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Self-assessed oral health, cognitive vulnerability and dental anxiety in children: testing a mediational model

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Abstract – *Objective:* To explain the association between children's self-perceived oral health status and dental anxiety, by considering their levels of cognitive vulnerability. *Methods:* Participants were 161 children (47.8% female; mean age = 11.93 years) who filled in a questionnaire comprising self-assessed oral health-related status, dental treatment-related cognitive vulnerability and dental anxiety measures. Gender, age and number of decayed, missing and filled permanent teeth were controlled for. Bivariate correlations, hierarchical regression analyses and structural equation modelling were conducted to test the hypotheses. *Results:* Subjective oral health status, cognitive vulnerability variables and dental anxiety were strongly correlated. Regression and structural models testing the mediating effects of cognitive vulnerability variables on the relationship between perceived oral health and dental anxiety were supported. *Conclusions:* The activation of the cognitive vulnerability schema, as a mediating variable, is a mechanism by means of which children's self-perceptions of a poor oral health might lead to dental anxiety. Both components of vulnerability analysed (threat and disgust) contribute decisively to this potential process.

Key words: cognitive vulnerability; dental anxiety; subjective oral health

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Dental fear is frequently cited as among the most severe problems in paediatric dentistry, not only because of its association with children's misbehaviour during dental treatments (1–5) but also because of its relationship with poorer oral health. Dental anxiety has been found to be associated with lower dental care utilization (6) and oral problems such as carious lesions, missing teeth and need for oral rehabilitation (7–9).

Mainly focused in adults (10–15), research has shown a relationship between dental anxiety and both oral health-related quality of life (OHRQoL) and subjective oral impacts (16). A poorer OHRQoL has been reported among those children exhibiting higher dental fear levels. For example, higher mean scores in global self-assessed OHRQoL and its social and emotional wellbeing dimensions, indicating a worse self-evaluation of their oral status, were obtained for children afraid of 'treatment of dental decay' (17).

Although previous aversive dental experiences may be associated with dental anxiety and are frequently proposed as a cause for dental fear through a direct or vicarious conditioning process (18–21), recent research points out that cognitive factors involved in the processing of dental-related stimuli are better predictors of the fearful behaviour (22). Dentally anxious people have been found to have a biased processing of information. They overestimate the likelihood of negative events at the dentist and anticipate extremely aversive or painful consequences (catastrophizing) (23–25). In

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addition, their beliefs about themselves and dentistry, as well as their self-statements during treatments, are more negative than those reported by nonanxious patients (26–28). This inaccurate or distorted cognitive style has been called 'dental pessimism' (29). Furthermore, the sense of a limited personal control over the occurrence of aversive dental experiences has been pointed out as a significant predictor of dental fear (30, 31).

The Cognitive Vulnerability Model described by Armfield (32) represents an integrative view of the aetiology of fear, and its application to the explanation of dental fear has received empirical support in the adult population (22, 33). The model proposes that for dentally anxious patients, the exposure to dental stimuli or situations automatically and unconsciously triggers a vulnerability schema, based on previous learning experiences and also influenced by personality traits or biological dispositions. The contents of this schema involve four interrelated perceptions of the dental event as being uncontrollable, unpredictable, potentially dangerous or harmful and disgusting. Once the vulnerability schema is activated, two simultaneous processes occur: an immediate automatic affective response (fear); and a relatively slower cognitive assessment of the event, similar to Folkman et al.'s model that encompasses primary and secondary appraisals (34, 35). A key point is that the vulnerability schema acts as a perceptual filter and guides the following interpretation of dental stimuli, thus favouring a biased handling of the dental-related information. The outcomes of these processes are the physiological, behavioural, emotional and cognitive responses of the individual.

Also from a cognitive perspective, Chapman and Kirby-Turner (36) have proposed an explanatory model of dental fear focused on children. Their theoretical contribution bears a resemblance to the Cognitive Vulnerability Model, as these authors suggest that five interconnected factors are involved in the aetiology and maintenance of children's dental fear: fear of loss of control, the unknown, actual pain or its anticipation, intrusion into the physical or psychological personal space and lack of trust in the dentist or fear of betrayal. The authors used the concept of 'locus of control' (i.e. the expectancy that positive or negative outcomes of a dental-related event are under one's own control) to refer to the links between the fear of the unknown and the fear of loss of control. Nevertheless, these two factors, together with the fear of pain, could be considered as examples of vulnerability cognitions in terms of the Armfield model (32, 33).

