design attributes at different levels hypothetically affecting patients' perceived stress while waiting for dental treatment.

1.2. Research Aims

There is a lack of research regarding the combined influence of the described factors on visitors' perceived stress. This study aimed to address this gap by combining these different factors in specific scenarios and asking participants to indicate their preferences among discrete choices, which, as far as we are aware, presents a novel approach. The main objective was to enhance understanding of how the interior design of dental clinics, involving these eight specific attributes at varying levels, might impacts patients' perceived stress. Primary research questions could thus be summarized as:

1. Which interior design attributes are the most important to consider in mitigating patients' perceived stress in dental clinic waiting areas?
2. Which levels of these attributes are generally most efficient in mitigating patients' perceived stress?
3. Which combinations of attributes/levels are most efficient in mitigating patients' perceived stress?

2. Materials and Methods

The primary aim of this research was to examine and assess how the interior design features of a dental clinic impact patients' perceived stress. To accomplish this, the discrete choice method was utilized which analyzes individual preferences based on their selections. Figure 2 summarizes the different steps of method, typical for the design of a discrete choice experiment.

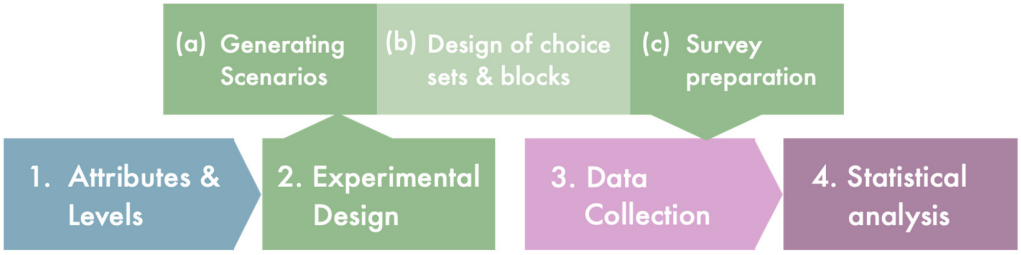

Figure 2. A diagram describing the main steps of the method, typical for the design of a discrete choice experiment.

2.1. Discrete Choice Method

The discrete choice method is used in various fields such as architecture, economics, marketing, and transportation due to its ability to analyze consumer behavior and decision-making [44–50]. This method, a subset of selection modeling, is a modern technique for gauging people's preferences. Originating from the works of Louviere and Hensher [51], and others, it provides an effective way to understand how individuals or communities make choices within certain contexts through surveys. The key objective is to uncover the structure of preferences and emphasize the relative importance of different attributes [52]. By allowing researchers to simulate various options in a controlled environment, the method helps identify influential attributes in a given scenario and facilitates the ranking of these attributes in comparison to each other. Its success is attributed to its strong theoretical foundation, drawing from Lancaster's consumer theory and McFadden's theory of random utility models [53]. Based on probabilistic choices, random utility theory posits that individuals choose the option that maximizes their utility within a set of alternatives, and the utility of a specific option depends on the utility associated with each of its attributes. In practice, a questionnaire presents participants with a series of options characterized by specific attributes organized into choice sets.

2.2. Study Area

The data for this study were collected inside three dental clinics in the city of Shiraz (Figure 3) during the afternoon shift (second shift) in an area of approximately 80 square meters, which included the waiting areas, reception, restroom, water cooler, staff rest area, dentist's room, treatment area, and instrument sterilization area. The selection of Shiraz as the study area was based on several key factors. Firstly, Shiraz is a major urban center with a diverse population, providing a representative sample for the study. Secondly, the city has a well-established healthcare infrastructure, including numerous dental clinics, which facilitates the collection of reliable data. The choice of the three specific dental clinics was made to ensure a comprehensive representation of different types of dental practices within the city. These clinics were selected based on their patient volume, range of services offered, and accessibility, ensuring that the study results would be both relevant and generalizable to similar urban settings.

