Oral health status in Navajo Nation Head Start children

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Abstract

Objective: This study assessed oral health status for preschool-aged children in the Navajo Nation to obtain data on baseline decayed, missing, and filled tooth surfaces (dmfs) and dental caries patterns, describe sociodemographic correlates of children's baseline dmfs measures, and compare the children's dmfs measures with previous dental survey data for the Navajo Nation from the Indian Health Service and the National Health and Nutrition Examination Survey (NHANES).
Methods: The analyzed study sample included 981 child/caregiver dyads residing in the Navajo Nation who completed baseline dmfs assessments for an ongoing randomized clinical trial involving Navajo Nation Head Start Centers. Calibrated dental hygienists collected baseline dmfs data from child participants ages 3-5 years (488 males and 493 females), and caregivers completed a basic research factors questionnaire.
Results: Mean dmfs for the study population was 21.33 (SD = 19.99) and not appreciably different from the 1999 Indian Health Service survey of Navajo Nation preschool-aged children (mean = 19.02, SD = 16.59, $P = 0.08$). However, only 69.5 percent of children in the current study had untreated decay compared with 82.9 percent in the 1999 Indian Health Service survey ($P < 0.0001$). Study results were considerably higher than the 16.0 percent reported for 2-4-year-old children in the whites-only group from the 1999-2004 NHANES data. Age had the strongest association with dmfs, followed by child gender, then caregiver income and education.
Conclusion: Dental caries in preschool-aged Navajo children is extremely high compared with other US population segments, and dmfs has not appreciably changed for more than a decade.

Introduction

National surveys of oral health status indicated that dental caries in children ages 2 to 5 years increased between 1988-1994 and 1999-2004, and marked differences existed among ethnic groups (1). Oral disease levels in American Indian and Alaska Native children are by far the highest, suggesting disparate risk and the need for effective, culturally acceptable interventions (2). A recent study reported that 68.4 percent of American Indian and Alaska Native preschool children had dental caries experience and 45.8 percent had untreated dental caries, and the mean decayed and filled teeth (dft) score was 3.5, which was three times higher than the scores of their non-Native counterparts. In the Navajo Nation, dental

caries among preschool children is especially severe; a recent survey reported a mean decayed, missing, and filled teeth (dmft) score of 6.5 for 2-5 year olds, the highest in Indian country (3).

The Center for Native Oral Health Research at the University of Colorado initiated a randomized clinical trial (Clinicaltrials.gov NCT01116739) in Navajo Nation Head Start Centers in 2010 to test the effectiveness of a community-based intervention to reduce dental caries in young children. The intervention consisted of delivery of fluoride varnish applications to Head Start children and oral health promotion events for children and their caregivers by specially trained Native paraprofessionals designated as community oral health specialists. The primary outcome variable was dmfs, measured at baseline and then annually for a duration of 3 years. At the time of acquisition of dmfs data, caregivers also completed a computerized 190-item basic research factor questionnaire to assess caregivers' dental knowledge, attitudes, and behaviors and other psychosocial characteristics that may be moderators or mediators of the observed treatment effect (4). This paper reports baseline dmfs data and patterns of dental caries, describes sociodemographic correlates of the children's baseline dmfs measures, and compares children's dmfs measures to previous dental Indian Health Service (IHS) survey data from Navajo Nation (2,3) and the National Health and Nutrition Examination Survey (NHANES) (1,5).

Methods

Approvals

This study was approved by the Navajo Nation Human Research Review Board, governing bodies at tribal and local levels, the tribal departments of Head Start and Education, Head Start parent councils, and the University of Colorado Multiple Institutional Review Board. The study also has ongoing oversight by the National Institute of Dental and Craniofacial Research (NIDCR).

Study design

The study was a cluster-randomized clinical trial. There were 100 Head Start Center-based classrooms in the Navajo Nation at the study inception. The Head Start Centers were first stratified on the basis of single versus multiple Head Start classrooms in each building location and by Navajo Nation agency (five agencies) and then randomized to intervention and control groups within those strata. Fifty-two Head Start classrooms were enrolled in the study, 26 in each treatment arm (4).