As mentioned earlier, previous research has successfully tested the relationship between dental anxiety and perceived oral health status. This has been performed by means of correlation studies. As a consequence, determining the direction of causality remains problematic. Dental anxiety could cause people to perceive their oral health more negatively; however, an impaired OHRQoL could also lead to higher levels of dental anxiety. McGrath and Bedi (11) and Mehrstedt et al. (13) have concluded that both directions are possible. As Salovey and Birbaum (37) remarked, correlation studies do not allow us to know whether psychological distress precedes or is a consequence of symptom appraisals.

Nevertheless, from our point of view, both alternatives are not irreconcilable. Researchers frequently state that dental anxiety results in a poor health status (10, 14) but a lack of dental care can also aggravate dental fear (9) while improvements in oral health condition are assumed to decrease dental fear (17). Dental research has identified a 'vicious circle' dynamic, linking dental fear to the avoidance of dental visits and subsequently to a worsening of the oral health status, which contributes to increases in anxiety levels and to the maintenance of the avoidant pattern (38–40). Treatment avoidance behaviours (i.e. not going to the dentist for checkups, cancelling or delaying dental appointments, denial of the oral problem) can explain the poorer oral health status found among dental fearful patients. But, what is the reason for a worse oral health status leading to the maintenance or increase in dental anxiety (i.e. the feedback loop in the 'vicious circle')? Cognitive models applied to health psychology may provide a useful framework to analyse this issue.

Consistent with classical transactional stress models (34, 35), subjective assessments on one's oral health status might act as eliciting stimuli for an anxiety response. Vingerhoets (41) has identified disease and its quality of life-related outcomes as powerful stressors. Not only do symptoms, functional limitations and social consequences of health problems represent a challenge for patients to cope with but they also increase the risk of being exposed to other stressors, such as medical procedures or health care settings. Therefore, oral symptoms or problems (e.g., pain or discomfort, dental status interference in daily life, embarrassment because of one's oral condition, etc.) might be

seen as stressors that activate a coping process. Looking for dental care would be an obvious way of coping with such stressors, but for a dental fearful person the mere anticipation of this alternative would likely lead to increased stress.

Self-perceptions of one's health status are also linked to cognitive elements in Leventhal et al.'s (42) model of illness cognition and behaviour. According to this model, the perception of illness-related stimuli activates the subject's cognitive representations of illness (i.e. identification of the illness from symptoms, its causes, timeline, possibilities of control and consequences) and illness-related emotions. These appraisals and emotions guide the subsequent coping process. Applying this model to dental health problems (see Fig. 1), we might assume that perceptions of oral symptoms/problems activate the patient's beliefs on the severity (identity, course, outcomes for quality of life) of the dental disease and on the need for seeking treatment (control). Again, for dental fearful patients, this could activate vulnerability schema and threat appraisals.

Our study's purpose was to shed light on the possible mechanisms linking self-perceived oral health status and dental anxiety in children. In particular, following the Cognitive Vulnerability Model of dental fear (33), we propose that children's fearful appraisals of dental treatments play a key role in the process that leads from a negative self-perception of oral health to the children's dental anxiety.

Hypothesis 1: Children's dental fear is associated with self-perceived oral health status; specifically, those children reporting worse oral health-related self-assessments are expected to show higher dental fear levels.

Hypothesis 2: The children's self-perceived oral health (i.e. their awareness of suffering oral symptoms, experiencing functional limitations and/or impaired emotional and social well-being due to dental problems) may be considered as an anxiety-relevant stimulus that activates a vulnerability schema, according to the Cognitive Vulnerability Model. Therefore, worse perceived oral health is expected to be associated with higher activation of the cognitive vulnerability schema and greater threat and disgust perceptions.

Hypothesis 3: Cognitive vulnerability is expected to play a mediational role in the relationship between perceived oral health and dental fear, i.e. the perception of dental treatments as uncontrollable, unpredictable, dangerous and disgusting is hypothesized to be the mechanism that links negative oral health-related evaluations and dental anxiety in children.

