Journal of Health Disparities Research and Practice
Volume 10, Issue 2, Spring 2017, pp. 75-88

School of Community Health Sciences
University of Nevada, Las Vegas

Exposure to Secondhand Smoke and the Development of Childhood Caries: NHANES (2011-2012)

Deborah Mattheus, University of Hawaii
Krupa Gandhi, University of Hawaii
Eunjung Lim, University of Hawii
Maureen Shannon, University of Hawaii

ABSTRACT

Dental caries continue to plague young children worldwide with numerous adverse effects including pain, poor growth and development, decreased quality of life as well as the potential for the development of life threatening secondary infections. Factors associated with the development of childhood caries are complex as they relate to social, economic and/or cultural behaviors. Recent evidence has linked secondhand smoke to the development of childhood dental caries. The purpose of the study is to re-examine the association between the frequency and extent of exposure to secondhand smoke with the development of childhood caries in the United States. Cross-sectional data of 1,511 children age 4 to 11 years from the U.S. National Health and Nutrition Examination Survey (NHANES) (2011-2012) were analyzed. Results indicate that children living in a home where one or more cigarettes were smoked inside per day were 1.59 times more likely to have caries compared to those who were not exposed to smoke inside the home (95% CI=1.02-2.47, p=0.041). Those children without insurance were also at highest risk for dental caries. However those with Medicare/Medicaid, despite having government mandated dental coverage, were also significantly affected and 1.67 times more likely to have dental caries compared to those with private insurance (95% CI=1.08-2.58, p=0.021). Creative approaches to improving health outcomes of families should include education about the adverse effects of ETS exposure, providing families with low or no cost community smoking cessation programs and reducing barriers to accessing preventive dental services for both children and their families.

Key Words: Environmental Tobacco Smoke (ETS) exposure; dental caries; children

INTRODUCTION

Dental caries or tooth decay is one of the most common preventable diseases worldwide. According to the Surgeon General, dental caries is the most common chronic disease of children within the United States (U.S.) occurring 5-8 times more frequently than asthma (U.S.

Department of Health and Human Services [USDHHS], 2000). Data from the National Health and Nutrition Examination Survey (NHANES), 2011-2012 revealed that approximately 37% of children 2-8 years of age experience dental caries in their primary teeth, while 21% of children 6-11 years of age experience caries in their permanent teeth (Dye, Thornton-Evans, Li & Iafolla, 2015). Of equal concern is the growing disparities in both the prevalence of dental disease in children, based on ethnicity and income, as well as the ability for families to access care for preventive as well as restorative care (de la Fuente-Hernandez & Acosta-Gio, 2007; Dye et al., 2015; Edelstein, 2002; Pew Center on the States, 2011; Schwendicke et al., 2014).

Untreated caries not only affect a child's ability to eat and drink, ultimately affecting their growth and development, but can also destroy some of the pleasure of being a child caused by severe pain as well as prohibiting the child from attending school which is critical to a child's quality of life (Acharya & Tandon, 2011; USDHHS, 2000). Additionally, children with dental caries in their primary teeth are at risk for the development of further decay in their secondary teeth as well as having a risk for the development of secondary infections that can becoming life-threatening (Li & Wang, 2002; USDHHS, 2000).

Dental caries is known as a multi-factorial infectious disease where there is interaction among various risk factors including low socioeconomic status (SES), limited parental education, maternal caries, history of previous caries, low exposure to fluoride, certain dietary and feeding practices, poor oral hygiene, poor oral health knowledge and beliefs, and specific medical conditions (Harris, Nicoll, Adair & Pine, 2004; Li & Wang, 2002). Dental caries is noted to be most prevalent in school-aged children from families with a low socio-economic status (SES) (de la Fuente-Hernandez & Acosta-Gio, 2007; Edelstein, 2002; Schwendicke et al., 2014; USDHHS, 2000). Lower SES can also create a situation where the child has a greater exposure to harmful environmental toxins.

