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Evidence of Early Emergence of the Primary Dentition in a Northern Plains American Indian Population

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Abstract: *The purposes of this study were to describe primary tooth emergence in an American Indian (AI) population during the first 36 mo of life to compare 1) patterns of emergence between male and female children and 2) tooth emergence between these AI children and other U.S. ethnic groups. Data were derived from a birth cohort of 239 AI children from a Northern Plains tribe participating in a longitudinal study of early childhood caries, with examination data at target ages of 8, 12, 16, 22, 28, and 36 mo of age (± 1 mo). Patterns of emergence in AI children were characterized and sex comparisons accomplished with interval-censored survival methodology. Numbers of erupted teeth in AI children at each age were compared via Kruskal-Wallis tests against those in children of the same age, as drawn from a cross-sectional study of dental caries patterns in Arizona; these comparisons were based*

on the dental examinations of 547 White non-Hispanic and 677 Hispanic children. Characterization of time to achievement of various milestones—including emergence of the anterior teeth, the first molars, and the complete primary dentition—provided no evidence of sex differences among AI children. AI children had significantly more teeth present at 8 mo (median, 3) than either White non-Hispanic ($P < 0.0063$) or Hispanic ($P < 0.0001$) children (median, 2 each). This was also true at 12 mo ($P < 0.001$; medians, 8 vs. 6 and 7, respectively) and 16 mo ($P < 0.001$; medians, 12 vs. 11 each). Less pronounced differences were seen at 22 mo ($P < 0.0001$). White non-Hispanic and Hispanic children did not differ at any time considered ($P > 0.05$). These results provide evidence of earlier tooth emergence in AI children than in the other 2 ethnicities. Although the underlying etiology of the severity of

early childhood caries in AI children is likely to be multifactorial, earlier tooth emergence may be a contributing factor.

Knowledge Transfer Statement: *The findings of this study have practical implications for practitioners providing childhood oral health care to ethnic groups with early tooth emergence. It may be important to provide parents with information on toothbrushing, dentist visits, and other practices supportive of good oral health as early as possible to protect their children's primary dentition.*

Keywords: tooth emergence, tooth eruption, children, oral health disparities, dental caries, minority health

Introduction

The emergence of the human primary dentition, while showing variation among individuals, follows a typical

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timeline and sequence. This pattern is sufficiently established such that landmark events of primary tooth emergence are commonly regarded as *developmental milestones*. Since radiographic evaluation is not commonly used for children during the first few years of life, observation of emergence is important to the assessment of primary tooth development and the diagnosis of associated developmental problems, as informed by known variances based on sex and ethnicity (Demirjian and Levesque 1980; Suri et al. 2004; Gupta et al. 2007). The term *emergence* refers to the appearance of any portion of the cusp or crown in the oral cavity, while the term *eruption* denotes the movement of the entire tooth to the final position of occlusion with the opposing tooth (Suri et al. 2004).

Tooth emergence may have particular significance in relation to early childhood caries, since early eruption of the primary teeth may lead to greater time of exposure to the caries process. Furthermore, caries risk may increase because the likelihood of colonization by mutans streptococci—believed to be the primary putative etiologic agents of early childhood caries formation—increases with the number of teeth present (Mohan et al. 1998; Bezerra et al. 2016; Chokshi et al. 2016; Johansson et al. 2016; Marsh 2016). Evidence from human and animal studies supports a correlation between the emergence of primary teeth and colonization by mutans streptococci and organisms such as *Streptococcus sanguinis* (Caufield et al. 2000). Early emergence of the primary teeth may therefore be associated with early acquisition of cariogenic organisms. Early colonization with mutans streptococci is associated with higher levels of salivary mutans streptococci and higher levels of decay (Köhler and Andréén 2012), and early acquisition of mutans streptococci is a major risk factor for early childhood caries and future caries experience (Berkowitz 2006).