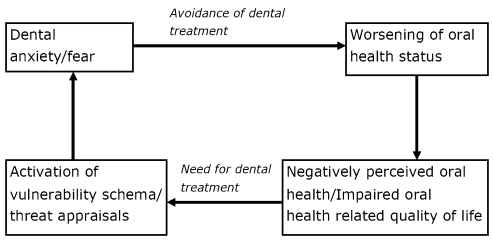

Fig. 1. Circular relationships among dental anxiety, oral health status, subjective oral health and cognitive vulnerability/appraisals.

Material and methods

Sample

Our sample was comprised of 161 children (77 female, 84 male) attending primary and secondary education state (public) schools located in the southern area of the Autonomous Community of Madrid, Spain. Their mean age was 11.93 years (SD = 1.41), ranging from 7 to 14 years old.

Data were collected during school or individual regular visits to the Rey Juan Carlos University Dentistry Clinic in February–March 2011. The clinic offers common dental care services such as check-ups, caries treatment and orthodontia to children and adults. For study participants, the examination of their oral health status was provided freely.

Prior to school visits, study information was sent to parents via school staff. Parents' informed consent to their children's participation was received at the University Dental Clinic prior to school visits. For individual visits, while being at the waiting room, parents were provided with information on the study by a member of the research team, and parental consent was obtained before their child entered the dental office. Ethical approval was obtained from the Rey Juan Carlos University Committee for Ethics in Research.

Measures

Data were gathered by means of a questionnaire that participants filled in at the waiting room prior to a dental examination. Instructions for completing the questionnaire were provided by a member of the research team. Our study's main variables, self-assessed oral health status, cognitive vulnerability and dental anxiety, were measured as follows:

Child Perceptions Questionnaire Short Form (CPQ_{11-14}-ISF:16). Self-assessments of one's oral health encompass both the children's awareness of oral symptoms/problems experienced and the negative effects that they may have on their wellbeing (43). The CPQ_{11-14}-ISF:16 consists of 16 items to assess the child's self-reported OHRQoL and comprises four dimensions: oral symptoms, functional limitations and emotional and social wellbeing. Participants responded on a 4-point Likert-type scale, ranging from 0 (the oral symptom/problem was never experienced during the last 3 months) to 3 (it was experienced everyday/almost every day). A total score was calculated by adding the item responses (range, 0–48). Alpha reliability for this scale was 0.64.

Cognitive vulnerability. Following the previous work of Armfield et al. (32, 33), we developed a scale for measuring children's dental-related cognitive vulnerability. It comprised 10 items related to the four components of cognitive vulnerability. The items represented assessments of dental treatments as being uncontrollable, unpredictable, dangerous and disgusting. Format response was a 4-point Likert-type scale, from 1 (not agree) to 4 (strongly agree). A total score ranging from 10 to 40 was obtained by adding the participants' responses. Cronbach's alpha for the total scale was 0.72. As the scale we used was ad hoc elaborated, an exploration of its dimensional structure was carried out. Models performed on the basis of a four-dimensional structure (unpredictability, uncontrollability, dangerousness and disgust) did not reach a good fit, possibly because the number of items per intended dimension was initially not homogeneous. Confirmatory factor analysis with maximum likelihood estimation showed that the data fitted very well to a bi-dimensional structure of the scale ($\chi^2 = 36.73$; d.f. = 30; $P = 0.19$; SRMR = 0.05; AGFI = 0.92; CFI = 0.97; RMSEA = 0.04). One of these dimensions comprised the seven items measuring perceptions of danger, unpredictability and uncontrollability in a dental treatment situation (e.g. 'I don't know what could happen when I will be at the dentist's', 'It will hurt when the dentist will be treating my teeth or my mouth'), while the other dimension comprised the three items measuring disgust (e.g. 'When I will be at the dentist's, it will turn my stomach'). We calculated two separate scores for each dimension, named cognitive vulnerability – threat (Cronbach's $\alpha = 0.62$) and cognitive vulnerability – disgust (Cronbach's $\alpha = 0.65$).

Dental anxiety. We used the 5-item Modified Dental Anxiety Scale (MDAS) (44). Participants' answers were given in a 5-point Likert-type scale, ranging from 1 (relaxed/not worried) to 5 (very worried/very nervous). To guarantee a better understanding by children, we incorporated faces to the response scale, following Howard and Freeman (45). A final score (range, 5–25) was calculated by summing all responses. The Cronbach's Alpha for this scale was 0.85.

