COHORT STUDY 0

Influence of Temperament As a Risk Indicator for Early Childhood Caries

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Abstract: ***Purpose:*** *To evaluate the association between temperament and caries.* ***Methods:*** *A total of 408 primary caregiver-child pairs were followed for 36 months; they completed the Early Childhood Behavior Questionnaire Very Short-Form (ECBQ-VSF) at age four years. Demographic, behavioral, and clinical data were obtained at ages one, two-and-a-half, and four years, with caries experience assessed each time using the International Caries Detection and Assessment System (ICDAS). The ECBQ-VSF (36 items) was used to measure three child temperament domains: (1) surgency; (2) negative affect; and (3) effortful control. The associations between cavitated carious lesion experience by age four years (decayed, missing, and filled primary surfaces [dmfs] score greater than zero; d equals ICDAS score greater than or equal to three) and the three ECBQ-VSF temperament domains were analyzed using generalized estimating equation models.* ***Results:*** *Temperament domains predicted the number of carious surfaces (dmfs). After adjusting for covariates, every one-point increase in surgency and one-point increase in negative affect were associated with 77 percent and 31 percent increases in dmfs, respectively (P<0.05), and every one-point increase in effortful control was associated with a 39 percent decrease in dmfs (P<0.05).* ***Conclusions:*** *By age four years, children with higher levels of surgency and negative affect have a higher caries experience, whereas children with greater effortful control have a lower caries experience.* *(Pediatr Dent 2020;42(6):470-5) Received May 6, 2020 / Last Revision July 8, 2020 / Accepted July 14, 2020*

KEYWORDS: TEMPERAMENT, DENTAL CARIES, CARIES RISK, COHORT STUDY, CHILDREN

Why does one three-year-old cling to her mother while walking in the dental office while another three-year-old enters with confidence and jumps into the dental chair? Even more interesting is why some clingy children present with early childhood caries (**ECC**), while others sharing similar behavioral, environmental, and genetic characteristics do not? The psychological literature offers childhood temperament as a scientifically validated framework to explain variations in life course development and health. Temperament refers to the initial state from which personality develops, and it links individual differences in behavior to underlying neural networks.[1] Temperament aligns well conceptually with Fisher-Owens' framework for ECC, outlining the complex interplay among multilevel determinants of oral health.[2]

While some empirical interest has emerged in understanding the behavioral determinants of ECC,[3-5] to date there is limited longitudinal evidence on the influence of biobehavioral characteristics on ECC, including childhood temperament. The literature continues to indicate that temperament is associated with dental status. For example, Spitz et al. reported on a group of American children and found that those with an easy temperament had nearly twice the odds of breastfeeding throughout the night while children with a more difficult temperament were more likely to bottlefeed to get to sleep.[4] Quinonez et al. demonstrated in a group of Canadian children that shyness together with duration of feeding habits was associated with increased risk of ECC.[5] Also, Aminabadi et al. highlighted in a group of Azerbaijani children the role of temperament in modulating the development of ECC, with positive temperament (cuddliness, soothability) appearing protective and negative temperament (fear, frustration, sadness, shyness) increasing the risk of dental caries.[6] Improved data with consistent measurements on the biobehavioral and developmental trajectories of dental disease are urgently needed to better predict the risk of disease and inform prevention and treatment strategies to optimize individual and population oral health.

This investigation is part of a larger study that aims to develop a practical, validated, and easily-scored tool that practitioners can use to accurately and reliably assess and effectively triage children at the highest risk for dental caries in primary care settings. The purpose of this component of the study was to understand the influence of behavioral markers, specifically child temperament, in predicting caries experience. It used the Rothbart three-factor model of temperament: (1) surgency (reflecting the degree to which a child is active and seeks stimulation/impulsivity); (2) negative affect (reflecting the degree to which a child is shy and/or not easily calmed); and

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HOW TO CITE:
Quinonez RB, Santos RG, Eckert GJ, et al. Influence of Temperament As a Risk Indicator for Early Childhood Caries. Pediatr Dent 2020; 42(6):470-5.