Head Start eligibility

Eligible participants were Head Start enrollees and their caregivers. On the Navajo Nation, Head Start eligibility is based on age and income. Children must be at least 36 months of age, and their family income must be equal to or less than 100 percent of the federal poverty level. Children from families with incomes exceeding federal poverty guidelines can be enrolled in Navajo Nation Head Start programs after all income-eligible children have been enrolled.

Study eligibility

All enrolled Head Start children were eligible to participate in the study. Children were American Indian or Alaska Native as defined by their tribe or children of other race/ethnic groups who were Head Start enrollees. Children younger than 3 years, children without a parent or legal guardian to give consent for participation in the study, and children unable to understand English were excluded. Children were also excluded if allergic to any components of the fluoride varnish or if they had health conditions or findings that, in the opinion of the investigator, would interfere with or preclude participation in the study, including ulcerative gingivitis, stomatitis, or other conditions resulting in chronically disrupted or irritated oral mucosa. The intervention was administered by the trained community oral health specialist over two Head Start program school years: fluoride varnish was offered four times per school year and oral health promotion activities provided to children four times per school year in the Head Start classrooms. Oral health promotion programs were offered to caregivers at specific Head Start events three times per school year, in addition to a parent–child kick-off event each year. Participants in the usual-care arm received toothbrushes and toothpaste for all family members at enrollment.

Outcome measures and data collection

The primary outcome measure was the number of decayed, missing, and filled tooth surfaces (dmfs) for each child. The dmfs data were collected by dental hygienists trained for the study and systematically calibrated to ensure consistency. Eight dental hygienists conducted study evaluations during 2011-2013. All dental hygienists completed calibration training with a gold-standard examiner. Calibration training was conducted in accordance with a designated protocol and criteria used by the NIDCR and the Centers for Disease Control and Prevention (NHANES program studies) for examinations and scoring. Two study investigators served as gold-standard examiners for calibration of the dental hygienists (the same two individuals conducted all training). Study investigators who served as gold-standard examiners

completed calibration training with an independent gold-standard examiner (the same individual conducted all training). Recalibration of all examiners was conducted annually. Kappa scores were calculated from a minimum of 13 dental examinations. Calibration scores were independently analyzed to determine when kappa scores met or exceeded target thresholds; specifically, for demineralized lesions, examiners had to achieve surface-level kappa values of 0.40 or greater, while for cavitated decayed lesions, examiners were required to achieve surface-level kappa values of 0.75 or greater. Overall surface-level kappa values for all types of decay had to be 0.70 or higher. The calibrated dental hygienists were blinded to the study condition. Dental hygienists completed visual assessment of children's teeth to obtain dmfs at baseline and at 12, 24, and 36 months. Data recording was conducted by trained study personnel using Mini laptop computers (Dell, Austin, TX, USA). The findings were recorded using an electronic dental research-recording instrument designated as CARIN (CAries Research Instrument), specifically designed for research documentation involving dmfs/DMFS. Examinations were conducted using a headlamp (SurgiTel, Ann Arbor, MI, USA) and lighted mouth mirror (Defend MirrorLite Illuminated Mouth Mirror, Hauppauge, NY, USA). Teeth to be examined were brushed for 30 seconds to remove debris, dried with gauze, and systematically evaluated for presence of decayed and filled surfaces. Caries detection and measurement criteria were used to visually evaluate and score lesions (6). Noncavitated lesions (demineralization) were not identified as decay. A cavitated lesion involving a smooth surface was defined as demonstrable loss of enamel structure and, for approximal smooth surfaces, undermining with discoloration under a marginal ridge and either direct extension onto the proximal surface or evidence of a break in the proximal enamel surface. A cavitated lesion involving pits/fissures was defined as demonstrable loss of enamel structure upon visual examination with evidence of active decay, such as demineralization or undermining of enamel. A second outcome variable, the percentage of children with at least one untreated carious tooth surface, was reported, as this outcome variable, in addition to dmfs, is often used in studies assessing oral health status. Caregivers completed a computerized 190-item basic research factor questionnaire to assess their dental knowledge, attitudes, and behaviors. The questionnaire also addressed other psychosocial scales as potential moderators or mediators of observed treatment effects in the trial. Caregivers were asked to complete the survey at enrollment and annually for three years. In this paper we report the results of baseline data collection.

