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ORIGINAL REPORT: HEALTH SERVICES RESEARCH

Child and Parent Demographic Characteristics and Oral Health Perceptions Associated with Clinically Measured Oral Health

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Abstract: ***Objective:*** *To examine child and parent reports about the child's oral health and assess the associations of these reports with clinical assessments of oral health status by dental examiners.*

Methods: *Surveys with 139 items for children and 133 items for parents were administered by Audio Computer-Assisted Self-Interview Software. In addition, the Children's Oral Health Status Index (COHSI) was computed from a dental examination.*

Results: *A total of 334 families with children ages 8 to 17 y participated at 12 dental practices in Los Angeles County. Ordinary least squares regression models were estimated separately for child and parent surveys to identify items uniquely associated with the COHSI. Ten of 139 items the children reported regarding their oral health were associated with the COHSI. The strongest associations were found for child's age, aesthetic factors (straight teeth and pleased with teeth), and cognitive factors related to perception of dental appearance (pleased/happy with the look of the child's mouth, teeth, and jaws). Nine of 133 parent items about the child's oral health were associated with the COHSI in the parent model, notably being a single parent, parent's gender, parent born in the United States, pleased or happy with the look of their child's teeth, and accessing the Internet.*

Conclusion: *These child and parent survey items have potential to be used to assess oral health status for groups of children in programs and practices in lieu of dental screenings.*

Knowledge Translation Statement: *The paper's results inform the development of a toolkit that can be used by schools, public health agencies, and dental programs to identify children with low oral health status based on parents' and children's responses to survey items across demographic, physical, mental, and social domains. These survey items can be used to inform parents of the desirability of proactively addressing inadequacies in their child's oral health status, enabling them to more rationally address dental needs.*

Keywords: psychosocial, health services research, oral health status, epidemiology, outcomes research, pediatric dentistry

Introduction

In 2016, the FDI World Dental Federation launched a new definition of *oral health*, a multifaceted concept

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encompassing "ability to speak, smile, smell, taste, touch, swallow, and convey a range of emotions through facial expressions with confidence and free from pain or discomfort, and disease of the craniofacial complex" (Glick et al. 2016). Children's clinical oral health status traditionally focuses on measures such as decayed, missing, and filled permanent and primary teeth, as well the need for orthodontic treatment need indices (Nikias et al. 1977; Marcenes et al. 1993; Burke and Wilson 1995; Benigeri et al. 1998; Freire et al. 2001; Bernabé et al. 2009; Golkari et al. 2016). The Children's Oral Health Status Index (COHSI) is a weighted index, derived from paired preferences of general and pediatric dentist judges on clinical cases (Gershen et al. 1980; Koch et al. 1985). Judges selected the case from the pair that is in better oral health; choice was the dependent variable, and the characteristics of each clinical case were independent variables in stepwise regression models. The analysis provided a set of variables that includes caries; missing teeth; occlusal relationships such as crossbite, overbite, and overjet; rotated teeth; and facial profiles. The advantage of this index is its ability to measure oral health in terms of a single value or components grouped according to disease or occlusion-related conditions. A perfect oral health score is 100, and any deficiencies in dental disease or occlusal discrepancies reduces the score, to the extreme situation in which an adolescent with all permanent teeth missing would have a score of –27.4.

Other approaches, such as the Child Oral Health Impact Profile, focus on oral health–related quality of life (Broder et al. 2007; Broder and Wilson-Genderson 2007; El Osta 2015). Reports from children and their parents about oral health status are also important (Gift and Atchison 1995; Do and Spencer 2007; Locker 2007; Agou et al. 2008; Paula et al. 2012) and have been shown to yield valid information (Barbosa and Gavião 2008a, 2008b). However, these measures have not been linked directly to comprehensive clinical measures of oral health status.

Another approach was developed in the *Patient-Reported Outcomes Measurement Information System* (*PROMIS*®; Fries et al. 2005; Cella et al. 2007; Forrest et al. 2014). *PROMIS*®, using pediatric self-report scales in children 8 to 17 y of age, could distinguish clinically meaningful subgroups for 6 chronic diseases, in terms of physical, mental, and social domains (Dewalt et al. 2015). Liu et al. (2016) applied the *PROMIS*® methodology to create oral health–related items for administration to children and their parents (Maida et al. 2015). The current study examines the associations between perceptions of the child's oral health by the child and his or her parent and a clinical index of oral health status