(3) effortful control (reflecting the degree to which a child can focus attention and restrain responses).[7] Based on theory and prior evidence, children with higher surgency, higher negative affect, and/or lower effortful control are expected to have higher levels of ECC.

Methods

Study population. Institutional review board (**IRB**) approval was obtained from Duke University, Durham, N.C., USA; Indiana University, Indianapolis, Ind., USA; the University of Iowa, Iowa City, Iowa, USA; and the University of Michigan, Ann Arbor, Mich., USA. A total of 1,323 child-caregiver dyads were enrolled at baseline (age one year) as part of a multicenter caries risk study from three sites: Duke University, Indiana University, and the University of Iowa.[8] Caregiver-child dyads were identified mostly through primary care medical settings. Eighty percent of children had a follow-up visit at age 2.5 years (N equals 1,060), and 74 percent (N equals 982) had a follow-up visit at age four years. Child temperament data using the Early Childhood Behavior Questionnaire Very Short Form (**ECBQ-VSF**)[9,10] were obtained from 422 caregivers at the third visit (when the child was approximately four years old). A total of 686 caregivers were approached. All children enrolled in the trial and active at the time of their third visit were invited to participate. However, in the case of Duke University, their IRB approval took longer than anticipated, and age four visits had already started. Thus, they decided to approach everyone they had left to see after they obtained IRB approval (54 caregivers, of whom 49 consented).

Data collection. A self-administered caries risk questionnaire (described in Fontana et al.[8]) and clinical data were obtained at all three study intervals, with decayed, missing, and filled primary surfaces (**dmfs**) scored using International Caries Detection and Assessment System criteria (**ICDAS**)[11] to document caries experience at each point. After the children's teeth were brushed, examinations were completed by trained and calibrated examiners at each study site using a mirror and a ball-ended probe (used gently and not under pressure only to confirm the presence of small cavitated lesions with no clinically visible dentin or ICDAS 3 lesions, when needed). Recalibration exercises occurred at baseline and before each examination wave (at one, two-and-a-half, and four years old). The ECBQ-VSF (36 items) was used as a measure of child temperament because it is psychometrically reliable and validated for use in early childhood.[9,10,12] The ECBQ-VSF measures the three higher-order temperament domains of surgency, negative affect, and effortful control (12 items each). There is no total temperament score. All domain scores range from one to seven, calculated from the average of the answered items for each domain. Each item uses a Likert scale of response options, with some of the items reverse-scored so that all items in a domain are interpreted in the same direction. Each domain score was calculated if more than half the items for the domain were not missing, using the nonweighted average scores calculated using all answered items.

The ECBQ-VSF was given to each participating family at the time of their third clinical visit at Indiana University and Duke University sites. The Iowa University site mailed questionnaires to each family still participating in the trial as the first age four dental visits were beginning. One reminder postcard was sent, and two additional questionnaire reminders were mailed to nonresponders within six weeks of the first mailing. Questionnaire responders at each site were provided $10.

Statistical data analysis. All analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, N.C., USA). Three different levels of ICDAS severity (all corresponding to cavitated lesions) were used to define the presence of a caries lesion or decay (ICDAS severity score of three or more [small cavitation, with no clinically visible dentin], four or more [lesion with a dentinal shadow, with or without small cavitation] and five or more [frank cavitation with clinically visible dentin exposing the floor and/or walls of the cavity]). Based on the three ICDAS cutoffs, dmfs was calculated (d3mfs, d4mfs, and d5mfs, calculated, respectively, using ICDAS severity scores greater than or equal to three, greater than or equal to four, and greater than or equal to five to define the decay portion of dmfs); the presence of any caries was defined as dmfs greater than zero. The timing of first cavitated caries lesion development was defined as early (d3mfs greater than zero at one or two-and-a-half years old), late (first d3mfs greater than zero at four years old), or none (d3mfs equal to zero at all three visits). Because of the small number of lesions with ICDAS severity scores of at least four before the age four years visit, caries timing using d4mfs and d5mfs were not examined.