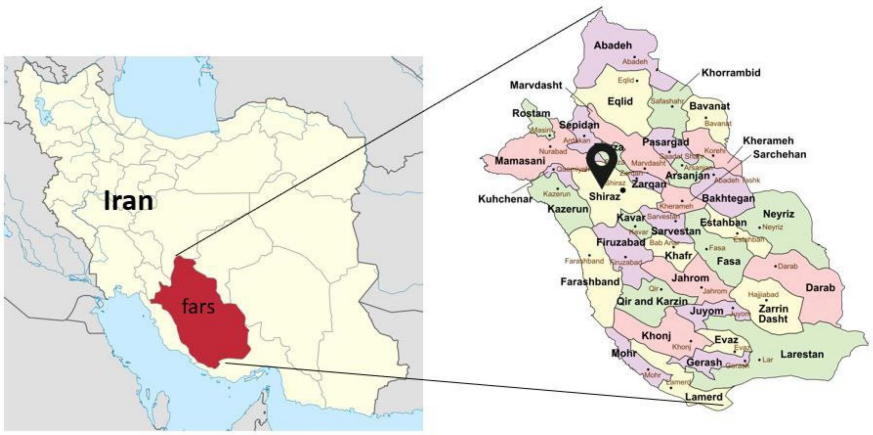

Figure 3. Study location, in Fars province, Iran.

2.3. Participants

The study involved a diverse group of participants in relation to gender, age, and educational attainment (Table 1). Of the total participants, 126 were male (50.4%), and 124 were female (49.6%). The age distribution was as follows: 15–35 years (40%), 35–55 years (42%), and 55–75 years (17.8%). The majority of participants were in the 35–55 age group. In terms of educational level, the breakdown was as follows: Undergraduate and diploma (57.6%), Bachelor of Science (28%), Master of Science (8%), and Doctorate (6.4%).

Table 1. Individual characteristics of the study participants.

	Classification	Frequency (%)
Gender	Male	50.4
	Female	49.6
Age	15–35 years old	40
	36–55 years old	42.2
	56–75 years old	17.8
Education	Undergraduate and Diploma	57.6
	Bachelor of Science	28
	Master of Science	8
	Doctorate	6.4

2.4. Questionnaire

To assess the perceived stress in patients, initial conversations were held with individuals present in the clinic's waiting area, presenting the research objectives. Individuals who were willing to participate completed a satisfaction survey form and then went on participating in the study. Here, the survey was divided into two sections: the initial section centered on a visual discrete choice experiment (DCE), while the subsequent section was comprised of close-ended inquiries. The purpose of the latter was to collect data regarding the varied backgrounds and traits of the participants, encompassing demographic details like gender, age, and education. Within the DCE segment of the survey, participants were asked to randomly select a block containing six pairs of computer-generated images of dental clinic scenarios. From the selected series of scenario pairs, they were then tasked with selecting the option that they believed would induce the least perceived stress while waiting for dental treatment.

2.5. Experimental Design

2.5.1. Attributes and Their Levels

The initial phase of the experimental design involved identifying the relevant attributes and their respective levels. Attributes here refer to the interior design variables used to define the options presented to the participants in the experiment and were selected based on their proposed relevance in mitigating perceived stress in individuals. Based on the presented literature review, eight attributes were chosen as the independent variables defining a dental clinic waiting area. Table 2 summarizes these eight attributes and their corresponding levels, together with references to the literature supporting each attribute's potential relevance in relation to individuals' perceived stress.

Table 2. Eight interior design attributes in different levels included in the study.

Attributes	Levels	References
Ambient lighting	Yes None	[13–16,42]
False ceiling	Virtual sky Virtual greenery None	[15,22]
Window size	Small Medium Large	[17,18]
Window view	Natural Urban Mixed	[19–22,36]
Indoor plants	Green Colorful	[32–34,43]
Wall shape	Curved Straight	[33,39]

Table 2. *Cont.*

Attributes	Levels	References
Wall material	Natural (bamboo) Artificial (bricks)	[38]
Seating options	Sociofugal Sociopetal Mixed	[34,35,44]

The Ambient lighting of the space in study had two levels: the presence of ambient lighting indicated in the ceiling and its absence. The False ceiling attribute had three levels: a false ceiling with a virtual sky pattern, a false ceiling with a virtual greenery pattern, and the absence of a false ceiling. The Window size was considered at three levels: windows of large, medium, and small size. The Window view of the waiting area also had three levels: views of natural scenery, views of an urban space, and views of a mixed nature and urban space. Indoor plants had two levels: green or colorful, represented by pots with green or colorful plants, respectively, placed by the window in the waiting area. The Wall shape of the window wall of the waiting area had two levels: a flat wall with a traditional straight-edged/sharp corner and a rounded wall with a curved corner transition. Similarly, the Wall material of the waiting area feature wall also had two levels: a natural material (bamboo) and an artificial material (brick). Finally, the Seating options had three levels: a social option facilitating interaction among individuals (sociopetal), a non-social arrangement facilitating privacy (sociofugal), and a combination of the two (mixed). Examples of the representation of these attributes and levels in the experiment are shown in Figure 4.