Original English language scales were adapted to Spanish by using a forward- and back-translation procedure. The understanding of the items comprising the used scales was checked by conducting 10 interviews with children prior to the elaboration of the questionnaire's final version. Furthermore, a member of the research team was present while children filled in the questionnaires to offer assistance in case participants needed it (e.g. to clarify instructions' or items' meaning).

Children's oral health was assessed during clinical examinations carried out by paediatric dentists using a flat-surface mouth mirror, gauze, sponges and compressed air, under artificial light. The World Health Organization (WHO) index for decayed, missing and filled permanent teeth (DMFT) was obtained.

Statistics

Descriptive statistics (means and standard deviations) and Pearson's (r) bivariate correlations were calculated. Our three hypotheses were tested by using the procedure described by Baron and Kenny (46) for the assessment of a mediation effect model. According to this approach, firstly oral health perceived status, cognitive vulnerability and children's dental anxiety levels should be significantly inter-correlated. Secondly, running separate hierarchical multiple regression analysis, oral health perceived status should be a significant predictor of children's dental anxiety (H1) and cognitive vulnerability (H2). Third, support for a full mediating effect of cognitive vulnerability (H3) is obtained if self-assessed oral health status ceases to be a significant predictor of children's anxiety when cognitive vulnerability is included in the regression model, while this variable remains as a significant predictor of children's dental anxiety.

In all regression analyses, age, gender (0 = female; 1 = male) and oral health status were controlled for, as these variables have previously been found to be associated with dental fear responses.

As an inspection of the frequency distribution of the DMFT index showed that 44.1% of participants did not present with any decayed, missing or filled teeth, this variable was recoded as a dichotomous one, with 0 representing DMFT = 0, and 1 representing the presence of at least one decayed, missing or filled tooth (DMFT ≥ 1).

All analyses were carried out using the statistical software PASW 19.0 (SPSS Inc., Chicago, IL, USA). The complete model of relationships among variables was tested by means of the structural equation modelling (SEM) software AMOS 16.0 (SPSS Inc.).

Results

Table 1 shows descriptive statistics (means and standard deviations) and bivariate correlations among the study variables. In general terms, children in our sample self-evaluated their oral health status fairly well (M = 7.02, SD = 4.41), showed moderate levels of dental anxiety (M = 10.96, SD = 4.74) and reported rather low levels of cognitive vulnerability (M_{Total} = 14.73, SD = 4.08). As can be seen, the first requirement for a mediation effect, an inter-correlation among the model's variables (self-assessed oral health, cognitive vulnerability and dental anxiety) was met. These relationships occurred in the expected direction. Worse self-assessed oral health (i.e. more experienced oral symptoms/problems) was associated with higher scores on the vulnerability variables (r ranging from 0.32 to 0.37, $P < 0.01$) and dental anxiety ($r = 0.29$, $P < 0.01$). Furthermore, the higher the children's cognitive vulnerability, the higher the dental anxiety they exhibited (r ranging from 0.44 to 0.52, Ps < 0.01).

Confirming the first hypothesis, the relationship between self-perceptions of oral health status and dental anxiety remained significant (Table 3, step 2) when age, gender and DMFT were controlled for ($\beta = 0.27$, $P < 0.01$). Furthermore, as shown in Table 2, self-assessed oral health was a significant predictor of total cognitive vulnerability ($\beta = 0.36$, $P < 0.01$), cognitive vulnerability related to threat ($\beta = 0.32$, $P < 0.01$) and cognitive vulnerability related to disgust ($\beta = 0.32$, $P < 0.01$), indicating that the children's negative assessments of their oral health is predictive of cognitive vulnerability

Table 1. Descriptive statistics and inter-correlations for study variables

	Mean (SD)	1	2	3	4	5	6	7
Gender	0.52[a]							
Age	11.93 (1.41)	−0.08						
DMFT	0.56[a]	−0.07	0.23**					
Self-assessed oral health status	7.02 (4.41)	−0.09	0.03	0.00				
Cognitive vulnerability – total	14.73 (4.08)	−0.06	0.05	0.07	0.37**			
Cognitive vulnerability – threat	11.13 (3.37)	−0.00	0.07	0.07	0.32**	0.97**		
Cognitive vulnerability – disgust	3.61 (1.30)	−0.14	−0.05	0.02	0.33**	0.66**	0.40**	
Dental anxiety	10.96 (4.74)	−0.16*	0.13	0.05	0.29**	0.52**	0.44**	0.47**

DMFT, decayed, missing and filled permanent teeth.
[a]For dichotomous variables, these values represent the proportion of sample participants in the category 1 (i.e. percentage of male children, and children presenting DMFT > 0); *$P < 0.05$; **$P < 0.01$.