Over 1.1 billion adults (29% of the adult population) currently smoke cigarettes worldwide (Anderson, 2006). Within the United States alone, 15 out of 100 (15.1%) or 36.5 million adults smoke cigarettes (USDHHS, 2014). While young children are unlikely to actively smoke, they are however vulnerable to the effects of secondhand smoke. Results from the NHANES analysis from 2011-2012 indicates that 40.6% of children between the ages 3 and 11 years were exposed to second hand smoke within their home (Homa et al., 2015). Infant and younger children, who spend more time at home, may be at higher risk for smoke exposure until they reach an age when they spend extended time outside the home in daycares or preschool, which prohibit smoking. The effects of second hand smoke to children are numerous and include the development of respiratory infections, cough, asthma and otitis media, as well as placing infants at higher risk for sudden infant death syndrome (Mannino, Siegel, Husten, Rose, & Etzel, 1996; USDHHS, 2006). A child's environmental tobacco smoke (ETS) exposure has also been reported to be a factor in the development of dental caries (Aligne, 2003; Hanioka, Ojima, Tanaka, & Yamamoto, 2011; Tanaka, Miyake, Nagata, Furukawa, & Arakawa, 2015a; Tanaka, Shinzawa, Tokumasu, Seto & Kawakami, 2015b). Studies indicate that ETS exposure is associated with the development of caries in deciduous but not permanent teeth, which may indicate the effects of toxins early in an infant's life during a period of increased vulnerability to ETS toxins (Aligne, 2003; Tanaka et al, 2015b).

The purpose of this study was to re-investigate the association between a child's exposure to secondhand smoke and the development of dental caries taking into account the child's sugar intake, dental care experiences and sociodemographic factors by using nationally representative

data collected about children ages 4 to 11 years through the National and Nutritional Examination Survey (NHANES) (2011-2012).

METHODS

Data Source

Cross-sectional data of children ages 4 to 11 years from the U.S. NHANES (2011-2012) were utilized. Data from NHANES was collected from representative U.S. populations using a multistage, stratified, and cluster sampling design. Data were obtained via personal household interviews and health examinations. The household interview collected demographic, socioeconomic, dietary, and health history information. The examination component consisted of physical and dental examinations and various laboratory tests.

Dependent Variable

The dependent variable for this study was the child's dental caries status, defined based on the dental examination performed by a trained dentist. Dental exams were conducted using a dental light for illumination, a dental mirror, and an explorer. Dental caries status was determined based on the presence or absence of a tooth and on the condition of the child's teeth. Categorization of dental caries was done according to the following observations: 1) missing a tooth due to dental disease, 2) missing a tooth due to dental disease but replaced by a removable or fixed restoration and/or, 3) a primary or secondary tooth with surface condition indicating dental decay.

Primary Independent Variable

The primary independent variables of interest, shown in Table 1, were ETS exposure determined by the following: 1) the number of people that smoked inside the house; 2) the total number of cigarettes that were smoked inside the house per day; and 3) serum cotinine levels. The number of people that smoked inside the house was listed as 0, 1, 2 and 3 or more. The total number of cigarettes smoked inside the house per day was categorized as never smoked inside the house or greater than one cigarette smoked inside the house per day. Serum cotinine was categorized as <0.2 (low exposure), 0.2-1.0 (moderate exposure) and >1.0 (high exposure).

Additional Independent Variables

Additional independent variables included in the analysis were specific to the child, child's mother and family. Children's variables included factors such as child's gender, race, current weight status, use of dental services, and sugar intake per day. Use of dental service included the time of last dental visit, the reasons for the last visit and if they needed dental care but could not get it. Time of the last dental visit was categorized as: 6 months or less; more than 6 months but not more than 1 year ago; more than 1 year but not more than 2 years ago; more than 2 years but not more than 3 years ago; more than 5 years ago; and never have been to the dentist. Responses for the reasons for last visit to the dentist included: went in on their own for check-up, examination or cleaning; was called in by the dentist for check-up, examination or cleaning; something was wrong, bothering or hurting; went for treatment of a condition that the dentist discovered at earlier checkup or examination; or other. Sugar intake per day was categorized based on tertiles as <96.75 g, 96.57-145.79 g, and >145.79 g. All categories were far above American Heart Association recommendations for daily sugar intake for preschoolers which are approximately 16 g per day for children under 4 years of age, 12 g per day for children 4 to 8 years old, and 20-32 g per day for a preteen and teen (Howard & Wylie-Rosett, 2002).

Maternal variables included maternal age when the child was born and the mother's smoking status during pregnancy. Family variables included the household reference person's age, marital status, education level, health insurance, and family income to poverty ratio. Family income to poverty ratio was categorized as <1.25, ≥1.25 and <2, ≥2 and <4, and ≥4. A ratio of ≥1.25 and <2, for example, indicated that the family's income was 125% up to 200% above the appropriate poverty threshold, which is based on household size and is updated each year using the average annual consumer price index for all urban consumers. Education level was categorized as less than 9th grade, high school graduate or GED equivalent, some college or Associate degree (AA) degree, and college graduate or above. Insurance status was defined as private, Medicare/Medicaid, other, and no coverage.