In a longitudinal study of an American Indian (AI) birth cohort recruited from a Northern Plains tribe (Drake

et al. 2015), observations from oral examinations provided an impression of early tooth emergence, including 4 reports of children with natal teeth. This study, which followed AI children to age 36 mo, investigated the risk factors associated with dental caries, with a focus on microbial outcomes—including the characterization of *Streptococcus mutans* transmission and the potential role of genetic diversity among *S. mutans* strains in this population, which is at notably high risk of early childhood caries: specifically, prevalence of cavitated lesions in this cohort exceeded 80% at 36 mo of age (Warren, Blanchette, et al. 2016). Moreover, early acquisition of *S. mutans* was observed in this cohort (Lynch et al. 2015).

In addition to the anecdotal information suggesting early tooth emergence, formal comparison of this AI population with U.S. Black and White children based on the number of teeth present at 12 mo revealed that AI children had significantly more teeth present at 1 y than did children in the other 2 ethnic groups (Warren, Fontana, et al. 2016). Published reports of early permanent tooth emergence in AI populations (Steggerda and Hill 1942; Titley and Paedo 1984; Phipps et al. 2013) suggested that formal comparisons of primary tooth emergence patterns with those of other populations were warranted, particularly if extended to a broader period, to address the paucity of published information regarding the timing and sequencing of primary tooth emergence in AI populations.

The objectives of this study were to describe primary tooth emergence in an AI population during the first 36 mo of life, to evaluate patterns of emergence between male and female children with longitudinal methods, and to compare tooth emergence in AI children with that in other U.S. ethnic groups.

Materials and Methods

Data for fulfillment of study aims were derived from 2 sources. The first aim—the delineation of primary tooth

emergence patterns in Northern Plains AI children (Drake et al. 2015)—utilized longitudinal data from an AI birth cohort. The second aim compared the tooth emergence status of these AI children at each longitudinal visit with that of U.S. Hispanic and White non-Hispanic children of similar ages from a large cross-sectional study (Douglass et al. 2001). In both studies, children received visual dental caries examinations. Teeth were considered to have emerged when any portion of the tooth was visible.

Northern Plains AI Population

A group of 239 AI mother-child dyads recruited perinatally in 2009 to 2010 participated in a longitudinal oral health project conducted on the reservation of a Northern Plains tribe. This study had an overall goal of identifying risk factors for early childhood caries in AI infants and toddlers, with a focus on the role of the mutans streptococci and specific genotypes of *S. mutans* in combination with behavioral and dietary factors and their interactions. Detailed dietary and oral hygiene behaviors, as well as family and demographic characteristics, were obtained for children and their mothers via questionnaire; plaque samples were also collected for microbial assays. Dental examinations, including caries assessments, were conducted by dental hygienists trained to criteria adapted from those used in the National Health and Nutrition Examination Survey and other studies. Further details have been given elsewhere (Warren et al. 2012; Drake et al. 2015; Warren, Blanchette, et al. 2016). Relevant to the present study are the dental examinations that were performed at baseline (approximately 1 mo of age) and at target ages of 4, 8, 12, 16, 22, 28, and 36 mo (± 1 mo). An individual tooth was considered present if any part of it was clearly visible in the mouth. All procedures were reviewed for proper ethical research practices and approved by the Tribal Community's Human Subjects Research Review Board, the Aberdeen Area Indian Health Service Institutional Review Board, and the University of Iowa Human Subjects

Committee (approval 200701741). Written informed consent was obtained by the Tribal Health Administration at the project site. Consent for the child was obtained from his or her parent/guardian.

Comparison Populations

A comparison group of similar age was drawn from a large cross-sectional study conducted from 1994 to 1995, which examined the dental caries patterns of Arizona infants and children (Douglass et al. 2001). This study focused on caries experience and oral health behaviors, as well as tooth emergence, among 2,428 children aged 6 to 36 mo. Children were recruited from the federally funded WIC (Women, Infants and Children) program for low-income children at nutritional risk and from health fairs and private day care centers. All children received visual dental caries examinations, and teeth were considered present when any portion of the tooth was detectable in the mouth.