Methods

Sample

The sample consisted of 334 dyads of children and their parents, who were selected from diverse dental clinics and private practices throughout the Greater Los Angeles Area. Twelve provider sites included community dental clinics, comprehensive health centers, and group and solo general and pediatric practices. Participating sites served children from low-income neighborhoods to high-income communities, with diverse racial and ethnic compositions. The practices provided lists of families consisting of names, ages of children, home address, phone numbers, and email addresses of children seen by the practice within the past 2 y. Using these lists, project staff contacted families by phone to explain the study and seek the family's participation. The goal was to select children in 2 age groups: 8 to 12 y and 13 to 17 y. One child from each family was selected. The parent and child dyads were scheduled for assessment at their practice during a Saturday between 8:30 and 4:00 pm. Participating families received $85 per family with children 8 to 17 y who completed surveys and for the child's dental exam. Institutional review board approval for this study was obtained from the University of California, Los Angeles, Office of the Human Research Protection Program (Institutional Review Board approval 13-001330). Voluntary informed assent and consent were obtained from children and their parents prior to participation. The exclusion criterion was the presence of orthodontic appliances that did not allow the examiners to perform a complete examination of the dentition and only 1 child per family could participate. This study conforms to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies (Von Elm et al. 2014).

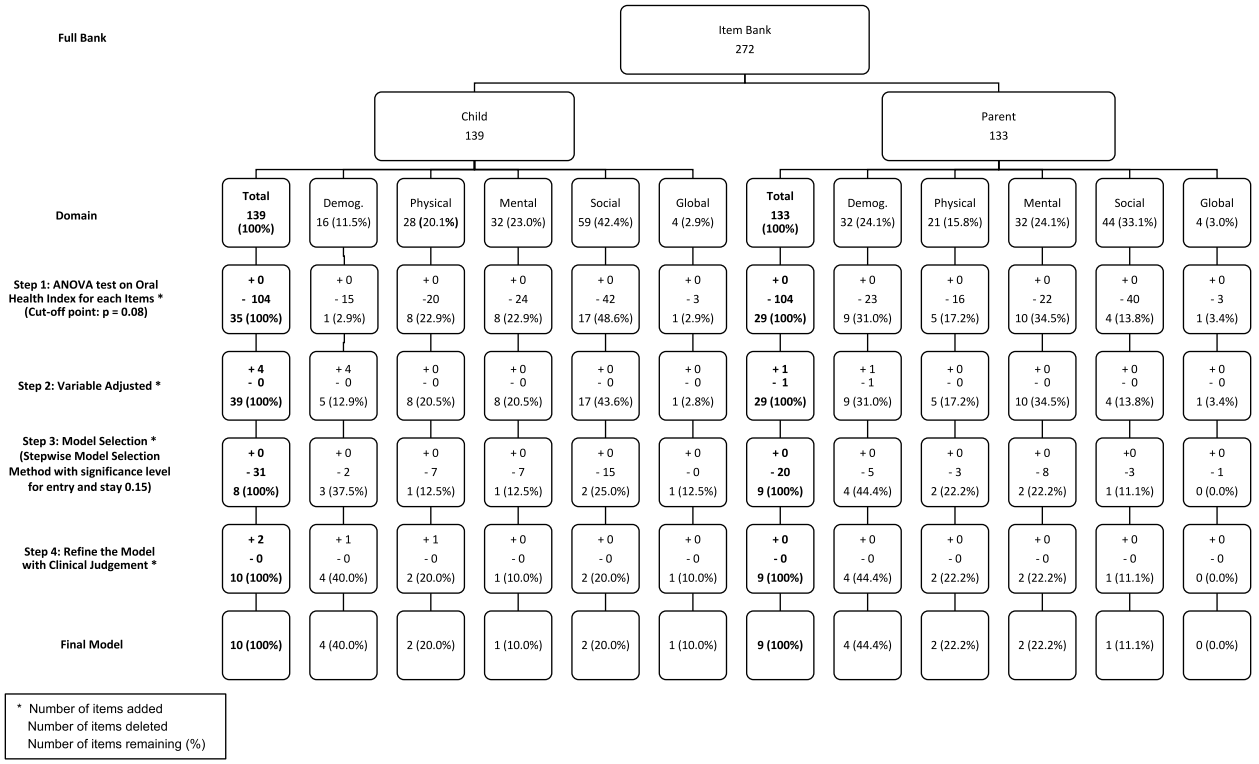
Clinical Examination

The COHSI assesses dental caries, occlusion, the position of the teeth, spacing, crowding, overbite and overjet, and facial profile. The examination consisted of a full-mouth examination of all primary and permanent teeth (Koch et al. 1985). Two faculty dentists were trained in the use of the COHSI criteria. Specially trained recorders entered clinical data into a preprogrammed SAS database on a laptop. The lead examiner had extensive experience in designing and conducting several clinical trials and national surveys, such as the National Health and Nutrition Examination Survey (NHANES) and the RAND Health Insurance Experiment. The other examiner had extensive clinical experience in practice and academia. Interexaminer reliability was conducted: 5% of the exams in sites with ≥30 subjects were conducted by both examiners; in sites with <30 subjects, 10% were provided.