Table 2. Cognitive vulnerability regressed on self-assessed oral health status

	Model 1 (DV: cognitive vulnerability – total)			Model 2 (DV: cognitive vulnerability – threat)			Model 3 (DV: cognitive vulnerability – disgust)		
	B	SE *B*	*β*	*B*	SE *B*	*β*	*B*	SE *B*	*β*
Gender	−0.11	0.61	−0.01	0.22	0.52	0.03	−0.29	0.20	−0.11
Age	0.05	0.22	0.02	0.12	0.19	0.05	−0.07	0.07	−0.07
DMFT	0.48	0.63	0.06	0.41	0.53	0.06	0.08	0.20	0.03
Self-assessed oral health	0.34	0.07	0.36**	0.24	0.06	0.32**	0.09	0.02	0.32**

DMFT, decayed, missing and filled permanent teeth; DV, dependent variable.
Model 1 = DV: cognitive vulnerability – total; $R^2 = 0.14$.
Model 2 = DV: cognitive vulnerability – threat; $R^2 = 0.11$.
Model 3 = DV: cognitive vulnerability – disgust; $R^2 = 0.10$.
*$P < 0.05$; **$P < 0.01$.

Table 3. Stepwise regression output of children's dental anxiety regressed on self-assessed oral health and cognitive vulnerability variables

	B	SE *B*	*β*
Step 1			
Gender	−1.40	0.75	−0.15
Age	0.39	0.27	0.11
DMFT	0.24	0.77	0.02
Step 2			
Gender	−1.15	0.73	−0.12
Age	0.35	0.26	0.10
DMFT	0.25	0.75	0.03
Self-assessed oral health	0.29	0.08	0.27**
Step 3a			
Gender	−1.09	0.65	−0.11
Age	0.32	0.23	0.10
DMFT	−0.01	0.67	−0.00
Self-assessed oral health	0.10	0.07	0.10
Cognitive vulnerability – total	0.55	0.08	0.47**
Step 3b			
Gender	−1.29	0.67	−0.14
Age	0.30	0.24	0.09
DMFT	0.00	0.69	0.00
Self-assessed oral health	0.15	0.08	0.14
Cognitive vulnerability – threat	0.55	0.10	0.39**
Step 3c			
Gender	−0.69	0.66	−0.07
Age	0.47	0.24	0.14
DMFT	0.03	0.68	0.00
Self-assessed oral health	0.15	0.08	0.14
Cognitive vulnerability – disgust	1.53	0.27	0.42**
Step 3d			
Gender	−0.86	0.64	−0.09
Age	0.39	0.23	0.12
DMFT	−0.00	0.66	0.00
Self-assessed oral health	0.08	0.08	0.07
Cognitive vulnerability – threat	0.40	0.10	0.28**
Cognitive vulnerability – disgust	1.19	0.28	0.33**

DMFT, decayed, missing and filled permanent teeth; MDAS, Modified Dental Anxiety Scale.
Dependent variable: children's dental anxiety (MDAS).
$R^2 = 0.04$ for Step 1; $\Delta R^2 = 0.07$ for Step 2 (Ps < 0.01); $\Delta R^2 = 0.19$ for Step 3a (Ps < 0.01); $\Delta R^2 = 0.14$ for Step 3b (Ps < 0.01); $\Delta R^2 = 0.15$ for Step 3c (Ps < 0.01); $\Delta R^2 = 0.22$ for Step 3d. *P < 0.05; **P < 0.01

perceptions. Hypothesis 2 was therefore supported.