Logistic regression was used to predict the presence of any carious lesion from ECBQ-VSF temperament domains, with study site included as a clustering effect in a generalized estimating equation model. Similarly, negative binomial regression was used to predict dmfs counts and ordinal logistic regression to predict first caries timing. Analyses were performed using each of the three temperament domains individually; then, the analyses were repeated including all three temperament domains in the model simultaneously while also including covariates. Covariates included patient characteristics and caries risk factors. Because of sample size limitations, covariates were limited to these variables: Medicaid status; child race/ethnicity; frequency of an adult brushing the child's teeth; sleeping while nursing or while drinking something other than water from a bottle/sippy cup; frequency drinking tap water; frequency of sugary drinks; caregiver cavities/fillings/teeth pulled in last two years; and frequency of caregiver's gums bleeding while brushing. As this is a secondary data analysis from the caries risk study, a post hoc power calculation indicated at least 80 percent power to detect an odds ratio of 1.5 for a one standard deviation difference in temperament domain scores for the analyses of the presence of any caries (ICDAS severity of at least three). A five percent significance level was used.

Results

The analyses were limited to the 408 children who had both complete temperament and caries data (out of 686 approached). Study population demographics at four years of age and oral health-related behaviors at age one year are summarized in Table 1. Approximately half of the child participants were male (52 percent), had Medicaid insurance (50 percent), and were white (52 percent). Over half of caregivers reported being college-educated or higher (55 percent) and having dental treatment in the past two years (55 percent). At age four years, 43 percent of caregivers reported giving their child sugary beverages at least daily. Table 2 shows the univariate distributions of the three temperament domain scores and the three dental caries experience thresholds. Dental caries prevalence ranged from 16 percent to 20 percent, depending on the threshold of outcome measured.

Bivariate analyses. Bivariate logistic regression analyses for presence or absence of a carious lesion showed that, when ICDAS of at least three or ICDAS of at least four were used to define decay, trends indicated (*P*-value between 0.05 and 0.10) that children with higher negative affect and lower effortful control, respectively, were at higher risk for caries (Table 3). When decay was more stringently defined as ICDAS of at least five, both results reached statistical significance ($P<0.05$). Surgency was not significantly associated with the presence or absence of caries.

Statistically significant results were found across all three caries threshold levels when examining dmfs counts. Children with higher negative affect had significantly higher d3mfs ($P<0.001$), d4mfs ($P<0.001$), and d5mfs counts ($P<0.001$). The models estimated a 30 to 35 percent increase in dmfs counts with each one-point increase in the negative affect scale. The incidence rate ratios (**IRRs**) were 1.4 to 1.5. Children with higher surgency had significantly higher d3mfs ($P=0.040$) and d4mfs ($P=0.049$), with d5mfs not being significant ($P=0.35$). The models estimated a five percent increase in dmfs counts with each one-point increase in the surgency scale. However, effortful control was not significantly associated with dmfs counts ($P=0.54$ for d3mfs, $P=0.56$ for d4mfs, and $P=0.48$ for d5mfs).

To better understand dental disease development, the authors examined the timing of carious lesion development (early versus late versus no caries by the age four years visit). Noting the small sample size, none of the temperament domains were significantly associated with the timing of caries development at the bivariate level.

