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Title

Food Deserts and Pediatric Oral Health Status in an Under-Resourced Urban Community

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science
in Dentistry at Virginia Commonwealth University.

By

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Abstract

FOOD DESERTS AND PEDIATRIC ORAL HEALTH STATUS IN AN UNDER-RESOURCED URBAN COMMUNITY

By: Jessica T. McAuliffe, D.M.D.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, 2023

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Introduction

In 2000, the Office of the Surgeon General (OSG) released a report stating: “Those who suffer the worst oral health are found among the poor of all ages, with poor children and poor older Americans particularly vulnerable.”¹ Members of racial and ethnic minority groups also experience a disproportionate level of oral health problems. In the same report, it was acknowledged that “the reasons for disparities in oral health are complex,” including socioeconomic factors.^{1,2} There are numerous studies which have found that children of lower socioeconomic standing are more likely to have untreated dental caries, and, in general, poorer oral health than children of higher socioeconomic standing.^{3,4}

In the United States, dental caries is the most common dental disease in children and is the most common chronic disease in children 6-19 years of age.¹ Data from the National Health and Nutrition Examination Survey (NHANES) presented in the NCHS Data Brief (2018) by Fleming et al reported that Hispanic youth had the highest prevalence of total caries, non-Hispanic black youth had the highest prevalence of untreated caries, and the prevalence of caries decreased as family income level increased.⁵

There are several conceptual models that have been developed and used to describe the complex nature of oral health and the multitude of variables that co-exist and interact, thereby contributing to an individual’s state of oral health. The Fisher-Owens model was developed specifically to apply to pediatric oral health (See Figure 1: Fisher-Owens model). The foundation of the Fisher-Owens model is the Keyes Triad, which is an earlier conceptual model of dental health at the individual, or host, level. It is comprised of a Venn diagram with 3 overlapping

circles showing “host,” “microflora,” and “substrate” (diet), each contributing to the development of caries. Keyes’ conceptual model is limited by not accounting for external, environmental, and social factors, which have been shown to have an important role in the development of dental caries. The Fisher-Owens conceptual model is more comprehensive in its scope. It is based on social science and population health epidemiology, and uses a series of concentric circles, each designated as having a different level of influence on overall oral health. These levels of influence range from community-level influences (social environment, physical environment, community oral health environment, etc.), to family-level influences (socioeconomic status, etc.), to child-level influences (biologic and genetic endowment, health behaviors and practices, etc.), to oral health (host and teeth, microflora, substrate/ diet). With the included variable of time, the model can provide an understanding of the complex interactions of the variables that contribute to a child’s oral health.⁶