Figure 4. Examples of representations of the included attributes at various levels used in the study (see Table 2 for a detailed list of these attributes and levels).

2.5.2. Scenarios and Choice Sets

The subsequent step in experimental design involved creating various scenarios and sets of choices for these scenarios. Using the eight attributes and their potential levels, the total number of possible combinations was determined using the complete factorial experiment method and Equation (1): full factorial (number of combinations) = Π Zk Equation (1), where Z denotes the number of levels of an attribute, and k represents the number of attributes with the same levels of Z. Consequently, a complete factorial experimental design yields 1458 probabilistic scenarios. This method allows for the examination of individual characteristics' effects as well as the bilateral and multilateral interactions among different attribute levels. While increasing the number of scenarios enhances the comprehensiveness of user responses, it also escalates the time and cost involved. Thus, adopting a fractional factorial design, with a reduced number of combinations, can still yield reliable results for primary and select interaction effects. Employing SAS software version 9.2, the number of scenarios was optimized, resulting in 72 scenarios.

These 72 scenarios were divided into six blocks, each containing six choice sets comprising three alternatives (scenario 1, scenario 2, and none). These blocks were randomly assigned to participants. Participants were instructed to select the scenario that induced the least perceived stress for them or to indicate no preference for either option. Including the "none" option aimed to alleviate pressure on participants to make a choice and minimize the likelihood of exaggerated estimates of individual preferences. Visual representations of the options for each choice task were created using SketchUp(2019) and Photoshop software (2020). This visual approach is effective for diminishing external influences during the decision-making process in Discrete Choice Experiments (DCEs). The images were designed to provide viewers with a realistic perspective, allowing them to evaluate the simulation as if they were physically present. Figure 5 illustrates two images forming a choice set. The left image (Figure 5, Option 1) displays a setting without ambient lighting, a false ceiling with a virtual sky pattern, a small window with an urban view, colorful indoor plants, a straight-edged window wall, a feature wall with an artificial material (bricks), and a sociofugal seating pattern. In contrast, the right image (Figure 5, Option 2) presents a space with ambient lighting present, a similar virtual sky false ceiling, a large window with an urban view, green indoor plants, a curved window wall shape, a feature wall with natural material (bamboo), and a sociofugal seating layout.

Figure 5. An example of a task chosen for the choice experiment with three available options.

The survey took place between February and March 2022, during which discrete choice surveys were distributed to individuals aged 18 and above at three dental clinics (see Section 2.2.). Upon introduction to the survey's objectives and tasks, participants used the interviewer's computer for data collection while following health protocols. With consent, participants randomly selected a block, each containing six sets with three options (Option 1, Option 2, and None; see Figure 5). They were then instructed to choose the scenario from each set that induced the lowest perceived stress, resulting in each participant evaluating

12 different clinic designs. In total, 250 questionnaires were collected, and the data were subsequently compiled into an Excel file.

2.6. Data Analysis

Random utility theory was utilized to examine the data collected from the choice experiment. A mixed logit (ML) model was used to account for variations in individuals' decision-making processes when selecting options. Attribute levels were grouped and represented using dummy codes to calculate their impacts.

2.6.1. Modeling Choice Data

DCE is commonly utilized in research to evaluate individuals' preferences by presenting them with several options in a choice set and requesting them to indicate their preferred choice. Lancaster's characteristics theory of value [51] suggests that each commodity's value is the sum of its constituent attributes, leading to the development of multiple discrete choice models based on this theory and McFadden's random utility [54]. These models aim to assess the influence of causal factors on individuals' decision-making [55]. It is hypothesized that individuals select the option with the highest utility, influenced by the attractiveness of that option's features [56]. The utility functions assigned to person n to choose alternative i from the available options are as follows:

$$U_{ni} = Vni + \varepsilon ni \tag{1}$$

The random utility theory, which is used to study people's decision-making, comprises two components. The initial component pertains to the observable aspects, denoted as (deterministic) Vni.

$$Vni = \beta i \; Xnmi \tag{2}$$

Within this formula, βi symbolizes the parameter coefficient vector for alternative i = (1,. . ., I), while $Xnmi$ denotes the observable attribute levels of i for individual n in choice situation m. Nevertheless, there exist unobservable factors, εni, which impact individuals' decisions. Therefore, as the second component, εni is a random error that, in a multinomial logit (MNL) model, is uniformly and independently distributed according to a Gumbell distribution [57].