Oral Health Databank Items

The development of the oral health databanks consisted of a series of steps that included 1) systematic review of the literature to identify survey items associated with oral health status, 2) focus groups of children and their parents, and 3) cognitive interviews to assess parents' understanding of the items, followed by item revision and field testing of the revised items.

Figure 1. Item bank selection steps by criteria for children and parents and domains.



Procedures

Prior to the field test, focus groups and cognitive interviews were conducted. The children and adolescents were composed of 2 age groups: 8 to 12 y and 13 and 17 y. Two focus groups with each age group were conducted, and separate focus groups were conducted with their parents. Focus groups probed parents' and children's attitudes about their children's oral health and elicited their perceptions. Focus groups were recorded, transcribed, and entered into NVivo Version 10, a qualitative text analysis database (Bazeley and Jackson 2013). After the qualitative analyses, child and parent perceptions regarding the child's oral health were identified, and a set of preliminary items were drafted to assess oral health perceptions. Cognitive interviews with 32 children and parents dyads evaluated their understanding of the meaning of the items. The draft items were revised based on the cognitive interviews.

As a result of these procedures, a 139-item child survey and a 133-item adult survey were configured to use Audio Computer-Assisted Self-Interview Software.

Data and Statistical Analyses

Data were analyzed to examine associations of self- and parent-reported survey items and the COHSI. Descriptive, bivariate (*t* tests, 2-way table chi-square, correlation coefficients, analysis of variance [ANOVA]) and multiple linear regression models were used to identify oral health survey items associated with the COHSI score.

For continuous variables, means, medians, standard deviations, standard errors, percentiles, and minimum and maximum values were calculated. For categorical variables, frequency distributions and Pearson product–moment and Spearman rank-order correlation statistics were computed to estimate bivariate associations of survey items with the child's COHSI score. ANOVA was used to compare means of COHSI scores across categorical variables. The Variance Inflation Factor (VIF) was used to evaluate collinearity in the regression models.

Figure 1 presents a flow chart of the item selection process by domain, summarizing steps used in evaluating whether items met criteria for selection. Starting with all survey items by domain (139 for the children and 133 for the parents), bivariate ANOVA comparisons were run for each item with the COHSI, and those with *P* values less than 0.08 went on to the next step. A *P* value of 0.08 or smaller was used at this early stage to allow for more items to be identified and included. This approach is consistent with the literature, which suggests that *P* values of up to 0.1 can be used to select variables (Derksen and Keselman 1992), resulting in the elimination of 104 child and parent items. Next, 4 demographic items were added to the child version to include demographic variables in the analysis. The remaining 35 child and 29 parent items were then analyzed by forward stepwise regression and items that had *P* values of ≤0.15, which is appropriate

for variable selection using a stepwise regression (Steyerberg 2008). Eight child and 9 parent items remained. The team then determined if any of the items dropped should be retained on content grounds. They added "pain," used by Delwalt et al. (2015), and "speaking English at home" to the child model. The final selection process yielded 10 child and 9 parent items. Separate multivariate analyses were conducted for children, 8 to 17 y, and their parents. These models were tested using the VIF for each variable in the model for collinearity.

We used a modified Hybrid bootstrap method to evaluate the internal validity with subsamples of both models, generating 100 random samples of the 334 subjects, with replacement, from the original sample that fitted the final model. The average and range of root mean squared errors and *R*-squares for each model were calculated. Statistical analyses were performed using SAS version 9.4.

Results

Our sample consisted of 334 child and parent dyads after 30 children were eliminated because of the orthodontic exclusion (see Table 1). Of the children in the sample, 52% were male, whereas 71% of parent respondents were female, which is due to the likelihood of mothers arranging and taking their child to dental appointments. Latinos represent 46% of the sample of participating families, followed by Whites (21%), multiracial (13%), and Asians (11%), with African Americans and "others" each representing less than 8% of the sample. This racial/ethnic distribution of the sample is similar to that of Los Angeles County (U.S. Census Bureau 2015). Slightly more than half of the parent respondents were born in the United States.