Statistical analyses

Basic descriptive statistics are reported for dmfs and percentage of children with at least one untreated carious tooth surface in Navajo Head Start Center enrollees by gender and age of the child and by income and education of the caregiver.

A mixed-effects analysis was used to assess the effects of child age and gender on dmfs. An interaction term was assessed to see if the relationship between dmfs and age differed between males and females. The interaction term was not statistically significant ($P > 0.05$) and was removed from the analysis. Head Start classroom was treated as a random effect in order to account for the clustering of children within each classroom. In addition, caregiver education and income were assessed as potential predictors of dmfs.

Logistic regression analysis was used to assess the simultaneous, independent association between sociodemographic predictors and children with any untreated caries. *t*-Tests were used to compare mean dmfs in the current clinical trial with mean dmfs reported in the 1999 IHS survey of Navajo Nation (2) and mean dfs (decayed and filled tooth surfaces) in the current clinical trial with mean dfs in the 1999-2004 NHANES survey (1). Chi-squared tests were used to compare the percentage of children with untreated caries in the current clinical trial with the same statistic in the IHS surveys of Navajo Nation reported in 1999 (2) and 2010 (3) and in oral health surveys of all race/ethnic groups in NHANES (1,5). All analyses were conducted in SAS version 9.3 (SAS Institute, Cary, NC, USA).

The target sample size for the clinical trial was 1,040 child/caregiver dyads in 52 Head Start classrooms to enable detection of a 10 percent increase in the intervention group compared to a 40 percent increase in the usual-care group using an expected baseline dmfs of 23 (standard deviation of 24) based upon the 1999 IHS dental survey. The target sample was also based on an average cluster (Head Start class) size of 20, an intraclass correlation for the dmfs measure of 0.045, a statistical power of 80 percent, and a retention rate of 70 percent.

Results

A total of 1,016 child/caregiver dyads from 52 Head Start classrooms were enrolled in the clinical trial. This represents 100 percent of the enrollment goal for Head Start classrooms and 97.6 percent of the children and caregivers goal. At baseline, the dmfs data were collected for 981 children (488 males and 493 females). Table 1 presents descriptive statistics for the mean dmfs measure and the percentage of children with untreated caries by age and gender of the children and by education and income of the caregivers. The dmfs was higher in males compared with females (23.3 versus 19.4, $P = 0.005$) and, as expected, in older compared with younger children (37.5 at age 5 years versus 22.9 at age 4 years versus 18.2 at age 3 years, $P < .0001$). It is noteworthy that the sample size is smaller in the 5-year-old group as compared to the 3- and 4-year-old groups. There was no statistically significant

Table 1 Decayed, Missing, and Filled Tooth Surfaces and Percentage of Untreated Decay by Child Age and by Gender and Caregiver Education and Income

Category		*n*	Mean dmfs	SD	Percent with untreated decay
Age of child (years)					
3		408	18.2	19.4	66.7
4		546	22.9	19.8	71.8
5		25	37.5	23.0	68.0
P value			<0.0001		0.34
Gender of child					
Male	Age 3	190	20.0	20.1	67.9
	Age 4	281	24.9	20.3	74.7
	Age 5	16	33.4	22.8	62.5
	All ages	488	23.3	20.5	71.7
Female	Age 3	218	16.7	18.6	65.6
	Age 4	265	20.7	19.0	68.7
	Age 5	9	44.9	22.7	77.8
	All ages	493	19.4	19.3	67.3
P value			0.005		0.18
Caregiver education					
Below high school		153	23.0	20.0	75.8
High school/GED		364	23.5	21.3	69.0
Some college		340	19.9	19.0	69.7
College graduate		112	16.8	17.7	62.5
P value			0.053		0.30
Caregiver income					
Missing		153	19.7	18.8	71.9
<$10K		411	24.0	21.1	71.5
$10K to <$20K		169	22.0	19.7	69.8
$20K to <$30K		90	15.0	16.9	66.7
$30K to <$40K		68	17.3	17.9	63.2
≥$40K		90	20.3	20.1	63.3
P value			0.012		0.80

Age data missing for one male and one female child.

interaction between gender and age. The dmfs tended to decrease with increasing caregiver education (23.0 for caregivers who did not finish high school to 16.8 for college graduates, $P = 0.053$) and income (24.0 for <$10,000 per year to 20.3 for ≥$40,000 per year, $P = 0.012$).