Statistical Analysis

Descriptive statistics were generated followed by bivariate analysis using chi-square tests or linear regression to determine associations with dental caries status depending on variable type. Variables with $p<0.1$ in the bivariate association were included in a multivariable logistic regression analysis and backward selection method was performed to determine final significant variables associated with dental caries. All analyses accounted for NHANES' complex multistage sampling design and a $p<0.05$ was considered statistically significant. Statistical analysis was conducted using SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

A total of 1,551 children age 4 to 11 years were included in the analysis with 52% (n=811) found to have at least one missing tooth or tooth with surface changes indicating dental decay. Overall, 13% (n=199) were noted to have a smoker inside the home, while 39% (n= 77) of these children had two or more active smokers in their homes. For those children noted to have dental caries, the bivariate analysis revealed serum cotinine levels were significantly associated with dental caries status and were at a moderate level (0.2-1.0 ng/ml) in 19.2% and at a high level (>1 ng/ml) for 13.5% of the children.

Table 1. Descriptive Characteristics of Child's and Household Reference's Demographics, Household Smoking Status, Child's Oral Health, Sugar and Serum Cotinine levels.

Variable	n	Unweighted %	Weighted %
Child			
Child's gender			
Male	802	51.7	50.7
Female	749	48.3	49.2
Child's race			
Mexican American	313	20.2	15.2
Other Hispanic	183	11.8	8.3
Non-Hispanic White	368	23.7	54.7
Non-Hispanic Black	448	28.9	14.2
Non-Hispanic Asian	153	9.9	4.1
Multi-racial / Other Race	86	5.5	3.6
Current weight status of the child			

Overweight	205	13.2	11.9
Underweight	125	8.1	8.7
About the right weight	1,221	78.7	79.4
Use of dental services			
When did you last visit a dentist			
6 months or less	967	62.3	67.0
More than 6 months, but not more than 1 year ago	321	20.7	17.5
More than 1 year, but not more than 2 years ago	122	7.9	6.9
More than 2 years, but not more than 3 years ago	29	1.9	1.8
More than 5 years ago	25	1.6	1.8
Never have been	87	5.6	4.9
Main reason for last dental visit			
Went in on own for check-up, examination, or cleaning	1,204	82.2	82.9
Was called in by the dentist for check-up, examination, or cleaning	31	2.1	1.9
Something was wrong, bothering or hurting	117	8.0	8.4
Went for treatment of a condition that dentist discovered at earlier checkup or examination	97	6.6	5.9
Other	15	1.0	0.8
Past year needed dental but could not get it			
Yes	86	5.9	4.6
No	1,378	94.1	95.4
Total Sugars (gm)			
<96.57	606	39.1	33.2
96.57-145.79	619	39.9	42.4
>145.79	326	21.0	24.4
Maternal			
Mother's age when born			
<19 years	196	12.6	10.1
20-24 years	419	27.0	23.9
25-29 years	401	25.9	26.8
30-34 years	317	20.4	23.5
≥35 years	218	14.1	15.7
Mother's smoking status during pregnancy			
Yes	166	10.7	10.8
No	1,385	89.3	89.2

Family			
Household reference's age			
18-25 years	94	6.1	4.2
26-35 years	578	37.3	36.2
36-45 years	603	38.9	41.3
46-55 years	193	12.4	14.2
56-65 years	63	4.1	3.1
≥66 years	20	1.3	0.9
Household reference's education level			
Less Than 9th Grade	153	10.1	7.9
9-11th Grade (Includes 12th grade with no diploma)	262	17.3	14.8
High School Grad/GED or Equivalent	316	20.9	18.5
Some College or AA degree	414	27.4	27.2
College Graduate or above	366	24.2	31.3
Household reference's marital status			
Married	926	59.9	68.1
Widowed	28	1.8	1.4
Divorced	105	6.8	7.6
Separated	98	6.3	4.7
Never Married	226	14.6	8.6
Living with partner	162	10.5	9.7
Health Insurance			
Private	540	34.8	45.1
Medicare/Medicaid	562	36.3	26.4
Other	305	19.7	19.6
No Coverage	143	9.2	8.9
Family income to poverty ratio			
<1.25	774	49.9	38.5
≥1.25 and <2	250	16.1	15.9
≥2 and <4	305	19.7	23.1
≥4	222	14.3	22.5
ETS Exposure			
Serum cotinine levels (ng/ml)			
<0.2 (Low exposure)	839	72.8	76.4
0.2-1.0 (Moderate Exposure)	186	16.1	13.4
>1.0 (High exposure)	128	11.1	10.2
Does anyone smoke inside home			
Yes	199	12.9	11.7
No	1,349	87.1	88.3
Total number of smokers inside home			
0	1,352	87.2	88.3
1	128	8.3	6.4
2	60	3.9	4.5
3 or more	11	0.7	0.8

