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Observed child and parent toothbrushing behaviors and child oral health

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Abstract

Background—Parent-led toothbrushing effectively reduces early childhood caries. Research on the strategies that parents use to promote this behavior is, however, lacking.

Aim—To examine associations between parent–child toothbrushing interactions and child oral health using a newly developed measure, the Toothbrushing Observation System (TBOS).

Design—One hundred children ages 18–60 months and their parents were video-recorded during toothbrushing interactions. Using these recordings, six raters coded parent and child behaviors and the duration of toothbrushing. We examined the reliability of the coding system and associations between observed parent and child behaviors and three indices of oral health: caries, gingival health, and history of dental procedures requiring general anesthesia.

Results—Reliabilities were moderate to strong for TBOS child and parent scores. Parent TBOS scores and longer duration of parent-led toothbrushing were associated with fewer decayed, missing or filled tooth surfaces and lower incidence of gingivitis and procedures requiring general anesthesia. Associations between child TBOS scores and dental outcomes were modest, suggesting the relative importance of parent versus child behaviors at this early age.

Conclusions—Parents' child behavior management skills and the duration of parent-led toothbrushing were associated with better child oral health. These findings suggest that parenting skills are an important target for future behavioral oral health interventions.

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Conflict of interest

Dr. Huebner reports receiving salary support from grants from National Institute of Dental and Craniofacial Research (NIH/NIDCR), during the conduct of the study. Dr. Wallace reports grants from National Institute of Dental and Craniofacial Research (NIH/NIDCR), during the conduct of the study. Dr. Seminario has nothing to disclose. Dr. Collett reports grants from National Institute of Dental and Craniofacial Research (NIH/NIDCR), during the conduct of the study. Dr. Gray reports grants from National Institute of Dental and Craniofacial Research (NIH/NIDCR), during the conduct of the study. Dr. Speltz reports grants from National Institute of Dental and Craniofacial Research (NIH/NIDCR), during the conduct of the study.

Introduction

Parent-supervised twice daily toothbrushing with fluoridated toothpaste is a simple, highly effective strategy for preventing ECC^{1,2}. Unfortunately, young children seldom receive the support needed to facilitate the development of this important health behavior^{3,4}. Even among parents who appreciate the importance of brushing, many have their child begin brushing independently at a young age rather than providing ongoing support with parent-led toothbrushing⁴. Interventions to promote regular toothbrushing have typically focused on increasing caregivers' awareness of the importance of brushing and early childhood oral health⁵ and on increasing children's own toothbrushing skills⁶. Little attention has been given, however, to the strategies that parents use during toothbrushing to manage child behavior problems and encourage compliance. A study by Huebner and Riedy⁴ suggests that this is an important oversight, as the barrier to twice daily toothbrushing that parents most often cited was child refusal. Thus, even when parents are motivated and educated about the importance of early oral health, they may struggle to help their child establish this routine.

Social learning theory, which has been influential in the development of interventions for child behavior problems⁷, illuminates the potential interplay between parenting and oral health behaviors. In this framework, parents' management of child behavior at home is seen as either promoting or discouraging child engagement in toothbrushing and other oral health routines. At the same time, the child's behavior 'shapes' caregiver responses, following the tenants of operant learning theory. For example, when a child tantrums during toothbrushing, a parent can be negatively reinforced for stopping the activity by termination of the child's aversive behavior. The child's defiant behavior is also negatively reinforced by escape from an unpleasant task. Such cycles are common in family interactions but insidious and self-perpetuating, making it more likely that the child will behave defiantly to escape toothbrushing and that the parent will discontinue toothbrushing to minimize unpleasant child behavior.