Table 1 presents descriptive statistics and bivariate comparisons with the COHSI. The mean COHSI score for the sample was 89 (SD, 8.8). The average age of the children in our sample was 12.1 y, which is between middle school–aged children (ages 8 to 12 y) and adolescents (ages 13 to 17 y). The younger age group represents 58% of the sample. Most of these children have mixed dentitions; the older group has permanent dentitions and their COHSI score is significantly higher ($P < 0.001$). Ninety-one percent of the children reported that English is their home language, and these subjects had a significantly higher COHSI score ($P = 0.01$), even though 45% of parents were not born in this country ($P = 0.06$). The COHSI score was significantly higher when the parent is female ($P = 0.01$).

Items involving physical, mental, and social questions were included. About one-third of the children reported having teeth that were not straight (physical domain), whereas half of the parents reported that their children had problems with their teeth being crooked, crowded, or with spaces; in both groups, the COHSI score was significantly lower than for those whose teeth were straight ($P < 0.0001$). About 15% of children reported having dental pain in the past 4 wk ($P = 0.07$). The majority of children and their parents were pleased with the child's mouth, teeth, and so forth ($P < 0.0001$); 50% of parents reported that their child's teeth had problems such as "crooked, crowded or spaces." Less than 4% of parents reported that their child's oral health was worse than their peers; those children had statistically lower COHSI scores ($P < 0.0001$). The next items involved social issues: 78% of children reported that they *always, almost always*, or *often* are good at making friends ($P < 0.01$). Parents who look online for information about their child's oral health had significantly lower COHSI scores ($P < 0.01$). Three-quarters of children rated their quality of life as *excellent* or *very good* ($P < 0.0001$). Bivariate comparisons provided some insight into the association the COHSI has with these variables; however, the multivariate analyses in Table 2 indicate which of these variables had unique associations with the COHSI.

Table 2 presents the results of both child and parent regression models with unstandardized coefficients and standard errors for each model's variables. The intercepts were 93 and 91 for the child and parent models, respectively. The R^2 values for the child and parent models were 0.21 and 0.27, respectively. Two demographic variables were common to both models: child's age coefficient was 0.48/y for the child model and 0.26 for the parent model, with P values of <0.01 and 0.1, respectively; if the child lived in a single-parent home, the coefficient was −1.91 for the child respondent and −2.41 for the parent, with P values of 0.09 and <0.01, respectively. If the child did not speak English at home, the coefficient was −1.38 for the child ($P = 0.38$). If the parent reported the household employment status as "not working," the coefficient was −2.83 ($P = 0.05$). If the parent respondent's gender was female, the coefficient was 2.52 ($P < 0.01$), and if the parent respondent was not born in the United States, the coefficient was −2.63 ($P < 0.01$).

Other variables listed in Table 2 concern physical, mental, social, and global heath domains. The physical variables involving occlusion and aesthetics reflect different aspects of this issue. The children's response regarding having straight teeth and the parents' response that the child's teeth have problems had coefficients of −4.49 and −4.00, respectively, both with $P < 0.0001$. The children's response regarding pain during the last 4 wk was not significant ($P = 0.49$). There were 2 cognitive (mental) variables related to perception of dental appearance, namely, the child's and their parent's response regarding how pleased or happy he or she was with the look of their child's mouth, teeth, jaws, and so forth; coefficients were –0.92 and –0.96, with P values of 0.01 and 0.03, respectively. The parent's perception of their child's oral health compared with his or her peers had a coefficient of –1.75 with a P value of 0.03. There were 3 social variables; 2 were in the child model and 1 was in the parent model. The child model's social variables were making friends and being reminded to brush his or her teeth. The coefficients varied from –0.9 to –0.35, with P values of 0.02 and 0.15,

Table 1.
Descriptive Statistics of Parent and Child Variables and Bivariate Comparisons with the COHSI.