Total number of cigarettes smoked inside home			
0 (Never Smoked)	1,357	87.5	88.9
≥1 cigarette smoked	194	12.5	11.0

The variables with p<0.1 in the bivariate association were included in a multivariable logistic regression analysis (Table 2). These variables included race, family income to poverty ratio, household reference's education level, health insurance, mother's age when the child was born, mother's smoking status during pregnancy, household members that smoked inside the house, total number of cigarettes smoked inside the house, when the child last visited the dentist, the main reason for child's last dental visit, child needed dental care but could not get it during the past year, child's serum cotinine level and birth weight.

Table 2. Bivariate association and Unadjusted Odds Ratios of Child's and Household Reference's Demographics, Household Smoking Status, Child's Oral Health, Sugar and Serum Cotinine levels with Dental Caries.

Variable	**Dental Caries**					
	Unweighted, n (%)		**Weighted, %**			**Unadjusted OR (95% CI)**
	No (n=740)	**Yes (n=811)**	**No**	**Yes**	***P*-value**	
Child						
Child's race					<0.001	
Mexican American	114 (15.4)	199 (24.5)	11.2	19.4		2.12 (1.53, 2.93)
Other Hispanic	93 (12.6)	90 (11.1)	8.4	8.1		1.19 (0.82, 1.73)
Non-Hispanic White	197 (26.6)	171 (21.1)	60.1	49.1		Ref
Non-Hispanic Black	206 (27.8)	242 (29.8)	12.6	15.7		1.52 (1.13, 2.05)
Non-Hispanic Asian	81 (10.9)	72 (8.9)	4.1	4.0		1.21 (0.82, 1.81)
Multi-racial / Other Race	49 (6.6)	37 (4.6)	3.7	3.6		1.18 (0.67, 2.08)
Use of dental services						
When did you last visit a dentist					0.013	
6 months or less	453 (61.2)	514 (63.4)	67.6	66.4		Ref
More than 6 months, but not more than 1 year ago	151 (20.4)	170 (21.0)	17.2	17.8		1.05 (0.75, 1.18)
More than 1 year, but not more than 2 years ago	54 (7.3)	68 (8.4)	5.5	8.2		1.51 (0.94, 2.43)
More than 2 years, but not more than 3 years ago	10 (1.4)	19 (2.3)	1.4	2.3		1.64 (0.57, 4.76)
More than 5 years ago	11 (1.5)	14 (1.7)	1.3	2.4		1.95 (0.70, 5.49)
Never have been	61 (8.2)	26 (3.2)	6.9	2.9		0.42 (0.22, 0.81)
Main reason for last dental visit					<0.001	
Went in on own for check-up, examination, or cleaning	617 (90.9)	587 (74.8)	92.0	74.0		0.21 (0.12, 0.36)
Was called in by the dentist for check-up, examination, or cleaning	8 (1.2)	23 (2.9)	0.6	3.3		1.33 (0.45, 3.92)
Something was wrong, bothering	29 (4.3)	88 (11.2)	3.5	13.3		Ref