The chance of individual n selecting option i is represented as $Lni(\beta)$, where Lni is a function determined by parameter β, and it is defined in the following manner:

$$L_{ni}\ (\beta) = \frac{exp(V_{ni}\ (\beta))}{\sum_{j=1}^{j} exp\ (V_{ni}\ (\beta))} = \frac{exp(X_{nmi}\ \beta)}{\sum_{j=1}^{j} exp(X_{nmi}\ \beta)} \tag{3}$$

In this context, $Vni(\beta)$ represents the deterministic (systematic) segment of the utility function, contingent on the fixed parameter β. Despite its benefits, the MNL model has various restrictions, such as the potential for individuals to assign differing importance to distinct attributes. The mixed logit model tackles these challenges by accommodating diversity; it serves as an expanded adaptation of the MNL, enabling parameters for all, or a subset of, variables to vary among respondents, instead of remaining consistent across all respondents.

By acknowledging potential disparities, such as variations in the sociodemographic characteristics of respondents, unrestricted substitution patterns, and correlations among unobserved elements, it has become one of the most widely utilized models for estimating random utility models in diverse fields [58]. The approach for determining the probability of selecting an alternative using the mixed logit model is as follows:

$$Pni = \int Lni(\beta) f(\beta)\ d\beta \tag{4}$$

Pni represents the likelihood of individual *n* selecting alternative *i*, while *Lni*(β) denotes the likelihood of individual *n* choosing alternative i in the MNL model, which is determined by parameter b. The function $f(\beta)$ is a density function defined by constant parameters b such that β = b, 1, $\beta \neq$ b, and 0.

2.6.2. The Mixed Logit Model

The PandaBiogene software (3.1.14) was used to estimate both the Multinomial Logit (MNL) and Mixed Logit (ML) models. The sample consisted of 250 respondents, each making six choices, resulting in a total of 1500 observations. After an initial estimation, variables with insignificant variability were identified and treated as fixed parameters. Out of the seven variables, two were designated as fixed, while the remaining five were considered random. The randomly estimated parameters (βn) for each variable *n* represent the mean effect, with the standard deviation indicating the level of variability in the sample for that specific variable [59]. In the final ML model, random parameters were estimated based on a normal distribution, allowing for equally positive and negative variations in the variables depending on the respondent. The estimation process involved the use of 200 Halton draws. Various criteria, including a pseudo-R2 or R2 (McFadden) value of 0.132, were used in logistic regression to assess the model fit, indicating satisfactory model performance.

3. Results

3.1. Parameter Values

The results presented in Table 3 illustrate the significance, or weights, attributed to each attribute as parameter values. Among these, it was found that the presence of ambient lighting (β19 = 2.43, p = 0.00) and mixed seating options (β8 = 2.35, p = 0.00) had the most substantial positive impact on individuals' selections. Following these, attributes such as a large window (β18 = 2.24, p = 0.00), green indoor plants (β2 = 1.54, p = 0.00), a virtual greenery false ceiling (β2 = 1.54, p = 0.00), and a virtual sky false ceiling (β1 = 1.36, p = 0.00) were highlighted for their potential importance. Attributes like a curved wall (β14 = 1.35, p = 0.00), a natural feature wall material (bamboo; β4 = 1.14, p = 0.00), a nature window view (β12 = 1.06, p = 0.00), and a medium-sized window (β17 = 0.8, p = 0.00) were noted to have a moderate impact on utility. Lastly, an artificial feature wall material (bricks; β5 = 0.37, p = 0.00) and a straight-edged window wall (β15 = 0.26, p = 0.04) were found to have the least utility value in study.

In this model, colorful indoor plants (β10 = −1.92, p = 0.00), no false ceiling (β3 = −1.54, p = 0.00), a small window (β16 = −1.53, p = 0.00), a mixed (urban and natural) window view (β13 = −0.57, p = 0.00), sociopetal seating (β6 = −0.61, p = 0.00), and sociofugal seating (β7 = −0.24, p = 0.02) were all identified as negative parameters, indicating general dissatisfaction regarding potential stress mitigation among participants, although these results were statistically significant.

Table 3. Parameter estimates of the ML model.