Question	Domain	Mean (SD)	Child Survey				Parent Survey			
			n	%	Mean of Index (SD)	*P* Value	*n*	%	Mean of Index (SD)	*P* Value
Child's Oral Health Status Index		89.0 (8.8)	334	100.0						
Child's age, y										
8 to 17	Demographic	12.1 (2.8)								
13 to 17			141	42.2	90.8 (8.9)	<0.001**				
8 to 12			193	57.8	87.6 (8.4)					
Gender	Demographic									
0 = Male			174	52.1	88.5 (9.0)	0.46	97	29.0	87.1 (9.2)	0.01*
1 = Female			160	47.9	89.5 (8.5)		237	71.0	89.7 (8.5)	
I would speak English at home.	Demographic									
0 = Yes			304	91.0	89.4 (8.7)	0.01*	282	84.4	89.3 (8.8)	0.07
1 = No			30	9.0	84.8 (8.3)		52	15.6	87.0 (8.4)	
Single-parent family	Demographic									
0 = No							253	75.7	89.5 (8.6)	0.06
1 = Yes							81	24.3	87.4 (9.2)	
Family employment status	Demographic									
Full-time (reference)							261	78.1	89.4 (8.5)	
Part-Time (1 = Yes; 0 = No)							33	9.9	87.3 (9.8)	0.26
Not working (1 = Yes; 0 = No)							40	12.0	87.5 (9.4)	0.27
Were you born in the United States?	Demographic									0.06
0 = Yes							183	54.8	89.8 (9.0)	
1 = No							151	45.2	88.0 (8.4)	
My/my child's teeth are straight.	Physical									
0 = Yes			226	67.7	90.8 (8.2)	<0.0001***	195	58.4	91.7 (7.6)	<0.0001***
1 = No			108	32.3	85.1 (8.7)		139	41.6	85.1 (8.8)	
My/my child's teeth have problems such as being crooked, crowded, or with spaces.	Physical					<0.0001***				<0.0001***
0 = No			195	58.4	91.1 (8.4)		166	49.7%	92.3 (7)	
1 = Yes			139	41.6	86.0 (8.5)		168	50.3%	85.7 (9.1)	

(continued)

Table 1.
(continued)

Question	Domain	Mean (SD)	Child Survey				Parent Survey			
			n	%	Mean of Index (SD)	*P* Value	*n*	%	Mean of Index (SD)	*P* Value
In the last 4 wk, how much of the time did you/your child have pain or discomfort?	Physical									
0 = Never			214	64.1	89.4 (9.1)		247	74.0	89.3 (8.9)	
1 = Almost never			68	20.4	89.4 (8.0)	0.07	48	14.4	88.6 (8.4)	0.15
2 = Sometimes			34	10.2	86.6 (7.4)		33	9.9	86.7 (8.5)	
3 = Often			10	3.0	86.7 (11.8)		3	0.9	93.9 (3.1)	
4 = Almost always			3	0.9	81.0 (9.1)		3	0.9	83.9 (11.0)	
5 = Always			5	1.5	89.3 (5.8)		0	0.0		
When I look at my/my child's teeth . . .	Physical									
0 = They look fine			165	49.4	90.6 (8.2)		159	47.6	92.0 (7.6)	
1 = They could look a little better			156	46.7	87.7 (9.1)	<0.0001***	134	40.1	86.9 (8.9)	<0.0001***
2 = They could look a lot better			13	3.9	83.7 (8.7)		41	12.3	84.1 (8.4)	
In the last 4 wk, how much of the time were you pleased or happy with the look of your/ your child mouth, teeth, jaws, or gums?	Mental									
0 = Always			114	34.1	90.7 (8.6)	<0.0001***	116	34.7	92.0 (7.5)	<0.0001***
1 = Almost always			104	31.1	89.9 (8.0)		122	36.5	88.7 (8.8)	
2 = Often			40	12.0	89.4 (9.3)		45	13.5	87.2 (8.3)	
3 = Sometimes			48	14.4	86.0 (9.5)		38	11.4	85.3 (8.7)	
4 = Almost never			16	4.8	83.0 (6.2)		10	3.0	80.5 (11.3)	
5 = Never			12	3.6	83.4 (7.7)		3	0.9	81.44 (4.5)	
Compared to other kids my/my child's age . . .	Mental									
0 = I/he or she has better oral health			121	36.2	90.1 (8.1)		159	47.6	90.8 (7.9)	
1 = I/he or she has the same oral health			198	59.3	88.5 (9.2)	0.04*	162	48.5	87.8 (8.8)	<0.0001***
2 = I/he or she has worse oral health			15	4.5	85.9 (7.3)		13	3.9	81.0 (12.1)	

(continued)

Table 1.
(continued)