or hurting						
Went for treatment of a condition that dentist discovered at earlier checkup or examination	20 (2.9)	77 (9.8)	3.3	8.5		0.68 (0.30, 1.55)
Other	5 (0.7)	10 (1.3)	0.5	0.9		0.46 (0.13, 1.60)
Past year needed dental but could not get it					0.007	
Yes	22 (3.2)	64 (8.2)	2.6	6.6		2.63 (1.39, 4.98)
No	657 (96.8)	721 (91.8)	97.4	93.4		Ref
Weight at birth in pounds (Mean ±SD)	7.1±1.4	7.3±1.4	7.2±1.7	7.4±1.6	0.035	1.08 (1.03, 1.14)
Maternal						
Mother's age when born					<0.001	
<19 years	68 (9.2)	128 (15.8)	6.5	13.7		3.91 (2.35, 6.51)
20-24 years	181 (24.5)	238 (29.3)	20.7	27.3		2.46 (1.57, 3.86)
25-29 years	190 (25.7)	211 (26.0)	26.4	27.2		1.92 (1.22, 3.04)
30-34 years	167 (22.6)	150 (18.5)	26.0	20.8		1.49 (0.92, 2.41)
≥35 years	134 (18.1)	84 (10.4)	20.3	10.9		Ref
Mother's smoking status during pregnancy					0.001	
Yes	68 (9.2)	98 (12.1)	7.8	13.9		1.90 (1.27, 2.85)
No	672 (90.8)	713 (87.9)	92.2	86.1		Ref.
Family						
Family income to poverty ratio					<0.001	
<1.25	309 (41.8)	465 (57.3)	30.4	46.9		2.84 (1.89, 4.27)
≥1.25 and <2	120 (16.2)	130 (16.0)	15.6	16.2		1.91 (1.16, 3.17)
≥2 and <4	163 (22.0)	142 (17.5)	24.9	21.2		1.56 (0.97, 2.23)
≥4	148 (20.0)	74 (9.1)	29.0	15.7		Ref
Household reference 's education level					<0.001	
Less Than 9th Grade	52 (7.2)	101 (12.8)	4.6	11.5		5.21 (3.25, 8.36)
9-11th Grade (Includes 12th grade with no diploma)	90 (12.5)	172 (21.8)	11.1	18.7		3.48 (2.23, 5.44)
High School Grad/GED or equivalent	130 (18.0)	186 (23.6)	14.4	22.9		3.29 (2.15, 5.02)
Some College or AA degree	209 (28.9)	205 (26.0)	27.9	26.5		1.95 (1.31, 2.91)
College Graduate or above	241 (33.4)	125 (15.8)	41.9	20.3		Ref
Health Insurance					<0.001	
Private	321 (43.4)	219 (27.0)	55.5	34.5		Ref
Medicare/Medicaid	226 (30.6)	336 (41.4)	19.9	32.9		2.67 (1.96, 3.64)
Other	133 (18.0)	172 (21.2)	17.5	21.7		2.01 (1.38, 2.93)
No Coverage	59 (8.0)	84 (10.4)	7.0	10.9		2.52 (1.55, 4.10)
SHS Exposure						
Serum cotinine levels (ng/ml)					<0.001	
<0.2 (Low exposure)	426 (79)	413 (67.3)	84.4	68.5		Ref
0.2-1.0 (Moderate Exposure)	68 (12.6)	118 (19.2)	9.3	17.5		2.32 (1.52, 3.53)
>1.0 (High exposure)	45 (8.3)	83 (13.5)	6.3	14.0		2.76 (1.62, 4.73)
Total number of cigarettes smoked inside home					0.002	
0 (Never Smoked)	666 (90.0)	691 (85.2)	92.5	85.3		Ref

≥1 cig smoked	74 (10.0)	120 (14.8)	7.5	14.7		2.11 (1.41, 3.17)

Column percentage.
Note: All of the analyses account for complex sampling design.

Results from the final regression model are displayed in Table 3. Children living in a home where one or more cigarettes were smoked daily were noted to be 1.59 times more likely to have dental caries compared to those who had no cigarette smoked in the house (95% CI=1.02-2.47, p=0.041). Children living in a family with an income to poverty ratio of less than 1.25 were 1.79 times more likely to have dental caries compared to an income to poverty ratio of 4 and above (95% CI=1.06-3.03, p=0.029). Children without any insurance were at highest risk and 2.50 times more likely to have dental caries (95% CI=1.41-4.41, p=0.002) while those with Medicare/Medicaid were 1.67 times more likely to have dental caries compared to those with private insurance (95% CI=1.08-2.58, p=0.021). Additionally, those individuals that responded that the child's last dental visit was for preventive services were 74% less likely to have a child with dental caries compared to those respondents whose main reason for their child's dental visit was an active problem (95% CI=0.14-0.46, p<0.001).

Table 3. Multivariable Logistic Regression for Dental Caries

Variable	**OR**	**95% CI**	**Weighted *P*-value**
Family income to poverty ratio			
<1.25 vs. ≥4	1.79	1.06-3.03	0.029
≥1.25 and <2 vs. ≥4	1.44	0.82-2.53	0.199
≥2 and <4 vs. ≥4	1.22	0.74-2.00	0.432
Health Insurance			
Medicare/Medicaid vs. Private	1.67	1.08-2.58	0.021
Other vs. Private	1.28	0.81-2.02	0.282
No coverage vs. Private	2.5	1.41-4.41	0.002
Total number of cigarettes smoked inside home			
≥1 cig smoked vs. 0 cigs smoked	1.59	1.02-2.47	0.041
Main reason for last dental visit			
Went in on own for check-up, examination, or cleaning vs. Something was wrong, bothering or hurting	0.26	0.14-0.46	<0.001
Was called in by the dentist for check-up, examination, or cleaning vs. Something was wrong, bothering or hurting	1.39	0.41-4.67	0.597
Went for treatment of a condition that dentist discovered at earlier checkup or examination vs. Something was wrong, bothering or hurting	0.86	0.36-2.03	0.727
Other vs. Something was wrong, bothering or hurting	0.37	0.09-1.52	0.170