Attributes/Level	Param.	Value	*p*	Random Param.	*p*	Age	Education	Gender
Constant (no choice)	B0	−1.31	0.00	-	-	-	-	-
False ceiling						-	-	-
Sky	B1	1.36	0.00	0.57	0.02	-	-	-
Greenery	B2	1.54	0.00	0.47	0.02	-	-	-
Feature wall						-	-	-
Natural (bamboo)	B4	1.14	0.00	0.58	0.00	0.00	-	-
Seating options							-	-
Sociopetal	B6	−0.61	0.00	0.4	0.01	0.00	-	-
Mixed	B8	2.35	0.00	0.69	0.02	0.00	-	0.00

Table 3. *Cont.*

Attributes/Level	Param.	Value	*p*	Random Param.	*p*	Age	Education	Gender
Indoor plants							-	
Green	B9	3.33	0.00	1.81	0.00	0.00	-	0.04
Colorful	B10	−1.92	0.00	−1.11	0.00	0.00	-	-
Window view						-	-	-
Urban	B11	0.97	0.00	0.65	0.02	0.00	-	-
Wall shape						-	-	-
Curved	B14	1.35	0.00	0.58	0.00	-	-	-
Window size						-	-	-
Small	B16	−1.53	0.00	−0.8	0.00	-	-	-
Large	B18	2.24	0.00	2.18	0.00	-	-	-
Fixed parameters	Param.	Value	*p*	Random st. Dev	*p*	Age	Education	Gender
False ceiling				-	-			
None	B3	−1.54	0.00	-	-	0.01	0.01	0.01
Ambient lighting				-	-		-	-
Yes	B19	2.43	0.00	-	-		-	-
Feature wall				-	-		-	-
Artificial (bricks)	B5	0.37	0.00	-	-	0.00	-	-
Seating options				-	-		-	-
Sociofugal	B7	−0.24	0.02	-	-	0.00	-	-
Window view				-	-		-	-
Natural	B12	1.06	0.00	-	-	0.00	-	-
Mixed	B13	−0.57	0.01	-	-	0.00	-	-
Wall shape				-	-	-	-	-
Straight	B15	0.26	0.04	-	-	-	-	-
Window size				-	-	-	-	-
Medium	B17	0.80	-	-	-	-	-	-

Note: The results were statistically significant in $p < 0.05$.

3.2. Random Parameters

The analysis indicated that all parameters demonstrated a mean positive effect with standard deviations at a significance level of $p < 0.01$, indicating considerable heterogeneity among the respondents. Therefore, these parameters should be considered fixed rather than random. It is important to note that colorful indoor plants (−1.11, $p = 0.00$) and small window size (−0.80, $p = 0.00$) both had noteworthy negative effects on the utility function. Regarding the random parameters, large window (2.18, $p = 0.00$), green indoor plants (1.81, $p = 0.00$), mixed (sociopetal and sociofugal) seating options (0.69, $p = 0.02$), urban window view (0.65, $p = 0.02$), curved window wall (0.582, $p = 0.00$), natural feature wall material (bamboo; 0.58, $p = 0.00$), virtual sky false ceiling (0.57, $p = 0.02$), and virtual greenery false ceiling (0.47, $p = 0.02$), were all statistically significant at $p < 0.05$, indicating diversity in the preferences of the respondents across these levels and attributes. Regarding sociopetal seating options, the negative coefficient (−0.61) indicates that, on average, the variable "sociopetal" has a negative effect on the dependent variable. This means that as the value of "sociopetal" increases, the likelihood of the outcome decreases. However, the positive standard deviation (0.40, $p = 0.02$) suggests that there is variability in the effect of sociopetal seating across individuals. This means that while the average effect is negative, for some individuals, the effect could be less negative or even positive.

Furthermore, individual characteristics were used as control variables in the mixed logit analysis [51], and sociodemographic factors were taken into consideration to address variations in preferences within the study. The model incorporating age, gender, and education significantly influenced heterogeneity among some variables.

4. Discussion

This study involved a discrete choice experiment with computer-generated images of dental clinic interiors. Individuals were asked to choose their preferred option among pairs of images based on their estimated stress-reducing influence. First, we discuss in more detail around each of the attributes presenting an important influence over participants' choices in study. This is followed by a discussion around the observed heterogeneity among certain influential parameters, i.e., attributes and levels for which there was a particular variation in how they influenced the choices of our participants. We conclude with a discussion around some important limitations of our study and finally present our conclusions and some potential implications of our results.