A recent study by de Jong-Lenters and colleagues⁸ offers preliminary support for a social learning theory model of oral health. Using a case-control design to study children with and without caries, the authors observed parent-child dyads during play, teaching, and planning/problem solving tasks. Cases were children ages 5-8 years old with a history of 4 caries, and controls were age-matched children with no caries history. Among case dyads, parents received worse scores than controls with regard to positive involvement, encouragement, problem solving, coercion, and interpersonal atmosphere. The authors suggest that parenting practices might be associated with interactions during toothbrushing and other oral health behaviors associated with caries. Building on this research, in this study, we investigated the associations between observed parent-child toothbrushing interactions and indicators of child oral health. We developed and validated an observational tool, the Toothbrushing Observation System (TBOS), to characterize parent and child toothbrushing behaviors. Based on a social learning model, we hypothesized that parents' child behavior management skills and child compliance would be associated with better oral health (e.g., fewer decayed, missing, or filled tooth surfaces).

Materials and methods

Participants

Children ages 18–60 months and their parents were recruited from a university-affiliated pediatric dental clinic. This developmental period was selected to capture variability in parent and child behaviors. Specifically, although the American Academy of Pediatric Dentistry recommends parent supervision of toothbrushing for all children in this age range², we anticipated age-related changes in the degree of child autonomy. This progression is of interest for future studies on behavioral strategies to support good oral health in young children.

Parents were approached in person after their child's dental visit or by mail. For families approached in person, the child's dental provider first determined whether the family was interested in hearing about the study. Those who expressed interest were then approached by a member of the study team, provided with information about the project, and screened for eligibility. Those who could not be approached in person (e.g., because their child did not attend a dental visit during the study period) were sent an approach letter and given an opportunity to 'opt out' of participation or indicate their interest by returning a response card. Project staff followed up by phone with families who either returned the response card or failed to respond. Families who expressed interest in participating were then screened to determine eligibility. In addition to child age 18–60 months, families were considered eligible if English or Spanish was the primary language spoken in the home. Children were excluded if they were in foster care or state custody. One hundred and one child–parent dyads consented to participate and completed a study visit, representing 45% of the eligible families approached.

All parents provided informed consent to participate in the study. Study procedures were approved by the Seattle Children's Hospital Institutional Review Board.

Measures

Toothbrushing observation system (TBOS)—The TBOS is coded from video-recorded toothbrushing interactions. Parents are instructed to 'Brush your child's teeth as you would at home' and are allowed to determine how long to brush, and whether brushing will be done by the child, parent, or combination.

The TBOS coding includes separate yes/no items for parent and child behavior (Fig. 1). The item format and some items were adapted from the NCAST Teaching and Feeding scales⁹, which have been used to evaluate parent–child interactions in pediatric populations^{10,11}. Parent items focus on behavior management strategies, including methods to increase desired behaviors and responses to child behavior problems. Child items include refusal behaviors and adaptive responses. Higher scores for both scales reflect more adaptive behavior. In some cases, items are not applicable to a given observation. For example, if a child does not exhibit refusal behavior during the interaction, items pertaining to the parent's management of behavior problems are not scored. When calculating scores, we assigned each adaptive parent and child behavior observed a score of 1, calculated the total scores, and divided the number of items coded by the total score (see Fig. 1). For both parent and

child scales, scores have a possible range of 0 (i.e., no adaptive behaviors coded) to 1 (i.e., all adaptive behaviors coded).

The duration of parent and child toothbrushing (in seconds) is also recorded. Parent toothbrushing is defined as the time the parent spent actively brushing the child's teeth (i.e., parent holding the toothbrush or guiding the child using hand-over-hand assistance, toothbrush in the child's mouth). Child toothbrushing is defined as the time the child spent independently brushing his or her own teeth (i.e., child holding the toothbrush alone, toothbrush in the child's mouth).

Parent dental health and behavior questionnaire (PDHBQ)—The PDHBQ is a parent-report questionnaire adapted from previous oral health measures^{4,12,13}. We included the following items: (1) *How often are you brushing your child's teeth now per day on average? (Never, Once a Day, Twice a Day, More than Twice)* and (2) *How does toothbrushing usually go for you? (Always a Struggle, Sometimes a Struggle, Easy/No Problems, Not Sure)*. For analyses, the frequency of parent-reported child toothbrushing was coded as 'less than twice per day' versus 'twice per day or more'. Parents' perceived difficulty brushing the child's teeth, coded as 'easy/no problems' or 'sometimes a struggle' versus 'always a struggle'.