To obtain comparison samples for the AI children who would be of similar age, Arizona children aged 8, 12, 16, 22, 28, and 36 mo (± 1 mo) were selected. The 1-mo window around these 6 target ages was the same as that specified by the protocol of the AI study. Tooth emergence data used for comparison with the AI population were restricted to racial/ethnic groups of sufficient sample size for meaningful comparisons, resulting in comparison groups of 547 non-Hispanic White children and 677 Hispanic children; insufficient sample sizes of Arizona African American and AI children of the requisite ages were available for study. Consent for the dental examination and survey was obtained from each caretaker after the procedures and risks were explained. The study and consent form was approved by the Arizona Department of Health Services Human Subjects Review Committee.

Although the 2 studies had distinct sets of examiners, they used very similar criteria for recording caries and erupted teeth, both of which were based on the

traditional dmf criteria. Both studies considered a tooth to be present if any part of it was visible in the mouth. The study of AI children used 4 dental hygienist examiners who were trained and calibrated by a gold-standard examiner and achieved excellent reliability (pairwise kappa values, 0.90 to 0.94). The study that included Hispanic and White Non-Hispanic children utilized 5 dentist examiners who were also trained and calibrated, also with excellent reliability (average kappa value, 0.97). In both studies, examinations were conducted at field sites with mouth mirrors and standardized light sources.

Statistical Analysis

Descriptors of the number of teeth present in the mouth at each longitudinal evaluation were generated for the AI population. Tooth emergence patterns in AI children were characterized with interval-censored survival methodology, including modifications of the Kaplan-Meier estimator (Sun 1966) and the log-rank test (Chen et al. 2013) used for sex comparisons. *Interval censoring* refers to situations where the outcome of interest is time to event, but the occurrence of the event of interest can be recorded only at specific intervals—in this case, at the time of periodic dental examinations. The outcomes considered included times to completion of 6 landmarks: emergence of the first primary tooth, the 4 maxillary incisors, the 8 anterior teeth, the first molars, all posterior teeth, and all 20 teeth in the primary dentition. In addition to generation of time-to-completion curves for each landmark, medians and interquartile range were estimated. The same approach was used to examine completion of emergence for each of the 4 tooth types to investigate their order of emergence. Results were obtained with the exact age of the child at the time of evaluation via the *interval* (Fay and Shaw 2010) and *survfit* (Therneau 2014) packages in R.

Kruskal-Wallis tests were used to compare the numbers of erupted teeth at each age in the 3 ethnic groups (AI, White, and Hispanic children). Pairwise

comparisons of groups were made with the Wilcoxon-Mann-Whitney procedure; multiple-comparisons adjustment was made with the Holm-Bonferroni method (Holm 1979) in conjunction with an overall 0.05 significance level. Wilcoxon-Mann-Whitney tests were also used to compare the number of teeth present in males and females for each age. Statistical analyses were performed with SAS 9.3 software (SAS Institute Inc.). Violin plots (Hintze and Nelson 1998) were generated with the *vioplot* package in R 3.1.0 (R Foundation; Adler 2005).

Results

Table 1 presents descriptive statistics for the number of erupted teeth observed at baseline (approximately 1 mo of age, ± 30 d) and at each of the 7 follow-up times for the AI cohort of 239 children. Four children had teeth at the baseline visit, which were reported to have been present at birth. These included a female seen at 1.1 mo of age, a male seen at 1.5 mo, and a female seen at 0.3 mo—all of whom had both mandibular central incisors present; the right mandibular central incisor only was present in the fourth child, a female seen at 1.8 mo. Retention of subjects was $\geq 95.0\%$ at each visit (Drake et al. 2015).