Multiple regression analyses. After adjusting for covariates, the temperament domains did not significantly

Table 1. DEMOGRAPHICS AND ORAL HEALTH-RELATED BEHAVIORS FOR PARTICIPANTS COMPLETING THE TEMPERAMENT QUESTIONNAIRE

		N (%)
Study site enrollment	Duke University	44 (11)
	Indiana University	177 (43)
	University of Iowa	187 (46)
	Total	**408 (100)**
Child sex	Female	197 (48)
	Male	211 (52)
Caregiver education	College degree or higher	223 (55)
	Some college	96 (24)
	High school or less	88 (22)
	Unknown	1 (<1)
Medicaid insurance	Yes	204 (50)
	No	197 (48)
	Unknown	7 (2)
Child race/ethnicity	Black	110 (27)
	Hispanic	42 (10)
	Multiracial/other	44 (11)
	White	212 (52)
How often does an adult brush your child's teeth? (Response at age 1 year)	Daily	211 (52)
	Weekly/monthly/ never	163 (40)
	No teeth	34 (8)
Does your child usually (throughout the day) drink from a bottle or sippy cup? (Response at age 1 year)	Yes	383 (94)
	No	25 (6)
How often does your child go to sleep while nursing or while drinking something other than water from a bottle/sippy cup? (Response at age 1 year)	Daily	166 (41)
	Weekly/monthly/ never	242 (59)
How often does your child typically drink tap water, including filtered water from the refrigerator? (Response at age 1 year)	Daily	250 (61)
	Weekly/monthly/ never	158 (39)
Have you (caregiver) had cavities, fillings, and/or teeth pulled in the last two years? (Response at age 1 year)	Yes	225 (55)
	No	177 (43)
	Missing	6 (1)
How often do your (caregiver) gums bleed when you brush? (Response at age 1 year)	Daily	30 (7)
	Weekly/monthly/ never	372 (91)
	Missing	6 (1)

Table 2. TEMPERAMENT AND DENTAL CARIES PREVALENCE DESCRIPTIVE DATA

	N (%)	Mean±(SD)	Range
*Temperament domain**			
Surgency	404 (100)	5.52±0.7	2.5-7
Negative affect	407 (100)‡	3.1±0.8	1.3-6.4
Effortful control	405 (100)	5.1±0.0	2.6-7
Cavitated level dental caries experience†			
d3mfs>0			
Yes	83 (20)	2.0±6.9	0-56
No	325 (80)		
d4mfs>0			
Yes	77 (19)	1.9±6.9	0-56
No	331 (81)		
d5mfs>0			
Yes	64 (16)	1.6±6.5	0-56
No	344 (84)		

* Early Childhood Behavior Questionnaire—Very Short Form (ECBQ-VSF): three temperament domains (12 items each); surgency reflects the degree to which a child is active and seeks stimulation/impulsivity; negative affect reflects the degree to which a child is shy and/or not easily calmed; effortful control reflects the degree to which a child can focus attention and restrain responses. All domain scores have a range from 1 to 7, calculated from the average of the answered items in the domain. Each item uses a Likert scale set of responses, with some of the items reverse-scored so that all items in a domain are interpreted in the same direction.

† d3mfs, d4mfs, and d5mfs are decayed, missing, and filled primary surface (dmfs) scores calculated using ICDAS severity scores ≥3, ≥4, or ≥5 to define the decay portion of dmfs.

‡ Numbers represent children for which a scale score was calculated (i.e., they were not missing more than half of the items for the scale).

predict the presence or absence of dental caries experience (Table 4), although they showed the same expected direction of relationship for effortful control, with higher scores for protective. Negative affect and surgency were not associated with caries experience.

For predicting dfms counts (Table 4), after adjusting for covariates, the association of higher surgency with higher d3mfs and d4mfs became stronger (higher IRR), and the associations of higher effortful control being protective of d3mfs and d4mfs counts also became stronger (lower IRR). However, the association of higher negative affect with higher d3mfs and d4mfs became weaker (lower IRR) but remained statistically significant.

For predicting the timing of carious lesion development, after adjusting for covariates, none of the three temperament domains were statistically significant predictors.