The percentage of children with any caries experience was 89.3 percent, and that of untreated dental caries was 69.5 percent. There were no statistically significant associations between the percentage of children with untreated dental caries and the children's gender or age or the caregivers' level of education or income (*P*-values ranging from 0.18 to 0.80).

Figure 1 presents the heat maps for each primary tooth with previous or current dental caries based on gender and age. The heat maps demonstrated a high prevalence of dental caries in the maxillary central incisors and mandibular first and second molars. Moderately high levels of dental caries prevalence were found in the maxillary first and second molars and maxillary lateral incisors. The teeth with the lowest prevalence of dental caries were the maxillary canines and mandibular incisors and canines.

Table 2 shows the simultaneous, independent relationships between the sociodemographic predictors and baseline dmfs. Age had the strongest association ($P < 0.0001$), followed by gender ($P = 0.005$), caregiver income ($P = 0.01$), and caregiver education ($P = 0.053$). On average, 5-year-olds had 18.5 more carious surfaces than 3-year-olds and 14 more than 4-year-olds. Males had 3.5 more carious surfaces than females, children of caregivers with less than a high school education had 3.7 more carious surfaces than children of college graduates, and children of caregivers with incomes <$10,000/year had from 1.1 to 7.7 more carious surfaces than children of families with incomes >$10,000/year. It is interesting that the relationship between the increase in dmfs and the decrease in income was not monotonic.

Table 3 presents the simultaneous, independent relationships between the sociodemographic predictors and children with untreated tooth caries. There were no statistically significant independent relationships between any of the sociodemographic predictors and untreated tooth decay in children.