Figure 1 provides further description of tooth emergence in this population, including time to completion of 4 landmarks. Figure 1A describes the time to emergence of the first tooth for male and female AI children, with nonparametric methods allowing for interval censoring (Sun 1966). Figure 1B and 1C provide the analogous information for the time to emergence of the 8 anterior teeth and the 4 first molars, respectively. Figure 1D includes the time to emergence for all 20 teeth of the primary dentition. Sex comparisons were made with respect to time to completion of 2 additional landmarks: emergence of the 4 maxillary incisors and all posterior teeth. The associated time-to-event curves are similar for the emergence of the 4 maxillary incisors and the 8 anterior teeth, though slightly earlier, and the curves are identical for

Table 1.

Descriptive Statistics for Number of Erupted Teeth Present at 8 Dental Examinations in a Birth Cohort of 239 American Indian Children.

Visit	Target Age, mo, ± 30 d	n	Erupted Teeth Present, n					
			Mean	SD	Min to Max	Lower Quartile	Median	Upper Quartile
1	1	238 ^a	0.03	0.23	0 to 2	0	0	0
2	4	232	0.29	0.70	0 to 3	0	0	0
3	8	230	3.50	2.49	0 to 8	2	2	6
4	12	233	7.75	2.39	0 to 16	7	8	8
5	16	231	12.44	3.31	2 to 18	10	12	16
6	22	234	16.21	1.23	11 to 20	16	16	16
7	28	227	18.93	1.55	16 to 20	18	20	20
8	36	232	19.95	0.39	16 to 20	20	20	20

^aReflects exclusion due to death of 1 child early in the study.

emergence of all posterior teeth and all 20 teeth of the primary dentition (figures not shown). There was no evidence of a difference between males and females in tooth emergence patterns for any of the 6 landmarks considered ($P > 0.54$ in all instances).

In the absence of evidence for sex differences, medians and the first and third quartiles were estimated on the basis of interval analysis of longitudinal data from both sexes. The estimated median time to emergence of the first primary tooth was 6.5 mo (first and third quartiles: 4.5 and 7.0 mo); for all 4 maxillary incisors, 9.4 mo (8.2 and 9.4 mo); and all 8 anterior teeth, 11 mo (8.8 and 11.6 mo). The relative closeness of the median and the first and third quartiles for each landmark indicates the considerable similarity of completion times among a substantial proportion of children in this AI cohort; this is also reflected in the steepness of the time-to-completion curves (Fig. 1) around the 50th percentile. Similar patterns were seen for the posterior teeth. The median time to emergence of the first molars was 14.5 mo (first and third quartiles: 14.5 and 20.2 mo). The estimates for emergence of all posterior teeth were identical to those for all 20 teeth of

the primary dentition (median time to landmark completion, 27.5 mo; first and third quartiles: 27.5 and 28.4 mo).

Within the limitations of these data, the general sequencing of emergence in terms of tooth type appeared to be consistent with typical expectations. Because of the interval-censored nature of the data and the possibility of occasional missed visits, sequencing could not always be completely determined for a given child. Nevertheless, based on analyses of the times to completion of the 5 tooth types, the sequencing of emergence generally observed was as follows: central incisors, lateral incisors, first molars, canines, and second molars. Discrepancies in this order of completion occurred between 0% and 3% of the time for any pair of tooth types. Median times to emergence for all 4 teeth of the 5 tooth types were as follows, as obtained via methods for interval-censored data: central incisors, 8.2 mo; lateral incisors, 11.0 mo; first molars, 14.5 mo; canines, 15.9 mo; and second molars, 27.5 mo.

Strong evidence supported earlier emergence of the primary dentition in AI children than in the 2 other U.S. ethnic groups. Tables 2 provides the mean and median numbers of teeth present

for 3 ethnic groups at 6 time points between 8 and 36 mo of age: the AI cohort and the Hispanic and White non-Hispanic children from the Arizona study (Douglass et al. 2001). The data provide consistent evidence that the distribution of the number of teeth present differed significantly among the ethnic groups at ages 8, 12, 16, and 22 mo ($P < 0.0001$) and 36 mo ($P = 0.0008$). There was no evidence of any difference in the number of teeth present among the 3 groups at age 28 mo. No evidence of a sex difference was found in any of the ethnic groups with respect to the number of teeth present at any of the 6 targeted ages ($P > 0.05$).