As can be seen in Table 3, when including in the same regression step self-assessed oral health and cognitive vulnerability variables (total, threat or disgust) as predictors of children's dental anxiety, only the vulnerability variables remained statistically significant ($\beta = 0.47$ for total vulnerability score; $\beta = 0.39$ for threat-related vulnerability; $\beta = 0.42$, for disgust-related vulnerability; $P < 0.01$). Supporting Hypothesis 3, children's cognitive vulnerability was found to mediate the relationship between subjective oral health status and

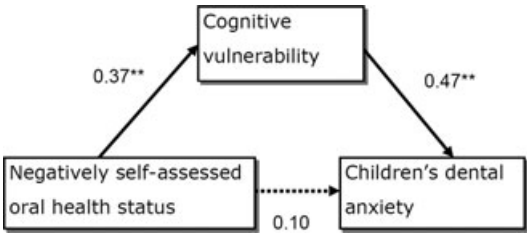

Fig. 2. Cognitive vulnerability as a mediator in the relationship subjective oral health-dental anxiety. Gender, age and decayed, missing and filled permanent teeth effects were controlled for; to provide a clear graphical representation, paths for these variables are not shown. Numbers represent standardized regression weights. **P < 0.01.

dental anxiety. To further explore the relationship between vulnerability – threat and vulnerability – disgust as mediating variables and dental anxiety as an outcome variable, we conducted a regression analysis including both mediators at the same step. As can be seen in Table 3 (Step 3d), both dimensions of cognitive vulnerability remained as significant mediating variables ($\beta = 0.28$ for threat vulnerability; $\beta = 0.33$, for disgust vulnerability; Ps < 0.01).

Finally, the complete model representing all the suggested relationships among our study's variables (depicted in Figs 2 and 3) was tested by means of SEM methodology. In the model represented in Fig. 3, a path from vulnerability – threat to vulnerability – disgust was included, as both variables were significantly correlated. Fit indexes revealed a very good fit of the model to the data ($\chi^2 = 0.89$; d.f. = 3; $P = 0.82$; SRMR = 0.01; AGFI = 0.98; RMSEA = 0.00) when considering a total cognitive vulnerability score; and also when considering cognitive vulnerability – threat and cognitive vulnerability – disgust separately ($\chi^2 = 6.04$;

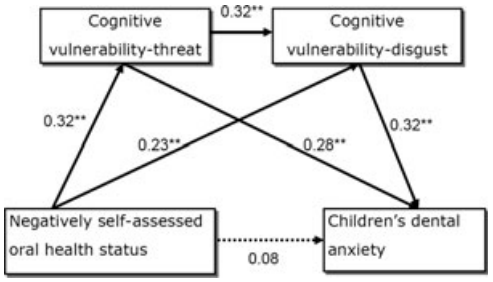

Fig. 3. Cognitive vulnerability's dimensions threat and disgust as mediators in the relationship subjective oral health-dental anxiety. Gender, age and decayed, missing and filled permanent teeth effects were controlled for; to provide a clear graphical representation, paths for these variables are not shown. Numbers represent standardized regression weights. **P < 0.01.

d.f. = 6; $P = 0.42$; SRMR = 0.03; AGFI = 0.95; RMSEA = 0.00). As can be seen, the path representing the previously obtained direct association between self-perceived oral health and dental fear was not significant, because the mediating variables (cognitive vulnerability total/threat and disgust) were included in the model. This supports the hypothesis of a chain mechanism, involving the mediator, in the path from children's self-assessed dental health to dental anxiety.

Discussion

The results provide empirical support for the study's three hypotheses. The child's perceptions of a poorer oral health status and higher dental-related cognitive vulnerability were both associated with higher levels of dental fear. Also, the more negatively oral health was self-assessed, the more cognitive vulnerability was shown by children. Therefore, children's cognitive vulnerability may play a mediating role in the relationship between perceived oral health status and dental fear, i.e. representing a mechanism by means of which the effect of the children's assessments on their oral health may lead to dental fear. The perceived oral health status (stimulus) would trigger the child's cognitive vulnerability (activation of cognitive process), which in turn would trigger dental fear (response).

It is especially remarkable that mediating effects were observed when both dimensions of vulnerability comprising our scale, threat and disgust were considered separately and also that both aspects remained as significant predictors of dental anxiety when they were included in the model. These dimensions bear a resemblance to the classical biphasic model of blood–injury–injection (BII) phobias, among which dental phobia is cited as an exemplar (47, 48). According to this model, in BII phobias, an initial activation of the sympathetic nervous system is rapidly followed by a parasympathetic response (49, 50). In our model, we considered that automatic assessments of dental treatment-related threat could activate automatic assessments of disgust. This path was significant, supporting the plausibility of a two-phase process in dental anxiety. Nevertheless, this biphasic mechanism is not the only one operating. Direct paths from cognitive vulnerability – threat and cognitive vulnerability – disgust to dental anxiety also remained significant in the model, suggesting that beyond the biphasic response, vulnerability dimensions may play individual roles in triggering dental anxiety. In line with previous research (51, 52), this result seems to support the idea of an overlapping, in contrast to a complete identification, of dental phobia and BII phobias.