Question	Domain	Mean (SD)	Child Survey				Parent Survey			
			n	%	Mean of Index (SD)	*P* Value	*n*	%	Mean of Index (SD)	*P* Value
I/my child was good at making friends.	Social									
0 = Always			201	60.2	90.1 (8.3)		185	55.4	89.1 (8.7)	
1 = Almost always			60	18.0	88.2 (8.6)		94	28.1	88.8 (8.7)	
2 = Often			33	9.9	87.4 (9.3)	<0.01**	22	6.6	86.2 (10.0)	0.97
3 = Sometimes			24	7.2	86.3 (8.4)		28	8.4	90.3 (9.0)	
4 = Almost never			10	3.0	89.0 (6.6)		2	0.6	99.1 (1.2)	
5 = Never			6	1.8	79.1 (17)		3	0.9	85.8 (8.5)	
How often do your parents/you remind you/your child to brush your/your child's teeth before you go to sleep?	Social									
0 = Never			52	15.6	90.4 (8.3)		16	4.8	94.3 (6.7)	
1 = Almost never			31	9.3	91.9 (7.4)		27	8.1	89.2 (9.4)	
2 = Sometimes			54	16.2	88.3 (8.5)	0.08	49	14.7	89.7 (7.2)	0.01*
3 = Often			25	7.5	87.4 (9.4)		35	10.5	90.7 (7.5)	
4 = Almost always			37	11.1	88.8 (8.6)		50	15.0	87.8 (8.2)	
5 = Always			135	40.4	88.3 (9.2)		157	47.0	88.1 (9.5)	
Have you gone online to look for information that would help you with your child's oral health?	Social									
0 = Yes							81	24.3	86.5 (10.9)	<0.01**
1 = Did not find the information online							3	0.9	89.8 (7.8)	
2 = No							250	74.9	88.8 (10.0)	
In general, would you say you/your child's quality of life is . . .	Global									
0 = Excellent			147	44.0	89.8 (8.7)		158	47.3	89.4 (9.1)	
1 = Very good			106	31.7	90.1 (8.1)	<0.0001***	137	41.0	88.2 (8.8)	0.79
2 = Good			71	21.3	87.0 (8.2)		39	11.7	90.0 (7.2)	
3 = Fair			7	2.1	79.0 (12.8)		0	0.0		
4 = Poor			3	0.9	78.6 (14.6)		0	0.0		

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 2.
Multivariate Linear Regression of Parent and Child Variables by the COHSI.

Variable	Children Model (R^2 = 0.21, n = 334)			Parent Model (R^2 = 0.27, n = 334)		
	Coefficient (SE)	*P* Value	VIF	Coefficient (SE)	*P* Value	VIF
Intercept	93.8 (1.4)	<0.0001***	0.0	90.6 (1.5)	<0.0001***	0.0
Child's age 8 to 17 y (0 = 8 y old, 1 = 9 y old, etc.)	0.5 (0.2)	<0.01**	1.2	0.3 (0.2)	0.10	1.1
Child: I would speak English at home (0 = yes, 1 = no)	–1.4 (1.6)	0.38	1.1			
Parent: Single-parent family (0 = no, 1 = yes)	–1.9 (1.1)	0.09	1.2	–2.4 (1.0)	0.01*	1.0
Parent: Family employment status						
Full-time (reference)						
Part-time (1 = yes, 0 = no)	–0.1 (1.6)	0.93	1.2			
Not working (1 = yes; 0 = no)	–2.8 (1.5)	0.05	1.2			
Parent: Gender of parent (0 = male, 1 = female)				2.5 (0.9)	<0.01**	1.01
Parent: Were you born in the United States? (0 = yes, 1 = no)				–2.6 (0.8)	<0.01**	1.03
Child: My teeth are straight. (0 = Yes; 1 = No.)	–4.5 (1.0)	<0.0001***	1.10			
Parent: My child's teeth have problem like crooked, crowded, or with spaces (0 = no, 1 = yes)				–4.0 (1.0)	<0.0001***	1.45
Child: In the last 4 wk, how much of the time did you have pain or discomfort? (0 = never, 1 = almost never, 2 = sometimes, 3 = often, 4 = almost always, 5 = always)	–0.3 (0.4)	0.49	1.1			
Parent: When I look at my child's teeth . . . (0 = they look fine, 1 = they could look a little better, 2 = they could look a lot better)				–1.4 (0.8)	0.07	1.6
Child/parent: In the last 4 wk, how much of the time were you pleased or happy with the look of your/your child's mouth, teeth, jaws, or gums? (0 = always, 1 = almost always, 2 = often, 3 = sometimes, 4 = almost never, 5 = never)	–0.9 (0.4)	<0.01**	1.27	–1.0 (0.4)	0.03*	1.5
Parent: Compared to other kids my child's age . . . (0 = he or she has better oral health, 1 = he or she has the same oral health, 2 = he or she has worse oral health)				–1.8 (0.8)	0.03*	1.2
Child: I was good at making friends (0 = always, 1 = almost always, 2 = often, 3 = sometimes, 4 = almost never. 5 = never)	–0.9 (0.4)	0.02*	1.2			
Child: How often do your parents remind you to brush your teeth before you go to sleep? (0 = never, 1 = almost never, 2 = sometimes, 3 = often, 4 = almost always, 5 = always)	–0.4 (0.2)	0.15	1.1			
Parent: Have you gone online to look for information that would help you with your child's oral health? (0 = yes, 1 = did not find the information online, 2 = no)				1.5 (0.5)	<0.01**	1.0
Child: In general, would you say your quality of life is . . . (0 = excellent, 1 = very good, 2 = good, 3 = fair, 4 = poor)	–1.1 (0.5)	0.05*	1.3			

COHSI, Children's Oral Health Status Index; SE, standard error; VIF, Variance Inflation Factor.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 3.
Descriptive Statistics of Model External Validation Using Hybrid Bootstrap for Children's and Parent's Models.