As indicated in Table 2 and Figure 2, AI children had significantly greater numbers of erupted teeth than children in one or both of the other ethnic groups at ages 8, 12, 16, and 22 mo after adjustment for the 18 pairwise multiple comparisons. These distributions are further described through violin plots (Fig. 2). Each plot is a modification of the traditional box plot, which displays the median and interquartile range of the number of teeth present for a given age and ethnic group, superimposed over a kernel density plot (also called a *density trace*) to further illustrate the

Figure 1. Time to completion of 4 tooth emergence landmarks in male and female American Indian children: time to emergence of the (A) first primary tooth, (B) 8 anterior teeth, (C) 4 first molars, and (D) all 20 teeth of the primary dentition. There was no evidence of a sex difference in time to completion for any of the landmarks considered.

distribution. This symmetric density trace is regarded as a smoothed histogram (Hintze and Nelson 1998), which provides insights into the shape of the distribution of interest not discernible from conventional box plots, including features such as bimodality and clustering. Figure 2A to 2C clearly illustrates the greater numbers of teeth present in the AI children at ages 8,

12, and 16 mo: the median number of teeth (indicated by the white circle) is consistently higher for AI children than for Hispanic children or non-Hispanic White children over this age range. A similar pattern is seen for the middle half of the data (signified by the black bar between the first and third quartiles). At 12 mo, the tight clustering of the distribution around the median is

particularly notable in the density trace (gray shaded area) for the AI children, with a more restricted interquartile range (black bar) than in the other 2 ethnic groups. At 16 mo, the density trace for AI children has a greater proportion in the higher range of the number of teeth (seen as the upper bulge in the density trace) relative to the other 2 ethnic groups.

Table 2.

Distribution of the Number of Teeth Present in Young Children from 3 Ethnic Groups: American Indian, Hispanic, and White Non-Hispanic.

Target Age, mo, ± 30 d	Teeth Present and Sample Size: Mean (Median), <i>n</i>			Pairwise Comparisons of Ethnic Groups, <i>P</i> Value ^a		
	American Indian	Hispanic	White Non-Hispanic	AI vs. H	AI vs. W	H vs. W
8	3.7 (2.5), 232	2.3 (2); 91	2.7 (2); 77	<0.0001 ^b	0.01237 ^c	0.23242
12	7.8 (8), 235	6.7 (7); 114	5.9 (6); 103	<0.0001 ^b	<0.0001 ^b	0.06881
16	12.4 (12), 232	10.9 (11); 110	10.5 (11); 88	<0.0001 ^b	<0.0001 ^b	0.43945
22	16.2 (16), 234	15.6 (16); 114	15.4 (16); 93	0.0074 ^c	<0.0001 ^b	0.27919
28	18.9 (20), 236	18.5 (20); 113	18.5 (20); 93	0.18938	0.22736	0.99472
36	19.9 (20), 229	19.7 (20); 135	19.7 (20); 93	0.01437 ^c	0.00237 ^b	0.55129

AI, American Indian; H, Hispanic; W, White non-Hispanic.

^a*P* value associated with the Wilcoxon-Mann-Whitney test of no difference in the distribution of the number of teeth present in the 2 specified groups.^bPairwise comparison significant after adjustment for multiple comparisons was made via the Holm-Bonferroni method in conjunction with an overall 0.05 level of significance.^cPairwise comparison associated with a *P* value <0.05 that was not significant after adjustment for multiple comparisons; these results may be regarded as suggestive.