4.1. Attribute Influence on Choices

The findings highlight existing ambient lighting and mixed seating options (i.e., a mix of sociofugal and sociopetal options) as the most positively influential factors in our participant's decision-making regarding potential environmental stress mitigation. Furthermore, attributes such as a false ceiling with virtual greenery, a large window, a natural window view, green indoor plants, a curved window wall, a natural feature wall material, were all deemed highly desirable in relation to stress mitigation. On the contrary, the absence of a false ceiling, a small window, a mixed window view, colorful indoor plants, and a sociofugal seating pattern were all found to have a relatively negative impact on choices in our study. In the following, our results in relation to each attribute are discussed in more detail.

4.1.1. Ambient Lighting

Ambient lighting may have a profound impact on the perceived stress levels of dental clinic visitors according to our findings. This is in line with earlier research suggesting that appropriate lighting can lead to shorter hospital stays and greater patient satisfaction [14]. It also aligns with the existing literature emphasizing the role of natural light in promoting positive emotional responses and reducing anxiety in healthcare settings [17]. Our findings here highlight the need for careful consideration of lighting design in dental clinics, balancing the benefits of natural illumination with the calming effects of softer ambient lighting. Future research should further explore the nuanced effects of various lighting types and designs, aiming to optimize patient comfort and well-being in clinical environments.

4.1.2. False Ceiling

False ceilings, particularly those featuring natural motifs such as sky or vegetation patterns, emerge in our study as a potentially significant factor influencing patient comfort and stress levels. This study found a strong preference for false ceilings with sky or greenery motifs, which aligns with the findings of Dutro et al. [15], who reported that ceilings adorned with floral and leaf patterns, as well as tree designs, effectively can alleviate pain and reduce stress among patients. The psychological impact of visual elements containing natural features in healthcare settings is well documented. Li and Samuelson [19] noted that exposure to images of the sky can enhance patients' health and well-being, suggesting that such designs can create a more uplifting and calming atmosphere in line with our findings here. This might be particularly important to consider in dental clinics, where patients often experience anxiety related to their treatment. Arguably, incorporating natural designs into false ceilings not only beautifies the space but might also foster a sense of connection to nature, which has been shown to have therapeutic benefits [56]. In conclusion, the expressed preference in this study for false ceilings with natural motifs underscores the importance of thoughtful visual design in healthcare environments, preferably using calming natural features as an aesthetic foundation, in line with what has been suggested by other studies and biophilic theories [31].

4.1.3. Window Size and View

In our study, large windows were preferred over small or medium-sized windows. This is consistent with the findings of Mascoso et al. [20], which indicates that larger windows contribute to creating environments that are perceived as more pleasant, interesting, and spacious. Larger windows allow for increased natural light, which not only brightens the space but also might enhance the overall ambiance. Such brightness is associated with improved mood and reduced feelings of stress and anxiety among patients. The presence of natural light has been shown to positively influence individuals' spatial perception, making them feel more connected to the outside world and less confined within the clinical environment [22]. According to previous research, the parameter of window display greatly affects user preferences. This suggests that users favor spaces with larger, unobstructed windows that offer better visibility [57]. Furthermore, users consistently choose rooms with the most natural views [58]. These findings are also consistent with Ozdemir's [59] study, which showed that office occupants with larger windows and natural views are more satisfied with their work environment. A preference for a natural window view in the present study thus aligns with the findings of other researchers showing that natural landscapes compared to urban landscapes promote greater relaxation [29] and improve mental health [18], and that the use of nature and natural views in healthcare environments increases patient satisfaction [60,61]. While urban landscapes with buildings commonly are seen as stress-inducing [26], our results here thus add to the evidence regarding the importance of taking the presence of outdoor natural features into consideration also from the interior design perspective and incorporate such features, where possible, into the architectural design.

4.1.4. Indoor Plants

In our study, participants expressed a clear preference for environments enriched with green indoor plants. This preference is supported by existing research that demonstrates the stress-reducing effects of plants in healthcare settings [44,53]. Studies have shown that exposure to green plants can lead to decreased anxiety and pain levels in patients, enhancing their overall well-being [61,62]. However, it is noteworthy that some studies, such as those by Helen [33], suggest that colorful flower combinations may be preferred over greenery. This indicates that while green plants have proven benefits, individual preferences can vary, and some patients may find vibrant flowers more appealing. It has been suggested, however, that particularly stressed individuals might find diverse environments, with a lot of variation regarding, e.g., species and colors, more stressful while preferring more cohesive and uniform settings [34]. This is supported by our results here, where green indoor plants were clearly preferred over options with colored plants. Future research could further explore such preferences and potential differences among individuals to optimize the design of clinical environments.