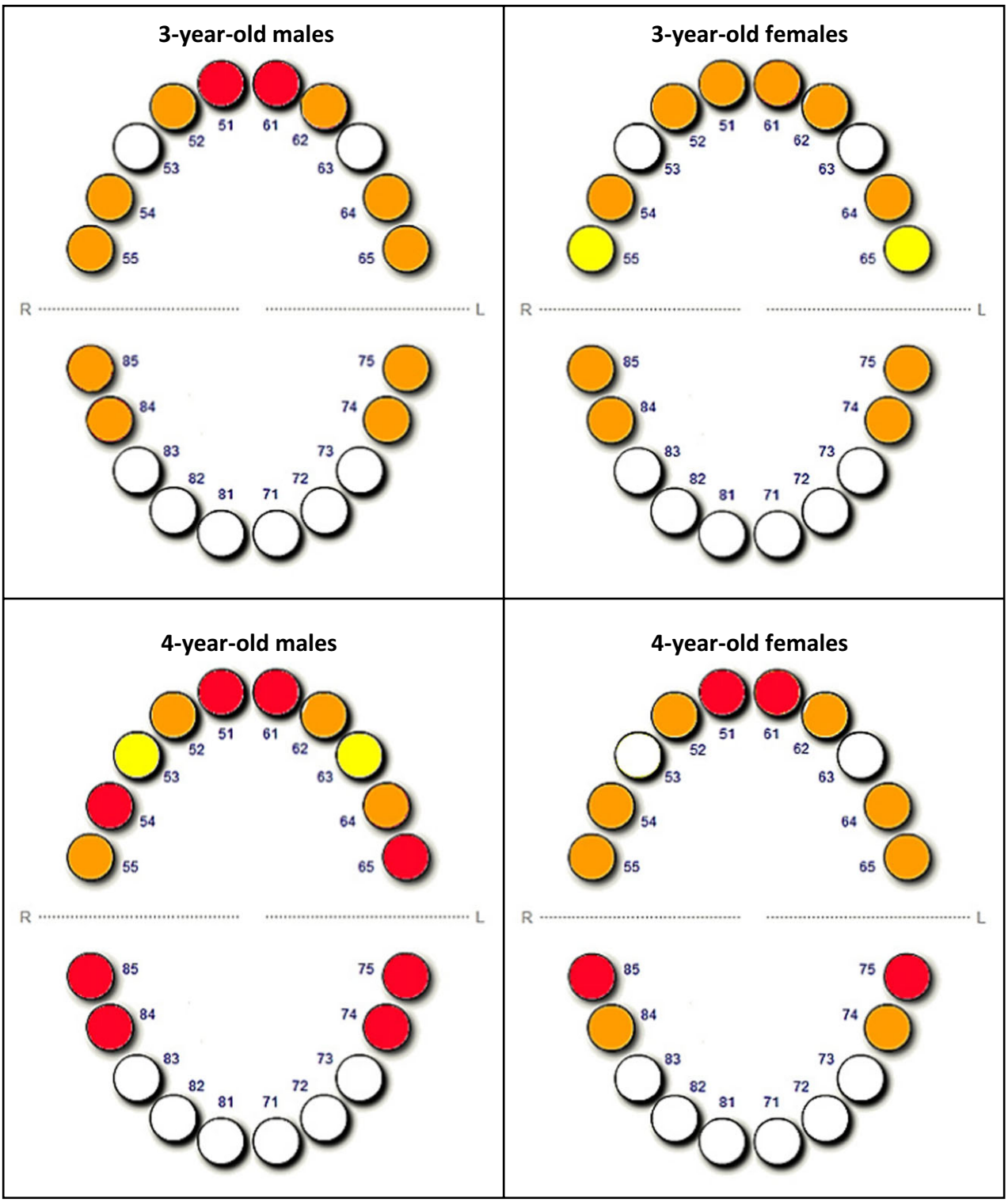

Figure 1 Percentage of children with decay, past or present, by primary tooth type (decay defined as ≥1 decayed or filled surface or having a tooth missing due to decay). Color index: red, ≥60 percent; orange, 40-60 percent; yellow, 20-40 percent; white, 0-20 percent.

Table 2 Multiple Linear Regression Analysis of Associations for Decayed, Missing, and Filled Tooth Surfaces with Child Age and Gender and with Caregiver Education and Income

Variable	Estimate	SE	Category *P* value	Overall *P* value
Intercept	41.56	4.33	<0.0001	
Age of child (years)				<0.0001
3	–18.53	4.17	<0.0001	
4	–14.28	4.14	0.0006	
5	Ref.			
Gender of child				0.005
Male	3.52	1.25	0.005	
Female	Ref.			
Caregiver education				0.053
College graduate	–3.67	2.51	0.14	
Some college	–2.07	1.93	0.28	
High school/GED	1.27	1.88	0.50	
Below high school	Ref.			
Caregiver income				0.01
Missing	–3.86	1.89	0.04	
≥$40K	–2.92	2.32	0.21	
$30K to <$40K	–4.72	2.60	0.07	
$20K to <$30K	–7.71	2.30	0.0008	
$10K to <$20K	–1.07	1.79	0.55	
<$10K	Ref.			