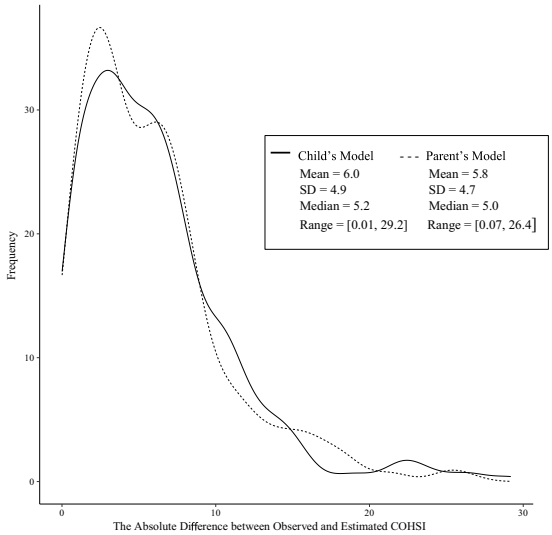
Model	Measure	Original	Bootstrap Sample		
			Mean	Min	Max
Child	Root mean squared error	7.9	7.7	6.7	8.6
	R^2	0.215	0.222	0.178	0.289
Parent	Root mean squared error	7.6	7.4	6.5	8.1
	R^2	0.273	0.278	0.213	0.343

respectively. The parent model's social variable was significant and involved using the Internet to seek information regarding oral health. Those who sought this information had children with a lower COHSI score, with a coefficient of 1.51 and a *P* value less than 0.01. The global variable, the child's perception of their quality of life, had a coefficient of –1.1, with a *P* value of 0.05.

The last column in Table 2 presents VIF scores. We assume that VIF scores 4 or lower indicate that there are no multicollinearity concerns among variables. Therefore, the range of VIF of 1.01 to 1.64 indicates that collinearity is not found with these variables.

Table 3 presents the results from a hybrid bootstrap analysis for 100 random samples generated with replacement using both the child and parent models, presenting average root mean squares of the absolute difference between the random samples and observed values and R^2. The observed root mean squared error was 7.9 for the child model and 7.6 for the parent model, with simulated means of 7.7 and 7.4, respectively, and simulated ranges of 6.7 to 8.6 and 6.5 to 8.1. The observed R^2 was 0.215 (child) and 0.273 (parent) compared with the simulated mean of the R^2 of 0.222 (child) and 0.278 (parent), with ranges of 0.178 to 0.289 and 0.213 and 0.343. These R^2 values, whether actual or simulated, show a fair degree of stability, although only the highest parent-simulated value explains a third of the variance. Root mean squared error provides a measure of external validity using simulated samples. It shows how well the model fits the data; moreover, the simulated samples provided different mixes of individuals who represent different populations with a dental home drawn from the sample. A low root mean squared error indicates better fits. Because of the higher R^2 percentage in the observed and simulated samples and the lower root mean squared error, the parent model is slightly better in estimating the COHSI score.

Figure 2. The absolute difference between observed and estimated COHSI by children's and parent's models. COHSI, Children's Oral Health Status Index.



We also examined the models in terms of the internal validity at the individual level based on the absolute difference, regardless of sign, between observed index score and estimated index score from the model for each subject, presented in Figure 2. The range for these differences for the child model is 0.01 to 29.2 and from 0.07 to 26.4 for the parent model. The curves presented show that 50% of the child and parent models' estimations are less than 6 index points, with a median value of 5.2 for the child and 5.0 for the parent model. The shape of the curve shows that the parent model tends to have slightly better estimates. The skewness of these curves indicates that there are a few outliers that have extremely high differences: 29.2 points (child model) and 26.4 (parent model), which tend to distort the results.

Discussion

The FDI definition of oral health described above is a broad-based concept (Glick et al. 2016) that, in addition to physical and functional aspects, includes emotional and

confidence dimensions. This view overlaps with the *PROMIS*® domains, such as mental and social aspects. The most important variables that influenced the oral health of the children were related to family structure, employment, parent being native born, aesthetics, pleased with dentition and quality of life; however, speaking English at home or having pain or discomfort in the last 4 wk was not important.