Dental records review—Children's dental records were reviewed by one of the authors (BC). These records included dental visits prior to the child's study visit and up to 6 months following the visit. Odontograms were reviewed to determine the number of decayed, missing, or filled tooth surfaces (dmfs), a measure of the presence and extent of dental decay. A dichotomous variable was also created to indicate any history of caries. We also coded dichotomous outcomes for any history of general anesthesia for dental procedures and any history of gingivitis. Coding was reviewed with a pediatric dentist (ALS) to ensure accuracy.

Procedures—Study visits were completed in a pediatric dental clinic, in a room equipped with a child-sized sink and unobtrusive video-recording equipment. Parents were instructed to first play with their child as they would at home. They were alerted that after approximately 5 min, a study assistant would knock on the door, cuing the parent to transition to toothbrushing. Toothpaste and child toothbrushes were provided, as well as an adult toothbrush for parents who chose to brush along with the child. Parents determined when they were 'done' brushing and were instructed to transition to another activity when toothbrushing was complete. After they transitioned, coding of toothbrushing behavior was discontinued. All participants completed two observations on the same day, before and after a snack break (Observations 1 and 2). Forty of the parent-child dyads returned within 2 weeks for a third observation (Observation 3).

Recordings were coded by the first author (BC) and by 5 research staff and undergraduate volunteers. A manual was developed with operational definitions for items and to document coding decisions (available from the authors upon request). Prior to coding observations for the study, coders reviewed the manual and coded preliminary video recordings to achieve inter-rater agreement of 70% with the first author for parent and child items. Throughout

the study, coders received periodic feedback on their reliability to reduce drift away from operational definitions. Observations for predominately Spanish-speaking families were coded independently by 3 of the coders who were fluent in Spanish. Coders did not receive identifying information or information related to children's oral health status. To reduce possible order effects (i.e., observation of one parent-child dyad affecting the coding of a subsequent dyad), coders each reviewed the observations in a unique, randomized order.

Analyses

Descriptive statistics—We calculated descriptive statistics, including means, standard deviations, ranges, and frequencies for demographic characteristics, TBOS scores, toothbrushing times, and oral health status. To aid interpretation, parent and child scores on the TBOS were converted to standardized z-scores, allowing us to examine associations per 1 standard deviation (SD) in TBOS scores. When examined as an exposure, toothbrushing times were divided by 10 to reflect 10-s increments of brushing.

Reliability—Inter-rater reliability was calculated using intraclass correlation coefficients (ICC) to evaluate agreement averaged across coders. Reliability estimates were calculated separately for child and parent scores for each observation. Similar procedures were used to determine inter-rater reliability for parent and child toothbrushing time.

To calculate test-retest reliability, parent and child scores from all coders were averaged, resulting in a single set of scores for each observation. We then calculated ICC for Observation 1:Observation 2 and for Observation 1:Observation 3.

Associations with oral health—Regression analyses were used to examine the associations between child and parent TBOS scores, child and parent toothbrushing times, and the associations between TBOS scores and data collected using parent-report measures and child dental records. All analyses were adjusted for child age (months), *a priori*, given the association between age and the incidence of caries¹⁴ and anticipated correlations between age and child and parent behaviors during toothbrushing. Because there was a high proportion of children without caries, we used zero-inflated negative binomial regression models to estimate incidence rate ratios (IRRs) for the magnitude of the association between parent and child score on dmfs score¹⁵. To determine the precision of these estimates, corresponding 95% confidence intervals were calculated using bootstrapped standard error estimates with 1000 resamplings. To examine the associations of child and parent interaction scores with toothbrushing times, we used linear regression analyses with robust standard error estimates. For dichotomous outcomes, we used logistic regression analyses to estimate odds ratios and 95% confidence intervals. Analyses were performed using Stata version 12¹⁶.