4.1.5. Wall Shape and Wall Material

Our findings indicate a preference for curved walls over straight-edged walls in relation to potential stress mitigation. This result is particularly relevant given the contrasting views in the existing literature regarding wall shapes in healthcare settings. Our findings here are consistent with the reports of Li et al. [35] and Shemesh et al. [36] in demonstrating a clear preference for curved walls over straight-edged walls in mitigating perceived stress. Participants reporting lower perceived stress in curvilinear environments might align with the biophilia hypothesis, suggesting that natural forms, such as curves, are inherently more calming and less stressful [37]. A preference for curvilinear designs again underscores the importance of thoughtful architectural design in healthcare settings to enhance patient comfort and reduce stress. Our findings suggest that incorporating curvilinear and natural elements in healthcare settings might improve mental health outcomes, perhaps by fostering a sense of connection with nature. To optimize healthcare environments for patient well-being, future research should continue to explore relationships between architectural

shapes in relation to perceived stress. In addition, there was a clear preference in our study for a feature wall with a natural material (bamboo) over an artificial material (bricks). This might again be seen in relation to ideas such as the biophilia hypothesis and the stress reduction theory, suggesting a calming effect from environmental features reminding of evolutionary supportive conditions [31].

4.1.6. Seating Options

Finally, Seating options, categorized into sociofugal, sociopetal, and mixed, were examined for potential influence on patients' perceived stress. Our findings reveal that exclusively sociofugal options did not significantly influence stress, while a mixed arrangement showed a notably positive effect. Sociofugal seating, which discourages interaction by creating physical separation, may offer some patients a sense of privacy. However, this layout might also lead to feelings of isolation, which could be detrimental for some individuals' perception of stress. In this regard, DevLin [43] suggests that the layout of a doctor's office seating can provide a supportive atmosphere socially. On the other hand, sociopetal seating promotes social interaction, potentially providing comfort for some patients but increasing anxiety for those who prefer solitude in a clinical environment. The tendency for exclusively sociopetal seating options to be the least preferred in relation to stress mitigation in our study is in line with other studies suggesting that stressed individuals might be bothered by highly social settings and often prefer solitude [45,46]. Mixed seating options, allowing patients to select their level of social engagement, appeared in our study to be the most preferred option in relation to stress mitigation. This offered flexibility might cater to individuals' varying preferences and foster a sense of control, essential in a healthcare setting often associated with anxiety. These results align with the principles of supportive design, which emphasize the importance of patient choice and comfort in reducing stress [17].

In summary, based on our findings regarding the studied attributes, Figure 6A illustrates an example of a generally more restorative, i.e., stress-reducing, dental clinic waiting area, while Figure 6B show a relatively more stress-inducing environment. In the first case (Figure 6A), ambient lighting is present, there is a false ceiling displaying a natural pattern (greenery), there is a large window with a nature view, green indoor plants, a curved window wall, a natural material feature wall (bamboo), and mixed seating options (supporting both sociopetal and sociofugal preferences). In the second case (Figure 6B), ambient lighting is missing, there is no false ceiling, there is a small window with an urban view, colorful indoor plants, a straight-edged window wall, a feature wall with an artificial material (bricks), and only sociopetal seating options. Although these examples illustrate general preferences according to our findings, many attributes also showed considerable variation among individuals in our study.

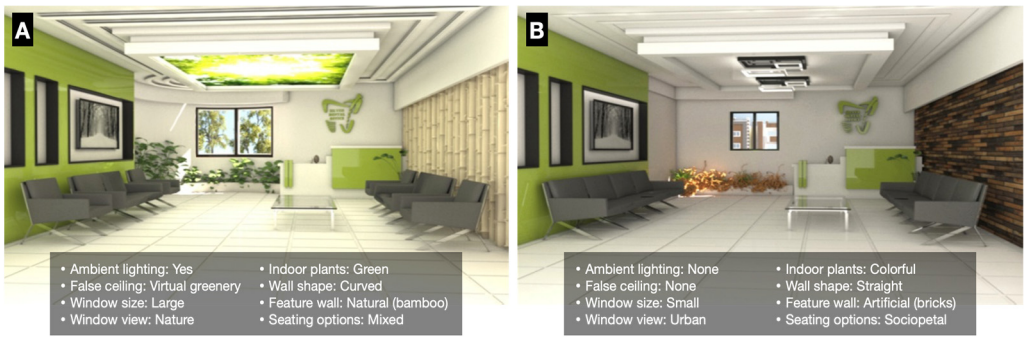

Figure 6. Examples of attributes in a generally more stress-reducing (**A**) and a relatively more stress-inducing (**B**) dental clinic environment according to our study findings.