OR = Odds Ratio; CI = Confidence Interval.
Note: The multivariable logistic regression was used with the bivariates of p<0.10 in Table 2 accounting for complex sampling design. Backward selection method was used to determine the final model.

DISCUSSION

In the present cross-sectional study, a child's ETS exposure in the home was associated with an increased risk for dental caries when compared to children who had no ETS exposure. These results are similar to those reported in previous studies in the U.S. (Aligne, 2003), as well as from studies conducted internationally (Hanioka, 2011; Tanaka et al., 2015a; Tanaka et al., 2015b). Based on the multi-factorial nature of dental caries, it is still unclear whether the relationship between smoke exposure and dental caries is mainly biological in nature or rather a marker for unhealthy habits in the home including those that affect dental outcomes such as dietary, oral hygiene habits and underutilization of preventive dental care services. The current study demonstrated how limited preventive dental visits affect caries status, with children being less likely to have caries if their last dental visit was for preventive care rather than care for an active dental problem. However, in this study sugar intake, a measure of poor dietary habits was not significantly associated with dental caries status.

Previous literature clearly outlines the biological pathways which explain the association between smoking and dental caries (Avsar, Darka, Topaloglu, & Bek, 2008; Best, 2009; Strauss, 2001; Vellappally, Fiala, Smejkalová, Jacob & Shriharsha, 2007). Both active and passive smoke exposure affects the function of healthy gum tissue cells. The chemicals released in cigarette smoke are known to increase the production of pro-inflammatory agents, resulting in tissue inflammation, vasoconstriction and edema (Lee, Taneja & Vassallo, 2012). Additionally, a decrease in vitamin C levels associated with smoke exposure further enhances the growth of cariogenic bacteria and decreases salivary flow, which has protective properties against caries (Avsar et al., 2008; Strauss, 2001; Vellappally et al., 2007).

It is important to also note the unique vulnerability of a child which can further accentuate the adverse biological effects associated with ETS smoke. An infant or young child's immune system, which is generally less mature due to their age, is further compromised by smoke exposure, increasing their risk for infections such as otitis media, respiratory infections and the development of dental caries (Best, 2009, USDHHS, 2014). Parents that smoke may also have poor oral health including an excess of bacteria which can be also be passed to their children due to the children being exposed to parental saliva when food, eating utensils or toothbrushes are shared among family members.

Consistent with previous studies (Aligne, 2003; de la Fuente-Hernandez & Acosta-Gio, 2007; Edelstein, 2002; Schwendicke et al., 2014), this analysis revealed an association between family income to poverty ratio and caries status. The relationship between socioeconomic factors including maternal education, family income, as well as feeding practices, and the development of childhood caries has been documented over the years. However, the degree in which each individual variable or combination of variables affect caries development is difficult to clearly understand (Harris et al., 2008). However, it is well understood that young children are dependent on adults, most often their parents, to care for their most basic needs. This places them in a vulnerable position, particularly if they are exposed to caregivers who have a limited education, lower income or reside in an area that lacks community resources to assist them in making better health decisions for themselves and their families. It is extremely important to recognize that smoking is not solely responsible for the development of caries but rather it may be a risk factor that in combination with other unhealthy behaviors and predisposing factors increases the child's risk for the development of caries.

The current study also identified medical insurance type or lack of insurance as a factor that significantly affects caries status. It is understandable that children without medical insurance will most likely not have dental coverage and, therefore, their utilization of preventive dental services will be limited. However, it is still unclear why children with Medicaid insurance, which provides dental coverage throughout childhood, continue to have higher rates of dental caries and lower utilization of preventive dental service. Lack of parent education as well as barriers to access care including provider's willingness to see patients with Medicaid are known to affect these rates (Chou, Cantor, Zakher, Mitchell, & Pappas, 2013; Edelstein, 2002; USDHHS, 2000). Identification of the barriers to accessing dental services for high risk families is a first and important step in developing interventions that can assist families in successful connecting them to dental providers in the community and receiving early and consistent preventive dental care.