Results

Descriptive statistics

Observations for 4 participants were eliminated from analyses due to poor audio on the recording. Another 4 observations were eliminated because the dyad spoke a language other

than English or Spanish for the majority of the observation, despite reporting that English or Spanish was the primary language spoken in the home. Data were coded for a total of 93 parent–child dyads in Observation 1, 93 dyads in Observation 2, and 32 dyads in Observation 3. Among the six coders, 4 scored all available observations for English-speaking dyads ($n = 86$) and two scored only a portion of the observations (46% and 63%, respectively). Forty-one observations were coded by all 6 coders.

Demographic characteristics for participants are summarized in Table 1. Most child participants were aged 42 months, male, and white/non-Hispanic. Families were diverse in terms of socioeconomic status (SES), with approximately half of participants from upper SES families¹⁷. Forty percent of children had a history of caries, 41% had a history of gingivitis, and 16% had a previous dental procedure requiring general anesthesia. Fifty-two percent of parents reported that it was ‘always a struggle’ to brush their child’s teeth, and 66% reported that their child brushed their teeth at least twice per day.

Child toothbrushing interaction scores ranged from 0.27 to 0.84, and parent scores ranged from 0.29 to 0.78. The correlation between parent and child scores was weak ($r = 0.13$). The total time spent toothbrushing (combined, parent and child toothbrushing times) was an average of 71 s (SD = 41.2) and ranged from 18 to 263 s. On average, children brushed their own teeth for 30 s (SD = 35.9), and parents brushed the child’s teeth for 41 s (SD = 30.1). Parent and child toothbrushing times were inversely correlated ($r = -0.23$).

TBOS reliability

Inter-rater reliabilities were calculated for the 4 coders who reviewed all observations. Reliability averaged across these coders ranged from ICC = 0.80 to ICC = 0.82 for child scores, and from ICC = 0.62 to ICC = 0.63 for parent scores (Table 2). Reliability was high for child and parent toothbrushing times (ICC = 0.93 to 0.99). Parent and child scores were moderately stable for same-day observations (ICC = 0.62 for both) and over a 2-week interval (ICC = 0.63 and 0.67 for parent and child scores respectively). Similarly, toothbrushing times were moderately to highly stable for same-day observations (ICC = 0.86 and 0.76 for parent and child times, respectively) and at 2-week follow-up (ICC = 0.75 and 0.93).

Associations with oral health

Higher parent scores were associated with longer parent toothbrushing times and were inversely associated with child toothbrushing time (i.e., higher parent scores were associated with less independent child toothbrushing) (Table 3). Child scores were not associated with either parent or child toothbrushing time.

Parent TBOS scores were inversely associated with dmfs (IRR = 0.53, 95% CI = 0.24, 0.81). For every 1 SD increase in parent scores, indicating better child behavior management strategies, there was a 47% decrease in dmfs scores. Parent toothbrushing time was also associated with lower dmfs scores (IRR = 0.88, 95% CI = 0.77, 1.00). Child toothbrushing scores showed a similar relationship with dmfs (IRR = 0.71, 95% CI = 0.20, 1.32), although the confidence interval was wide and included the null. There was a modest, positive association between child toothbrushing time and dmfs (IRR = 1.08, 95% CI = 0.96, 1.21),

indicating that more child toothbrushing time was associated with higher dmfs scores. The confidence interval was, however, again wide and included the null.

Similar patterns emerged in dichotomous analyses. Higher parent scores were associated with lower odds of the child having any history of caries (OR = 0.59, 95% CI = 0.35, 0.99). Although estimates were imprecise and included null values, higher parent scores were also associated with lower odds of gingivitis (OR = 0.70, 95% CI = 0.44, 1.10) and any dental procedure requiring general anesthesia (OR = 0.58, 95% CI = 0.32, 1.06). Parent scores were not associated with reported difficulty brushing the child's teeth at home or toothbrushing frequency. Child scores were not significantly associated with dichotomous measures of oral health status. Higher child scores were associated, however, with lower odds of parent reported difficulty brushing teeth at home (OR = 0.26, 95% CI = 0.12, 0.56). Parent toothbrushing time was not significantly associated with any of the dichotomous outcomes. Child toothbrushing time was associated with greater odds of any dental procedure requiring general anesthesia (OR = 1.16, 95% CI = 1.00, 1.36). In other words, children who spent more time brushing their own teeth were more likely to have required general anesthesia for a dental procedure.