Table 4 presents comparisons between the baseline oral health data in the current clinical trial and previous IHS surveys of the Navajo Nation and NHANES samples. There was no statistically significant difference between mean dmfs in the current clinical trial and the 1999 IHS survey in Navajo Nation (21.33 versus 19.02, $P = 0.08$), indicating that prevalence of dental caries has not appreciably changed in Navajo Nation in the past 10-15 years. Although mean dmfs in the current clinical trial was slightly higher, the 1999 IHS survey included some 2-year-old children, which the current trial did not. Inclusion of younger children may result in a comparatively lower dmfs mean due to primary tooth eruption and dental caries increasing with age. The dfs measure in the current clinical trial is 6.8 times higher than the dfs measure for all race/ethnicity groups in the national 1999-2004 NHANES Survey (17.45 versus 2.58, $P < 0.0001$), indicating that the rate of dental caries continues to be more severe in the Navajo Nation compared with US national rates. There appears to be some improvement over time in percentage of children with untreated caries between the 1999 IHS Survey and the current clinical trial (82.9 percent versus 69.5 percent, $P = 0.0001$). The percentage of children with untreated caries is about the same between the 2010 IHS Survey and the current clinical trial (65.8 percent versus 69.5 percent, $P = 0.16$), giving additional credence to both of these measures. Finally, the percentage of children with untreated caries is much higher in the current clinical trial compared with the white-only population in the 1999-2004 NHANES national sample (69.5 percent versus 16.04 percent, $P < 0.0001$) and with all race/ethnicity groups combined (69.5 percent versus 20.48 percent, $P < 0.0001$), again reflecting the severity of dental caries in the Navajo Nation.

Table 3 Logistic Regression Analysis of Associations for Untreated Primary Tooth Decay with Child Age and Gender and Caregiver Education and Income

Variable	Odds ratio	95% CI	Overall *P* value
Age of child (years)			0.34
3	0.93	0.37, 2.34	
4	1.15	0.46, 2.87	
5	Ref.		
Gender of child			0.18
Female	0.83	0.63, 1.09	
Male	Ref.		
Caregiver income			0.80
Missing	1.06	0.69, 1.62	
≥$40K	0.76	0.47, 1.25	
$30K to <$40K	0.75	0.43, 1.30	
$20K to <$30K	0.86	0.53, 1.42	
$10K to <$20K	0.97	0.65, 1.44	
<$10K	Ref.		
Caregiver education			0.30
College graduate	0.56	0.34, 1.04	
Some college	0.80	0.51, 1.24	
High school/GED	0.73	0.47, 1.13	
Below high school	Ref.		

Table 4 Comparison of Dental Caries Measures for Primary Teeth in the Current Study versus Earlier Dental Surveys

Study	Race/ethnic groups	Age range (years)	*n*	dmfs, mean (SD)	dmft, mean (SD)	dfs, mean (SE)	dft, mean (SE)	Percentage of children with untreated decay	Percentage with caries experience
1999 IHS survey	Navajo Nation	2-5	208	19.02 (16.6)	7.45 (4.9)	NA	NA	82.9*	90.7 (dmft > 0)
2010 IHS survey	Navajo Nation	2-5	411	NA	6.52 (3.6)*	NA	NA	65.8	85.9 (dmft > 0)
NHANES, 1999-2004	All race/ethnic groups	2-5	2,379	NA	NA	2.58 (0.2)*	1.17 (0.1)*	20.48*	27.9 (dft > 0)*
NHANES, 1999-2004	Whites only	2-4	385	NA	NA	NA	NA	16.04*	20.45 (dft > 0)*
Current study	Navajo Nation	3-5	981	21.33 (20.0)	7.35 (5.0)	17.45 (0.5)	6.47 (0.1)	69.5	89.3 (dmft > 0); 88.69 (dft > 0)

* Significantly different from current study, $P \leq 0.001$.

IHS, Indian Health Service; NHANES, National Health and Nutrition Examination Survey; NA, not applicable.

Discussion

Dental caries experience in Navajo Nation Head Start children was extremely high, and mean dmfs was higher with older age, with male gender, and when the caregiver's educational attainment and income were low. Mean dmfs in the study children was also 6.8 times higher than national averages for children of the same age, and their mean dmfs had not appreciably changed over the previous decade. The percentage of children with untreated decay appears to have declined in the past decade, although it remains today substantially higher (3-4 times) than national averages. However, when comparing study data with previous surveillance studies on the Navajo Nation, it is important to note the 1999 IHS data were collected solely from children seeking care at dental units. What this means in terms of comparability of the data is unknown; children in the 1999 survey may have accessed care at a dental unit due to presence of oral disease or may have had less disease given that their caregivers had demonstrated ability to access care at a dental unit.