The qualitative approach used in this study revealed that newly developed survey items, when added to previously used legacy survey items, yielded child and parent data banks totaling 272 items. These items were reduced to 10 child and 9 parent items by a series of statistical methods and expert panels. Selected survey items administered to children 8 to 17 y and their parents yielded 2 regression models that related to clinical oral health status. The models explained one-fifth (child model) to more than one-quarter (parent model) of the variance, partially reflecting traditional low R^2 values based on survey data. For example, age had a positive impact on the oral health of these children. In the child model, for each year greater than the age of 8 y, oral health increased by almost a half of an index point. The difference between an 8- and a 17-y-old, with all other factors being equal, amounts to a 4.3 higher index score. The reason for this is that the index includes occlusal dimensions that are likely to be more evident in the transitional dentition than in than that of the adolescent. Occlusal issues resolve themselves, are treated at this stage, or are evidenced in the adolescent dentition. The child's response that he or she spoke English at home was not significant, while the parent's immigrating to the United States reduces the child's index by 2.63. Household composition was important in both models; for children residing in single-parent households, the parent model had a significant difference in their child's COHSI score. Not surprisingly, this item reflects the economic and social issues that may have an impact on the child's oral health. Similarly, living in a household with unemployed adults results in a loss of 2.83 index points in the child model, while this variable was not a factor in the parent model. An interesting finding was that if the respondent was female, the oral health status of their child was significantly higher, by 2.52 points. This raises the question as to whether mothers are more optimistic or more knowledgeable than their partners in assessing their child's oral health. While direct questions regarding oral health were not selected, aesthetics played a significant role in estimating oral health status. Children who said their teeth were not straight had 4.49 less index points than their counterparts, while their parents who answered that their children had problems, such as crooked or crowded teeth or with spaces, had 4.0 less index points. In both models, being happy with the look of the child's teeth was an important consideration. The presence of pain was included in the child's model because it is considered an important aspect of oral health status, although it was not a significant factor in terms of coefficient or *P* value, probably because only 8 or 2.4% of child responders reported that they *always* and *almost always* had pain or discomfort. The fact that so few reported pain or discomfort in the last 4 wk is a function, with this short time interval, of both having a dental home and the interpretation of discomfort. It was also interesting that a single item on assessing quality of life entered the children's model at the $P = 0.05$ level, while a question asking the child to rate oral health was not selected. It is interesting to consider why general quality of life is strongly related to oral health status while a direct question rating oral health is not.

The findings of this study point to the real possibility of using child and parent survey data to estimate oral health status in lieu of more complex methods such as screenings, which do not focus on oral health status but rather need for treatment. *PROMIS*® oral health measures may provide a picture of oral health status among populations, which can be the basis for targeting subgroups who have issues that can best be understood by estimating oral health status. This is a different perspective from that of specific disease entities, by bringing both children and parents into the process in the way that *PROMIS*® is doing in medicine.

Our future research will employ other cutting-edge statistical approaches such as item response theory, a method that permits more appropriate analyses of unobservable or latent traits that can be measured by both the individual respondent and a group of items (Stata Press 2017).

Implications of This Study

The translational implications of this research can inform efforts to broaden the concept of oral health, by offering sets of parent and child items that encompass the domains used in the *PROMIS*® methodology. The study will inform research studies on behalf of enhancing an understanding of the link between perceived and clinically determined oral health. It also advances oral health research by developing tools to establish estimates of oral health status of groups of children. Survey items from this study can also advance care for children by providing a basis for care programs to better screen their patient populations.

Limitations of the Study

This study has several limitations. First, this article is limited to the parents of children and adolescents, ages 8 to 17 y. Second, the *PROMIS*® approach looks at patients in care, and because our study uses the *PROMIS*® methodology, our analyses apply only to children who have access to oral health care. By using a population-based approach, which includes children not in care, we can determine if the same variables are associated with oral health status.

Author Contributions

M. Marcus, H. Liu, contributed to conception, design, data acquisition, analysis, and interpretation, drafted

and critically revised the manuscript; C.A. Maida, contributed to conception, design, data acquisition, and interpretation, drafted and critically revised the manuscript; Y. Wang, contributed to data acquisition and analysis, critically revised the manuscript; D. Xiong, contributed to data acquisition, critically revised the manuscript; R.D. Hays, I.D. Coulter, V.W. Spolsky, J.J. Crall, contributed to conception and design, critically revised the manuscript; S.Y. Lee, contributed to conception, design, data acquisition and interpretation, critically revised the manuscript; J. Shen, contributed to data acquisition and analysis, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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