At 22 mo (Fig. 2D), the lead of the AI group is beginning to attenuate, although the greater level of completion or near completion of primary tooth emergence in the AI children is still evident, with few children having ≤ 14 teeth. The distributions did not differ significantly at 28 mo, as illustrated by the identical medians and general forms in Figure 2E. Figure 2F indicates that the significant and suggestive results given in Table 2 for age 36 mo are largely attributable to the greater number of “stragglers” in the non-Hispanic White and Hispanic groups who did not yet complete emergence of the primary dentition at 36 mo. There was no difference between non-Hispanic White and Hispanic children at any age considered ($P > 0.05$).

Discussion

These results provide evidence of earlier primary tooth emergence in this group of AI children than in the other 2 ethnic groups studied. No sex differences with respect to primary tooth emergence were identified in this AI population, nor were sex differences in the number of teeth present at a specified age found in either the Hispanic or non-Hispanic White children

in the Arizona comparison populations. This study extends the previous report of Warren, Fontana, et al. (2016), which documented greater numbers of teeth present in this cohort of AI children at 12 mo of age relative to U.S. White and African American children of the same age who were participating in a study of early childhood caries risk prediction in Indiana, Iowa, and North Carolina. The current study provides evidence of earlier tooth emergence in these AI children relative to other U.S. populations and demonstrates that earlier emergence is seen across a greater age span, with differences at 8, 12, 16, 22, and 36 mo of age. Note that although no evidence of such differences was found between the Hispanic and White non-Hispanic groups, their sample sizes were somewhat smaller, and power would therefore be less.

Two comparatively recent published reports support the presence of earlier emergence in the permanent dentition in AI populations: Phipps et al. (2013) found that AI first graders participating in the Indian Health Service oral health surveillance survey (2011 to 2012) had a higher prevalence of (permanent) first molar emergence than did children from a survey of Ohio schoolchildren in

1987 to 1988. Titley and Paedo (1984) reported delays and accelerations in the emergence of the permanent teeth of Cree and Ojibway children as compared with a sample of French-Canadian children, depending on the teeth considered; they also identified sex differences in time to emergence. This is in contrast to the current study and that of Warren, Fontana, et al. (2016), which identified no evidence of sex differences. The earlier anthropologic study of Steggerda and Hill (1942) was largely descriptive but suggested earlier emergence of the permanent dentition in Navajo AI populations than in the White, African American, and Mayan groups studied; it also suggested sex differences, although these were less evident in the Navajo population. Both contemporary reports noted that greater understanding of the timing of the emergence of permanent teeth may aid in the assessment of preventive and treatment priorities and the timing of such services. It is unclear why tooth emergence appears to be earlier in at least some groups of AI children; nevertheless, these considerations are important for considering the elevated prevalence and severity of dental caries observed in AI populations (Phipps et al. 2013).

Figure 2. Violin plots showing the distribution of the number of teeth present at ages 8, 12, 16, 22, 28, and 36 mo (A–F, respectively) in children from 3 ethnic groups: American Indian, Hispanic, and White non-Hispanic. Violin plots display the median (white circle) and interquartile range (black bar) of the number of teeth present for a given age and ethnic group, superimposed over a kernel density plot to further describe the distribution. Gray shaded area indicates density trace.

Some limitations of the present work may be noted. Consideration of the literature makes clear that availability of information related to eruption times is limited, and few studies are done with a focus on tooth eruption. This is true even of the present study, where exact times of eruption were not available and interval-censored survival analysis had to be used. Monthly evaluations with tighter windows around the target dates for examination would be desirable but may be unlikely to be realized. The reported differences in eruption are fairly modest, and limitations in estimation have been noted. A further limitation is the comparison made with an external cross-sectional data set. Based on these considerations, it seems that more accurate quantification of early eruption and its potential impact will have to await further study and perhaps the collection of appropriate data for more refined time-to-event analyses.

Nevertheless, there are reasonable explanations why earlier eruption might predispose to earlier and greater caries burden. Early emergence may undermine current preventive efforts, since the institution of regular oral hygiene and the delivery of oral health information to parents would both need to be implemented at an earlier age. Furthermore, *emergence* implies longer exposure to risk of caries and thus greater potential for decay. Moreover, early emergence of the primary teeth may be associated with earlier acquisition of cariogenic organisms. From a microbiological perspective, early emergence of the primary teeth may be associated with earlier colonization of hard surfaces by the oral bacteria that appear to be the primary drivers of demineralization.