Discussion

The primary aim of this study was to investigate the associations between parent-child interaction processes and key indicators of child dental disease. As hypothesized, parents' behavior management strategies were associated with several indicators of child oral health. This was most evident with regard to caries, where an improvement of 1 SD in the TBOS parent score was associated with 47% fewer dmfs. We also found consistent associations between the duration of parent-led toothbrushing and oral health status. Associations between child scores on the TBOS and oral health status were not as robust, although higher child scores, reflecting more adaptive behavior, were modestly associated with better oral health. As might be expected, child TBOS scores were associated with parents' perception of toothbrushing as being a struggle at home.

The observed time spent on toothbrushing, 71 s, is comparable to that observed in previous studies of child tooth brushing¹⁸ but much shorter than recommended¹⁹. Interestingly, longer durations of independent child toothbrushing were associated with more dmfs and greater likelihood that the child had required general anesthesia for a dental procedure. Our timing required only that the child was holding the toothbrush in his or her mouth, and we did not quantify the effectiveness of brushing. For example, young children often sucked the toothpaste off of the toothbrush or chewed on the toothbrush with little actual brushing, and by our definition this was counted as toothbrushing time. Independent child toothbrushing may have been less effective than parent-led toothbrushing, and it appears that child toothbrushing replaced rather than added to parent toothbrushing. These findings underscore the importance of parent involvement in toothbrushing routines for young children.

The TBOS parent and child scales were relatively stable over time and showed moderate inter-rater reliability. Similarly, reliability estimates were high for measures of parent and child toothbrushing duration. Reliability may be improved with refinement of the

observational coding system, and by averaging scores over at least two observations. Reliability may also be higher when observing a more homogeneous population (e.g., children within a narrower age range, only English or Spanish-speaking families). We found adequate range in parent and child behaviors during toothbrushing, despite possible changes in behavior associated with being observed. As summarized by Gardner²⁰, there is little research examining the effects of setting on parent–child observational data. In the case of toothbrushing interactions, we would anticipate greater behavioral variability in the home versus laboratory setting. For example, punitive parenting behaviors that were rare in the laboratory setting may be expected with greater frequency in the home. If anything, we anticipate that the toothbrushing times observed would be overestimates relative to toothbrushing time at home. Replication of our findings using video recordings of toothbrushing at home would help to clarify the extent of setting effects.

In addition to the possibility of observer effects, limitations of this study include the relatively low consent rate and ascertainment of families from a pediatric dental clinic. Participating families may differ from those who declined in important ways, including the emphasis parents place on oral health and their effectiveness in managing their child's behavior. For example, parents who anticipated child behavior problems may have been less likely to take part in the study. This possible ascertainment bias would not be expected to affect the reliability of our coding system and, if anything, would make it more difficult to detect an association between parent and child behaviors and oral health. The pediatric dental clinic used as the recruitment site serves a high percentage of children receiving healthcare coverage through Medicaid as well as children with special healthcare needs. These populations are at particular risk for poor oral health outcomes^{21,22}, and this was reflected in the high rate of caries and dental procedures under general anesthesia in our participants. Measures such as the TBOS are therefore highly relevant for future work aimed at improving child oral health in similar 'at risk' populations; however, these factors may limit the generalizability of our findings and replication is needed in community-based samples.

Our findings support the notion that family factors, and parent–child relationships in particular, are important in understanding risk for caries in young children²³. Further, these findings and those of de Jong-Lenters *et al.*⁸ suggest a potential mechanism linking family factors to child oral health. Specifically, family adversity in the form of parent distress and poor mental health may strain parent–child interactions during oral health routines with both short and long-term implications for child health. Based on our findings, we hypothesize that parents' use of adaptive behavior management strategies allows longer parent-led toothbrushing, with downstream benefits for child oral health. Parents who struggle with child behavior management may either reduce demands for toothbrushing at home or allow their child to brush his or her teeth independently, which is likely to be inadequate. Ideally, this hypothesis would be tested further in prospective studies that track toothbrushing interactions and oral health over a longer interval. Additionally, future studies utilizing observed parent–child interactions may help to identify specific, actionable targets for parent-focused behavioral interventions to improve child oral health.