Discussion

This study adds to growing evidence linking temperament and ECC. Negative temperament (specifically, higher surgency and higher negative affect) was associated with a higher risk for ECC, whereas positive temperament (specifically, higher effortful control) was associated with a lower risk for ECC, consistent with previous studies.[4-6] The ECBQ-VSF (36 items) is a promising addition to ECC assessment. Using child temperament data, clinicians can focus their anticipatory guidance with parents of children who are high in surgency (very active, impulsive, or stimulation-seeking), high in negative affect (very shy or challenging to calm), and/or low in effortful control (very challenged in focusing attention or self-restraint), and personalize their interventions accordingly using available evidence-based approaches.[13-15] Interventions can include a focus on more effectively reducing known risk factors such as the use of sugary drinks and snacks and improving the effectiveness of the use of oral hygiene practices in early childhood.[16] Interventions can also help influence treatment options, given that children referred secondarily to uncooperative behavior differ from children receiving ordinary dental care, not only in dental fear level but also in temperament characteristics.[17] These

Table 3. BIVARIATE RESULTS FOR TEMPERAMENT DOMAINS AND PRESENCE OF ANY CARIOUS LESION, dmfs COUNT, AND TIMING OF CARIES LESION DEVELOPMENT *

Caries experience (yes/no)	Caries (d3mfs >0)		Caries (d4mfs >0)		Caries (d5mfs >0)	
	OR* (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Surgency	1.13 (0.76, 1.67)	0.544	1.12 (0.78, 1.61)	0.540	0.96 (0.66, 1.40)	0.840
Negative affect	1.35 (0.97, 1.86)	0.071	1.33 (0.96, 1.83)	0.083	1.31 (1.05, 1.63)	**0.017**
Effortful control	0.73 (0.52, 1.02)	0.065	0.72 (0.49, 1.06)	0.100	0.67 (0.45, 0.99)	**0.044**
Caries experiences (dmfs count)	**Surfaces (d3mfs†)**		**Surfaces (d4mfs†)**		**Surfaces (d5mfs†)**	
	IRR (95% CI)	*P*-value	IRR (95% CI)	*P*-value	IRR (95% CI)	*P*-value
Surgency	1.12 (1.01, 1.24)	**0.040**	1.11 (1.00, 1.24)	**0.049**	1.07 (0.93, 1.22)	0.347
Negative affect	1.43 (1.21, 1.69)	**<.001**	1.44 (1.20, 1.74)	**<.001**	1.52 (1.32, 1.75)	**<.001**
Effortful control	0.82 (0.44, 1.53)	0.536	0.83 (0.44, 1.56)	0.557	0.79 (0.40, 1.54)	0.482
Timing of caries lesion development (early vs. late versus none)	**Odds ratio (95% CI)**	***P*-value**				
Surgency	1.19 (0.72-1.96)	0.574				
Negative affect	1.28 (0.96-1.69)	0.120				
Effortful control	0.80 (0.57-1.13)	0.120				

* OR=odds ratio; CI=confidence interval; dmfs= decayed, missing, and filled primary surfaces; IRR=incidence rate ratio.

† d3mfs, d4mfs, and d5mfs are dmfs scores calculated using International Caries Detection and Assessment System (ICDAS) severity scores >3, >4, or >5 to define the decay portion of dmfs.

Table 4. MULTIPLE REGRESSION MODELS FOR TEMPERAMENT DOMAINS AND PRESENCE OF ANY CARIOUS LESION, dmfs COUNT, AND TIMING OF CARIES LESION DEVELOPMENT *