Our research represents a successful application of the Cognitive Vulnerability Model (32, 33) to explain a result obtained recurrently in previous research, i.e. the association between perceived oral health and dental anxiety. Furthermore, it contributes to linking two research topics, subjective oral health (or OHRQoL) and the aetiology of dental anxiety, which have for the most part been treated separately. Finally, our study also supports the use of the Cognitive Vulnerability Model, previously tested among adults, to explain children's dental fear in paediatric dentistry settings.

This research has some obvious limitations. First, we used a convenience sample composed of school children who were visiting a University Dental Clinic, and therefore, it may not be assumed to be representative of a larger child population. This would mainly affect the prevalence data obtained for our study variables, which cannot be generalized. Nevertheless, our hypotheses do not refer to prevalence rates but to relationships among variables, and the power of our analyses lean on statistical assumptions on the variables' distribution that were adequately met. A second limitation comes from the use of self-reported measures that may be affected by biases such as social desirability in the participants' responses.

A third limitation comes from the cognitive vulnerability scale we used. Items comprising this scale may have failed to adequately characterize the whole cognitive vulnerability schema, as both the unpredictability and uncontrollability dimensions were underrepresented. A previous version of this scale (22) comprised a greater number of items (three for uncontrollability, three for unpredictability, three for disgust and four for dangerousness), to better capture the various dimensions of each of these concepts. Nevertheless, in the current study, two items attempting to measure uncontrollability and one item measuring unpredictability lowered reliability considerably. Factor analysis also yielded confusing results when including these items. We observed that these three items were reverse-scored and included negative wording in their formulation. During previous interviews with children, we had noticed that items formulated this way might be difficult to

understand by children. As a result we decided not to use these items. Therefore, our final scale comprised 10 items, and the number of items per vulnerability dimension was not homogeneous. However, as stated in the Methods section, this 10-items scale had acceptable properties and the factor structure obtained had meaningful content. Items corresponding to uncontrollability, unpredictability and dangerousness were grouped in the factor we called 'threat', while items corresponding to disgustingness represented another factor.

A fourth limitation refers to the impossibility of clearly establishing the direction of causality between variables that are correlated. As we have previously noted, the correlation methods we employed do not allow us to rule out alternative relationships between variables (i.e. dental anxiety leading to a poor subjective oral health, or a negatively perceived oral health activating vulnerability schema and resulting in anxiety). This remains a point for future studies that could approach this topic by using experimental methods. However, drawing from previous research, we have considered that influences between these variables should be seen in the light of a circular model of causality.

Important implications for paediatric dentistry practice can also be derived from our research. The conclusion that cognitive vulnerability seems to be decisively involved in the relationship between oral health negative self-assessments and dental fear offers a potential way to short-circuit this connection. If paediatric dentists are able to reduce the child's perceptions of threat and disgust associated with dental treatments, it might be that a worse perceived oral health would not increase dental anxiety. This point may suggest an issue for further development: the design of strategies and techniques aiming to decrease children's vulnerability cognitions and enhance dental anxiety prevention. These strategies may be of a wide range. For instance, providing children with realistic information on how dental treatments are and what is going to happen in the course of a dental session might reduce vulnerability related to unpredictability. Agreeing on a 'security signal' used to stop dental work if the children need it could help to foster perceptions of controllability during treatments. Other cognitive-behavioural techniques such as rational-emotive imagery, reality-tests or debate on irrational beliefs could be also applied to the change of disgust or harm-related cognitions.

To conclude, our study represents an application of the Cognitive Vulnerability Model to explain children's dental anxiety. This analysis of child dental anxiety from a cognitive perspective could be useful to gain a better understanding of the mechanisms involved in dental anxiety; and especially to identify appraisals that might be present at the origins of dental fear development. Furthermore, this model could be taken as a basis to suggest possible targets (i.e. cognitive vulnerability dimensions) for interventions aiming to prevent or reduce child dental fear.

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