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Why this paper is important to paediatric dentists

- Preventive dental care may be enhanced by targeting parents' behavior management strategies during toothbrushing as part of parent education and anticipatory guidance.
- As part of parent education, it is important to emphasize the importance of *parent-led* toothbrushing, versus independent child toothbrushing, to promote good child oral health.
- Parents' management of child behavior during toothbrushing and other oral health routines may be a modifiable 'mechanism of action' in the association between family adversity and child oral health.

Parent Items ^a	Yes	No	N/A
Offered one or more appropriate choices			
Physically scaffolded the interaction			
Prompted child to open his/her mouth wide			
One or more positive messages to motivate (e.g., "Your teeth will be so clean!")			
Laughed or smiled during toothbrushing			
Used bribery to resolve problem behavior			
3 or more unlabeled praise statements related to toothbrushing			
One or more negative remarks about or to the child			
Used distraction to help child brush teeth (e.g., singing a toothbrushing song)			
Yelled at child or raised voice			
1 or more labeled praise statements related to toothbrushing			
Made threats			
<i>Parent Score = Total of Unshaded Items / [12 – Total of Items Marked N/A]</i>			
Child Items ^a	Yes	No	N/A
Easily transitioned to toothbrushing			
Imitated parent's demonstrations of toothbrushing			
Played with toothbrush, toothpaste, or water > 50% of the time			
Looked at parent's face			
Focused attention on toothbrushing > 50% of the time			
One or more verbal descriptions of toothbrushing			
Sucked, bit, or chewed on toothbrush			
Initiated gentle, social physical contact with parent (e.g., sitting on parent's lap without prompt)			
Gentle with parent and toothbrushing materials			
Asked questions related to toothbrushing			
"Bossy" towards parent			
Responded to parent's cues > 50% of the time			
Showed any distress			
Comforted by parent's response to distress			
Showed any refusal behavior			
Whined, complained, or other mild verbal protest			
Yelled or screamed			
One or more major refusal behaviors			
<i>Child Score = Total Unshaded Items / [18 – Total of Items Marked N/A]</i>			

Fig. 1.
Parent and child items coded for the Toothbrushing Observation System (TBOS).

Table 1

Demographic characteristics of participating children.

	<i>N</i>	%
	93	100.0
Age		
<24 mos	7	7.5
24–42 mos	43	46.2
>42 mos	43	46.2
Gender		
Female	40	43.0
Male	53	57.0
Race		
Non-white or Hispanic	27	29.0
White, non-Hispanic	65	69.9
Socioeconomic status [*]		
I (high)	16	17.2
II	34	36.6
III	22	23.7
IV	15	16.1
V (low)	5	5.4

^{*} Socioeconomic status scored using the Hollingshead Index¹⁵.

Table 2

Inter-rater reliability of measures by observation.

Measure	Intraclass Correlation Coefficients by Observation	
	Observation 1 <i>n</i> = 86	Observation 2 <i>n</i> = 86
Parent score	0.62	0.63
Child score	0.82	0.80
Parent time	0.99	0.99
Child time	0.99	0.93

Associations between child and parent scores on the Toothbrushing Observation System (TBOS) and parent, child, and total toothbrushing times.

Table 3

Exposure	Outcome								
	Parent time brushing (seconds)			Child time brushing (seconds)					
	Beta	95% CI		Beta	95% CI	Total time brushing (seconds)			
Parent TBOS score (per 1 SD increase)	11.77	6.44	17.10	-7.31	-16.40	1.78	4.46	-4.77	13.69
Child TBOS score (per 1 SD increase)	2.77	-4.48	10.02	-0.51	-10.20	9.18	2.26	-7.93	12.45