Caries experience (yes/no)	Caries (d3mfs >0)		Caries (d4mfs >0)		Caries (d5mfs >0)	
	OR* (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Surgency	1.21 (0.77, 1.90)	0.410	1.21 (0.79, 1.88)	0.381	1.05 (0.65, 1.67)	0.847
Negative affect	1.02 (0.91, 1.14)	0.761	0.98 (0.92, 1.04)	0.468	0.86 (0.74, 1.00)	0.055
Effortful control	0.81 (0.62, 1.05)	0.115	0.79 (0.57, 1.09)	0.154	0.72 (0.47, 1.10)	0.126
Caries experiences (dmfs count)	**Surfaces (d3mfs†)**		**Surfaces (d4mfs†)**		**Surfaces (d5mfs†)**	
	IRR (95% CI)	*P*-value	IRR (95% CI)	*P*-value	IRR (95% CI)	*P*-value
Surgency	1.77 (1.50, 2.09)	**< 0.001**	1.80 (1.59, 2.04)	**< 0.001**	1.12 (0.92, 1.35)	0.254
Negative affect	1.31 (1.00, 1.71)	**0.046**	1.33 (1.05, 1.68)	**0.018**	1.50 (1.18, 1.92)	**0.001**
Effortful control	0.61 (0.49, 0.75)	**< 0.001**	0.58 (0.48, 0.71)	**< 0.001**	1.04 (0.70, 1.56)	0.836
Timing of caries lesion development (early vs. late versus none)	**Odds ratio (95% CI)**	***P*-value**				
Surgency	1.13 (0.67, 1.92)	0.642				
Negative affect	1.00 (0.98, 1.02)	0.808				
Effortful control	0.83 (0.83, 1.18)	0.293				

* OR=odds ratio; CI=confidence interval; dmfs= decayed, missing, and filled primary surfaces; IRR=incidence rate ratio.

† d3mfs, d4mfs, and d5mfs are dmfs scores calculated using International Caries Detection and Assessment System (ICDAS) severity scores >3, >4, or >5 to define the decay portion of dmfs. Covariates included in all models were Medicaid status, child race/ethnicity, frequency an adult brushes the child's teeth, sleeping while nursing or while drinking something other than water from a bottle/sippy cup, frequency drinking tap water, frequency of sugary drinks, caregiver cavities/fillings/teeth pulled in last two years, and frequency of caregiver's gums bleeding while brushing.

interventions can expand to include anticipated variability in dental treatment acceptance, including when using sedation.[18]

There is also substantial evidence that temperament itself is amenable to interventions across the lifespan that support individuals and their parents,[19,20] particularly in reducing negative affect.[21] Future longitudinal ECC follow-up in this study will begin to fill a significant gap in the temperament-ECC literature and help dentists understand developmental trajectories so that prevention and treatment of ECC can be improved.[16]

This study should be considered in the context of its limitations. First, although temperament is generally stable throughout the life course, the authors had only one data point for temperament even though they had longitudinal caries data. Longitudinal data with larger study populations will help elucidate the understanding of temperament in health care settings, including the influences of behavioral markers on disease patterns (e.g., early versus late onset). Second, as dentists begin to understand the role of behavioral risk factors in disease development and management, the ability to capture such markers requires brief and clinically practical assessment tools. Notwithstanding the considerable psychometric work in reducing the original 201-item ECBQ into the 36-item ECBQ-VSF, this number of items remains challenging to complete in a busy clinical practice.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Negative temperament (higher surgency and negative affect) was associated with a higher risk for early childhood caries, and positive temperament (higher effortful control) was associated with a lower risk for ECC.
2. Further assessment of caries patterns and behavioral markers shows promise for informing clinical pathways and future interventions for preventing ECC.
3. The study of temperament and its influences on children's oral health abound with opportunities for further exploration to positively influence caregiver-child relationships in the dental setting.

Acknowledgments

This study was supported by NIH grant number 5U01DE 021412, NIH CTSA grants (UL1-TR000442 [University of Iowa, Iowa City, Iowa, USA], 2UL1-TR000433 [University of Michigan, Ann Arbor, Mich., USA], and UL1-TR000006 [Indiana University, Indianapolis, Ind., USA]), and a grant from the DentaQuest Institute, Boston, Mass., USA. The authors acknowledge the help of Emily Yanca, project and data manager, and Chase Ellis, at the time a DDS student, both at the University of Michigan, and the clinical research coordinators at each clinical site for the collection of these data: Jeanette Daly, RN, PhD (University of Iowa; Department of Family Medicine), Sue Kelly and Lorena Galvez (Indiana University; Oral Health Research Institute), and Jennifer Talbert, MS, BSN, RN, RDH, CCRP and Fredrica Gallack, RDH (Duke University, Durham, N.C., USA).

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