Overall this study builds on the existing evidence linking secondhand smoke to the development of dental caries in the pediatric population (Aligne, 2003: Hanioka, 2011; Tanaka et al., 2015b). Children with family members who smoked were noted to have more decayed, missing or filled teeth compared to children who have do not have smokers in the family. Despite having Medicaid insurance, which includes dental coverage, children living below the poverty level continue to suffer from dental disease at a higher rate than those with private insurance. This highlights the importance of recognizing those risk populations and targeting them to assure they receive proper oral health screenings, risk assessments and assistance with accessing dental services at an early age. Parental behaviors associated with tobacco use may also result in other unhealthy behaviors related to childhood caries, such as poor oral hygiene practices, poor dietary habits and decrease use of preventive services.

This study has several limitations including a lack of information on the dental hygiene habits of the children, which is been known to be a factor related to dental outcomes. Also unavailable but important to note is the parent's dental hygiene habits as well as their utilization of dental services which can indicate their oral health beliefs and behaviors. Parental oral health beliefs and behaviors can directly affect the care that they provide to their children. It is also not known whether a child received fluoride supplementation, either through community water supply, fluoride toothpaste, and fluoride oral supplements prescribed by their doctor or dentist or fluoride varnish application, all of which are known to protect the teeth and reduce caries formation. Based on self-reported data this information may or may not be completely accurate and the frequency and amount of cigarettes smoked in the house, which is known to be harmful, may be underestimated in the responses. Additionally, a cross-sectional design limits the ability to analyze behaviors beyond smoking exposure known to affect caries formation such as the frequency and quality of foods and drink, parent's assessment of the child's oral health habits as well as professional dental visits. The nature of this design did not allow assessing the temporal relationship between ETS exposure and dental caries.

CONCLUSION

Dental caries, a preventable disease, continues to be a common chronic problem experienced by children world-wide. The results of this study provide further evidence of the vulnerability of children to environmental exposures especially those from lower socioeconomic levels that place them at risk for adverse health outcomes including dental caries and possible long term health consequences associated with dental decay. This study again shows that

children with family members who smoke inside the home have more decayed, missing or filled teeth compared to children who have no smokers in the house. Reducing those risk factors that are amenable to change can make a significant impact on the development of dental caries and ultimately the child's current health as well as their future adult health.

Parent's see their child's health provider frequently and more often than their own provider. Each visit provides a teachable moment to influence parent's own health behaviors that affect their children including nutrition, dental care as well as smoking. Creative approaches to improving oral and primary care health outcomes of families should include education about the adverse effects of ETS exposure on children, providing families with low or no cost community smoking cessation programs and reducing barriers to accessing preventive dental services for both children and their families.

REFERENCES

Acharya, S., & Tandon, S. (2011). The effect of early childhood caries on the quality of life of children and their parents. *Contemporary Clinical Dentistry*, *2*(2), 98–101. doi: 10.4103/0976-237X.83069.

Aligne, C. (2003). Association of pediatric dental caries with passive smoking. *Jama*, *289*(10), 1258. doi:10.10001/jama.289.10.1258.

Anderson, P. (2006). Global use of alcohol, drugs and tobacco. *Drug and Alcohol Review*, *25*(6), 489-502. doi: 10.1080/09595230600944446

Avsar, A., Darka, O, Topaloglu, B., & Bek, Y. (2008). Association of passive smoking with caries and related salivary biomarkers in young children. *Archives of Oral Biology*, *53*(10), 969-974. doi:10.1016/j.archoralbio.2008.05.007

Best, D. (2009). Secondhand and prenatal tobacco smoke exposure. *Pediatrics, 124*(5). doi: 10.1542/peds.2009-2120.

Chou, R., Cantor, A., Zakher, B., Mitchell, J., & Pappas, M. (2013). Preventing dental caries in children <5 years: systematic review updating USPSTF recommendation. *Pediatrics*,132, 332-50. doi: 10.1542/peds.2013-1469

de la Fuente-Hernandez, J. & Acosta-Gio, E. (2007). The effects of poverty on access to oral health care. *Journal of American Dental Association.*; 138: 1443-1445. doi: http://dx.doi.org/10.14219/jada.archive.2007.0078

Dye, B. A., Thornton-Evans, G., Li, X., & Iafolla, T. J. (2015). Dental caries and sealant prevalence in children and adolescents in the United States, 2011–. NCHS data brief, no 191. Hyattsville: National Center for Health Statistics; 2015.