Specific etiologies for disparities in dental caries are not known; however, several factors, including social environment, physical environment, health behaviors, and access to dental and medical care, have been associated with oral health disparities (7,8). However, the high prevalence of untreated dental caries in Navajo Nation children was not associated with education or income level of their caregivers. An examination of the dental care delivery system identifies one concern. The Navajo Nation resides on the largest reservation in the U.S. at 25,000 square miles (9). There are 22 dental clinics serving 225,639 individuals (9). In Navajo Nation the dentist-to-population ratio is 32.3 dentists per 100,000 (10), at the lowest end of the range for the dentist-to-population ratio in the US by state (excluding the District of Columbia, with 31.1 to 69 per 100,000) (11). The geography of the area is challenging, with a dispersed population living in a vast region with lack of public transportation. Clearly, accessing dental care is often difficult, and this likely contributes to oral health disparities. The percentage of children with one or more untreated carious lesions was less than the percentage reported in 1999 (82.9 percent compared with 69.5 percent), but still very high at 3.39 times that reported for all races combined in the NHANES data (5). Untreated dental caries may be related to the ability of the caregivers to access dental care for their children. Future research should be designed to test for a relationship between untreated caries and accessibility of dental services.

The Navajo Nation's division on economic development reports that 43 percent of the population lives below the poverty level; the median household income is $20,000, and 42 percent of residents are unemployed (12). Other studies have identified a relationship between poverty and poor oral health (13), and children living in poverty are most likely to be affected by dental disease (7). However, income in this study was inconsistently related to dmfs. Children with caregivers of the lowest income category (<$10,000 per year) had a mean dmfs of 24.0, and mean dmfs dropped for the next two highest income levels. However, dmfs increased to 17.3 for the $30,000-$40,000 income category and rose to 20.3 for the greater than $40,000 category. Previous studies of factors associated with dental caries of the primary dentition concluded that even in a low-income population, slightly higher income was a protective factor for dental caries (14). The rise in dmfs in the highest-income groups may be related to greater financial ability to maintain dietary habits that include consumption of convenience foods high in fermentable carbohydrates.

To achieve a deeper characterization of dental caries beyond prevalence or mean surfaces, the distribution of surface-level data was evaluated using mapping based on age and gender. The pattern of dental caries in this population was found to be similar to that in other studies of preschool children in Arizona (15). In both populations, the primary maxillary anterior teeth were most frequently

decayed and primary canines and mandibular anterior teeth least frequently affected. Primary maxillary teeth are generally among the first primary teeth to erupt and subject to greater exposure from dietary factors, such as prolonged exposure to a cariogenic liquid in a bottle or sippy cup. Maxillary canines are less frequently affected by dental caries due to later eruption in the sequence of primary tooth development. Involvement of the maxillary and mandibular primary molars increased with age as dental caries progressed. The severity of dental caries in 4-year-old children in this study was highest, with greater than 60 percent of the children found to have carious involvement of primary incisors and molars.

Males were found to have higher dmfs scores compared to females. This finding may be related to female children having more positive oral health behaviors. Specifically, studies in the United States and Europe have observed that female children are more likely to brush more than once per day compared with their male counterparts. It has also been postulated that female adolescents consider oral appearance more important than males, and perhaps this is a motivating factor in younger children as well (16).

This study has several strengths: It is representative of the prevalence of dental caries in the Navajo Nation, as the sample was large; a broad geographic sample of children from the Navajo Nation were included in the study; and strict calibration measures were used to maintain the quality of data collected. However, the limitation of the study is that the representative dmfs in preschool children does not describe dental caries experience for children of other ages. Study results are based on Head Start children who were primarily 3- and 4-year-olds at the time of survey; thus, future approaches should emphasize the importance of establishing access to care at the earliest ages when primary teeth first erupt.

Future research is warranted to gain a deeper understanding of dental caries in the Navajo Nation population and to design interventions to improve oral health for Navajo Nation children. A three-part approach is suggested to improve oral health of Navajo Nation children: increased access to effective preventive services, culturally sensitive and effective oral health education programs, and improved access to restorative care. The current study strives to improve the first two. Improved access to restorative dental services will require innovation, financial support, and political will.

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