4.2. Heterogeneity among Attributes

In the mixed logit model, random parameters were examined to identify variations in preferences and choices among participants. Virtual sky and virtual greenery false ceilings, natural feature wall material (bamboo), the sociopetal and mixed seating options, green and colorful indoor plants, urban window view, curved window wall, and large window size all displayed substantial diversity in how they were perceived in relation to potential stress mitigation. Furthermore, the analysis of preferences based on age, gender, and ethnicity using random parameters in the mixed logit model indicated significant differences in how these demographic factors influenced patient choices. First, age significantly influenced preferences for certain design attributes. Older participants tended to prefer larger windows and natural views, which may be linked to a desire for comfort and connection to nature. In contrast, younger participants showed a stronger preference for more modern design elements, such as vibrant colors and innovative seating arrangements. Gender differences were also notable. Female participants expressed a higher preference for green indoor plants and natural materials, suggesting a greater inclination towards elements that promote a calming environment. Males, on the other hand, were more favorable toward bold design choices, such as sociopetal seating arrangements that encourage interaction.

Although our study primarily focused on age and gender, the results also suggest that education might also play a role in preferences, particularly regarding the choice of wall materials and colors. Participants from different educational backgrounds may have varying levels of associations with certain design elements, impacting their stress perception in dental clinics. It is thus recommended for future similar studies to also consider similar demographic factors as background variables, as they might potentially influence people's preferences.

4.3. Study Limitations

In research that examines people's preferences, particularly when spatial elements are involved, researchers commonly employ visual representations to depict the scenarios under scrutiny and gauge their impact on the utility function [52]. In this study, computer-generated images were utilized to showcase a combination of eight variables. These images were assessed based on their influence on the perceived stress of individuals in a dental clinic environment. However, this study faced some limitations. Primarily, the discrete choice experiment method, while useful, imposes constraints on the number of attributes that can be included. While an increase in the number of scenarios generally improves the quality of participant responses, it is advisable to limit the alternatives in the selection set to ensure obtaining the most reliable results due to time and cost limitations.

In our study, respondents were presented with two scenarios in the questionnaire and asked to choose the option that induced the least sense of perceived stress or indicate if neither option was preferred. Although there was a fourth option where both scenarios were perceived as equally preferred, the focus in our study remained on those who selected one of the images. It is believed that including the fourth alternative would not have significantly altered the outcomes in our study, but it could be considered in future research. An important omission from this study is that it did not assess participants' initial stress levels in any formal way. This made it impossible to investigate whether individual stress levels might affect choices regarding environmental preferences. Future similar studies should consider assessing the initial perceived stress of the participants with a suitable tool to assess the impact of perceived stress on attribute preferences.

Ultimately, more comprehensive, and diverse studies are necessary to ensure dependable results. Such studies could also include other potentially important attributes that were not considered in our study here, such as, e.g., differences between different wall colors (not only materials), the presence of other people, etc. It would also be interesting for such further investigations to use potentially more immersive options for stimuli presentation, such as, e.g., virtual reality (VR) solutions. The potentially increased realism offered by such technologies might improve the ecological validity of similar studies.

5. Conclusions

To design better dental care environments, it is crucial to understand the impact of specific interior design attributes in dental clinic waiting areas on patients' perceived stress. This study aimed to identify key interior design attributes that could mitigate waiting patients' perceived stress. A discrete choice experiment was carried out, and our findings suggest the potentially critical role of ambient lighting in mitigating stress of waiting patients. Our study suggests that well-designed ambient lighting, preferably in combination with a false ceiling displaying a natural motif, might be useful to reduce stress and enhance patient comfort. Furthermore, a large window with a natural view appears as a preferred option with regards to general stress mitigation, as opposed to small windows displaying urban elements. Designers might also consider curved wall shapes over straight edges, feature walls with natural materials, as well as enrichment of the waiting area with green indoor plants. Finally, by providing mixed seating options, supporting social interactions as well as privacy, the design might cater to the varied needs among individuals and offer a sense of control important to reduce the stress often associated with dental clinic visits.

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