Edelstein, B.L. (2002). Disparities in oral health and access to care: Findings of national surveys. *Ambulatory Pediatrics*, 2, 141-147. doi:10.1367/15394409(2002)002<0141:diohaa>2.0.co;2

Hanioka, T., Ojima, M., Tanaka, K., & Yamamoto, M. (2011). Does secondhand smoke affect the development of dental caries in children? A systematic review. *Int J Environ Res Public Health, 8*(5), 1503-19. doi: 10.3390/ijerph8051503

Harris, R., Nicoll, A., Adair P., & Pine, C. (2004). Risk factors for dental caries in young children: A systematic review of the literature. *Community Dental Health*. 21: 71-85. doi: 10.1111/j.1600-0722.2004.00113.x.

Homa, D. M., Neff, L. J., King, B. A., Caraballo, R. S., Bunnell, R. E., Babb, S. D., & Wang, L. (2015). Vital signs: disparities in nonsmokers' exposure to secondhand smoke—United States, 1999–2012. *MMWR Morb Mortal Wkly Rep*, *64*(4), 103-108.

Howard, B, & Wylie-Rosett, J. (2002). AHA scientific statement: Sugar and cardiovascular disease: A statement for healthcare professionals from the committee on nutrition of the council on nutrition, physical activity, and metabolism of the American Heart Association. *Circulation, 106, 523- 527, doi:10.1161/01.CIR.0000019552.77778.04*

Lee, J., Taneja, V., & Vassallo, R. (2012). Cigarette smoking and inflammation cellular and molecular mechanisms. *Journal of dental research, 91*(2), 142-149.

Li, Y. & Wang, W. (2002). Predicting caries in permanent teeth from caries in primary teeth: An eight year cohort study. *Journal of Dental Research*, 81, 561-566. doi: 10.1177/154405910208100812

Mannino, D., Siegel, M., Husten, C., Rose, D., & Etzel, R. (1996). Environmental tobacco smoke exposure and health effects in children: Results from the 1991 National Health Interview Survey. *Tobacco Control, 5*(1), 13-18. doi:10.1136/tc.5.1.13

Pew Center on the States (2011), The state of children's dental health: Making coverage matter. Washington DC. Retrieved from http://www.pewstates.org/research/reports/the-state-of-childrens-dental-health-85899372955

SAS Institute Inc., (2013).SAS Version 9.4, Cary, NC: SAS Institute Inc.

Schwendicke, F., Dorfer, C. E., Schlattmann, P., Page, L. F., Thomson, W. M., & Paris,S. 2014). Socioeconomic inequality and caries: A systematic review and meta-analysis. *Journal of Dental Research, 94*(1), 10-18. doi: 10.1177/0022034514557546

Strauss, R. S. (2001). Environmental tobacco smoke and serum vitamin C levels in children. *Pediatrics, 107*(3), 540-542. doi:10.1542/peds.107.3.540

Tanaka, K., Miyake, Y., Nagata, C., Furukawa, S., & Arakawa, M. (2015a). Association of prenatal exposure to maternal smoking and postnatal exposure to household smoking with dental caries in 3-year-old Japanese children. *Environmental Research, 143*, 148-153. doi:10.1016/j.envres.2015.10.004

Tanaka, S., Shinzawa, M., Tokumasu, H., Seto, K., & Kawakami, K. (2015b). Secondhand smoke and incidence of dental caries in deciduous teeth among children in Japan: population based retrospective cohort study. *BMJ*, 351:h6009. doi: 10.1136/bmj.h5397

U.S. Department of Health and Human Services [USDHHS]. (2000). *Oral health in America: A report of the Surgeon General*. Retrieved from http://www.nidcr.nih.gov/DataStatistics/SurgeonGeneral/Documents/hck1ocv.@www.**surgeon**.fullrpt.pdf

U.S. Department of Health and Human Services [USDHHS]. (2006). The health consequences of involuntary exposure to tobacco smoke: A report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. Retrieved from: http://www.surgeongeneral.gov/library/reports/secondhandsmoke/fullrepo rt.pdf

U.S. Department of Health and Human Services. [USHHHS]. (2014). The health consequences of smoking -50 years of progress: A report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention,

National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014

Vellappally, S., Fiala, Z., Smejkalova, J., Jacob, V., & Shriharsha, P. (2007). Influence of tobacco use in dental caries development. Cent Eur J Public Health. Sep;15(3):116-21. Retrieved from http://apps.szu.cz/svi/cejph/archiv/2007-3-06-full.pdf