Erupted teeth are rapidly colonized by members of the oral microbiome (Heller et al. 2016; Welch et al. 2016).

These patterns of microbial community development on teeth have been extensively studied (Xu et al. 2015; Johansson et al. 2016; Welch et al. 2016). Mutans streptococci are the primary etiologic agents of caries and are typically late colonizers of existing microbial communities on teeth (Bezerra et al. 2016; Chokshi et al. 2016; Johansson et al. 2016; Marsh 2016). Under conditions associated with caries development, such as a diet rich in fermentable sugars, this group of bacteria become dominant within the microbial communities on the teeth, leading to acid production and demineralization of the teeth (Bezerra et al. 2016; Hajishengallis et al. 2016; Johansson et al. 2016; Welch et al. 2016). These considerations suggest that earlier emergence may be a contributing factor to the high prevalence of caries in this AI cohort, particularly given the poor nutritional environment in this AI community, which

predisposes AI children to dental caries (Marshall et al. 2014).

Adding to these concerns are descriptions in the literature of the predictive relationship between caries in the primary dentition and caries in the permanent dentition. In an 8-y cohort study of 362 Chinese children aged 3 to 5 y at intake (Li and Wang 2002), children with caries in the primary teeth were 2.6 times more likely to develop caries in their permanent teeth. Similarly, Skeie et al. (2006) found significant correlation between caries experiences in the 2 dentitions, comparing caries status in 186 Norwegian children examined as 5-y-olds and reexamined as 10-y-olds. This suggests a grim prospect for this AI cohort, given the generally high caries levels in AI populations relative to the general U.S. population (Centers for Disease Control and Prevention 1985; Phipps et al. 2013) and the specific experience of this cohort, where cavitated lesions were first observed in the primary dentition at 8 mo of age. By 36 mo of age, cavitated lesions were found in 80.2% of these AI children, with a median 8.5 decayed, missing, or filled surfaces. The longitudinal caries experience reflected the rapid pace at which children developed caries as well as the aggressiveness of the disease.

We acknowledge that the role of early emergence in the underlying etiology of the severity of early childhood caries in AI children is speculative at this point. Although the high caries rates in these pediatric populations have been recognized for >50 y and various preventive approaches tried, a single factor explaining these extremely high caries rates is yet to be identified, and this heavy caries burden is likely due to a combination of factors. Given these results, early eruption may be represent a part of this multifactorial etiology, at least in some AI populations, but the extent is yet to be determined. These findings could have practical implications for childhood oral health care in the AI community, in terms of 1) the setting of public health preventive and interventional schedules and 2) the

timing of parental education regarding the oral health of their young children. It may be important to provide parents with information on toothbrushing, dentist visits, and other practices supportive of good oral health as early as possible to protect their children's primary dentition.

Author Contributions

D.V. Dawson, contributed to conception, design, data analysis, and interpretation, drafted and critically revised the manuscript; D.R. Blanchette, contributed to conception, data analysis, and interpretation, drafted and critically revised the manuscript; J.M. Douglass, N. Tinanoff, contributed to data acquisition, analysis, and interpretation, drafted and critically revised the manuscript; K.W.O. Kramer, T.R. Mabry, K. Pagan-Rivera, contributed to data analysis and interpretation, critically revised the manuscript; J.J. Warren, D.R. Drake, contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript; K.R. Phipps, contributed to conception, design, data acquisition, analysis, and interpretation, critically revised the manuscript; D.E. Starr, contributed to conception, data acquisition, and interpretation, critically revised the manuscript; T.A. Marshall, contributed to conception, design, data analysis, and interpretation, critically revised the manuscript; J.A. Banas, contributed to data interpretation, drafted and critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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