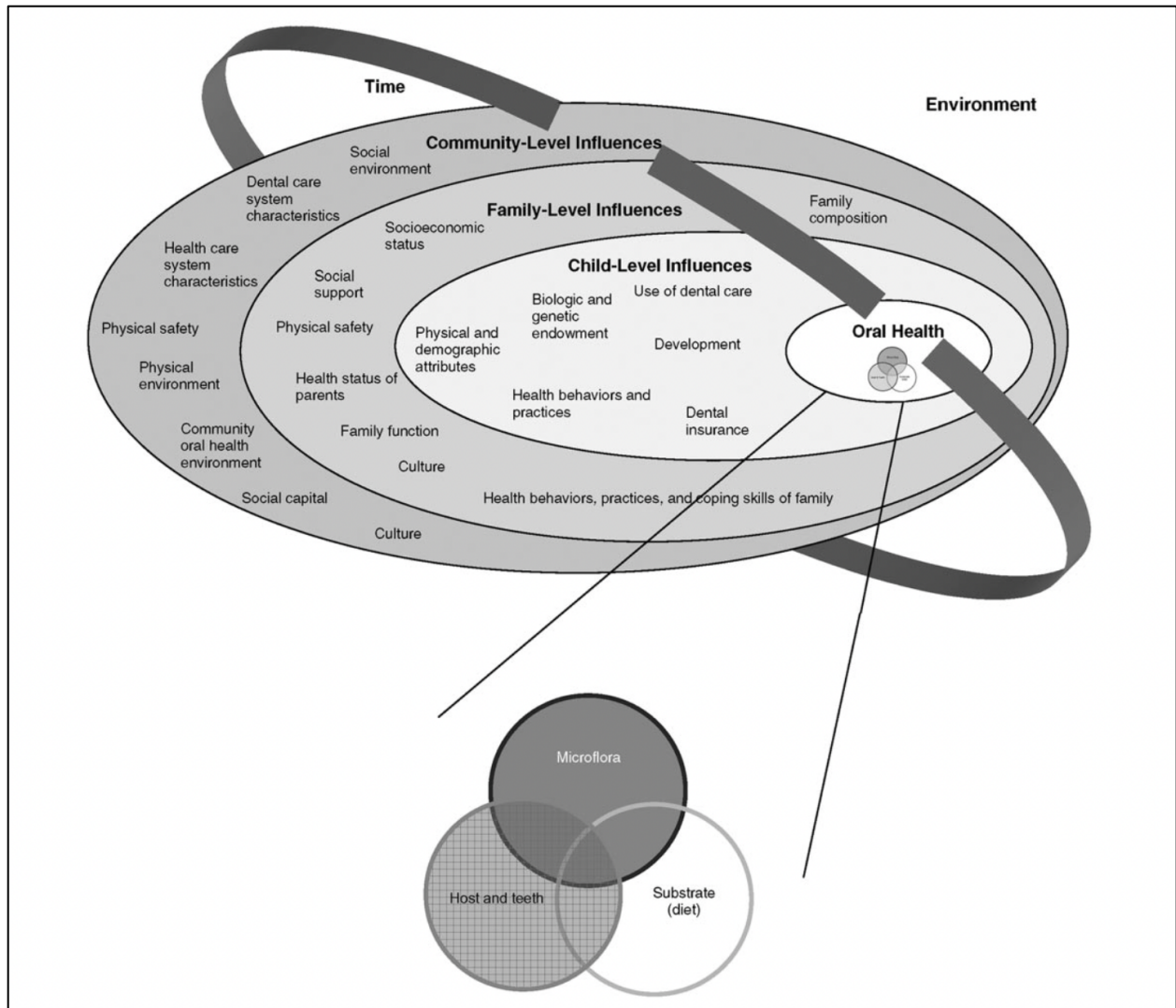


Figure 1: Fisher-Owens model

Figure 1: Fisher-Owens model⁶

Within the Fisher-Owens model, several contextual factors can be identified that contribute to overall dental health. These include health behaviors and practices, such as dietary choices;

socioeconomic status; utilization of dental services; the physical environment, including access to stores with healthy foods at affordable prices as well as access to dental services.

As noted with the Fisher-Owens model, the development of dental caries is a multifactorial process. These factors include the host and their teeth, their microflora, and their dietary habits in the context of the family, community, and environment in which the child lives.⁷ Cariogenic dietary factors are numerous. Carbohydrates, including starches and sugars, are cariogenic. There is a strong association between carbohydrate intake and incidence of dental caries.⁸⁻¹¹ A higher incidence of dental caries was found in populations with free sugar intake greater than 10% of total energy intake, as compared to those with free sugar intake comprising less than 10% of total energy intake.¹² Socioeconomic status is associated with increased intake of calorie-types associated with the development of dental caries. In a study of 436 children aged 3 to 5 years from families living at less than 250% of the US federal poverty level by Kolker et al, 75% of the children experienced some form of carious lesion.¹³

Food Insecurity and Food Deserts

Socioeconomic status also affects access to healthy foods.¹⁴ Lower socioeconomic status can lead to what is known as “low food security.” In 2006, the US Department of Agriculture (USDA) introduced new language to define and classify ranges of food security, as opposed to using the older term “food insecurity.” It includes food security (high vs marginal) and food insecurity (low food security and very low food security). Low food security, previously referred to as “food insecurity without hunger,” is described as “reports of reduced quality, variety, or desirability of diet” with “little or no indication of reduced food intake.” Very low food security,

previously referred to as “food insecurity with hunger,” is described as “reports of multiple indications of disrupted eating patterns and reduced food intake.”¹⁵ According to the USDA Economic Research Report No. 270, an estimated 11.1 percent of U.S. households were food insecure at least some time during the year in 2018, meaning they lacked access to enough food for an active, healthy life for all household members.¹⁶ Recent studies examining the impact of the child tax credit (CTC) found that CTC payments lessened food insecurity and reduced children’s intake of added sugar.

Food insecurity and socioeconomic status have both been linked with higher rates of dental caries in children.^{17,18} In preschool-aged children, Angelopolou et al. found a significant association between food insecurity and dental caries as defined by the decayed, missing, filled teeth (dmft) index¹⁹. Chi et al. found that children living in households with low or very low food security had significantly higher dental caries prevalence.²⁰ Hill found that the odds of having dental caries was 2.9 times higher for children who have very low food security.²¹ The association of food insecurity and higher rates of dental caries has also been demonstrated in international studies in Brazil, the Middle East and North Africa.^{22,23}

There are various terms and concepts that have been used to characterize place-based access to healthy foods and food insecurity. Some of these include “food swamps,” “food mirages,” and “food deserts.” The term food desert is believed to have originated in Scotland in the 1990s to describe geographic areas with poor access to an affordable, healthy diet.²⁴ The USDA 2008 Farm Bill defined a food desert as an “area in the United States with limited access to affordable

and nutritious food, particularly such an area composed of predominantly lower income neighborhoods and communities.”²⁵

The terms food insecurity and food desert are related conceptually but differ in terms of definition and application. As noted above, a food desert refers to a geographic area, while food insecurity refers to one’s inability to obtain food, which may be affected by various factors (income, physical safety, transportation, geography, etc.). Testa et al. found that food-insecure women have worse oral health during pregnancy.²⁶ Living in an area defined as a food desert could increase risk for food insecurity, with geographic factors limiting access to healthy foods. These factors impact dental health at the community level.

In summary, the individual-level and community-level influences of diet and living in a food desert have significant implications for an individual’s dental health. The evidence reviewed here affirms the theory put forth in the Fisher-Owens model, with overlapping forces affecting dental health.

The city of Richmond is the capital of the Commonwealth of Virginia. In 2020, the Richmond metropolitan area had a population of 1,263,617 inhabitants.²⁷ Similar to other major American metropolitan areas, the region is home to a population with diverse socioeconomic backgrounds. In 2016, an estimated 24.8 percent of Richmond residents were living below the poverty line with an estimated child poverty rate of 39 percent.^{28,29} Henrico County (Figure 2) is one of the larger counties making up the Richmond metropolitan area. In 2020, Henrico County had an estimated population of 334,389 inhabitants.³⁰ The county lies just north of the city of Richmond

and expands west and east-by-southeast of the city. The county is bisected by Interstate 95, a major north-south route of travel. This study will focus on the population of the eastern portion of Henrico County. The geographic area heretofore referred to as “East Henrico County” or “East Henrico” will include Henrico County zip codes that lie to the east of Interstate 95.

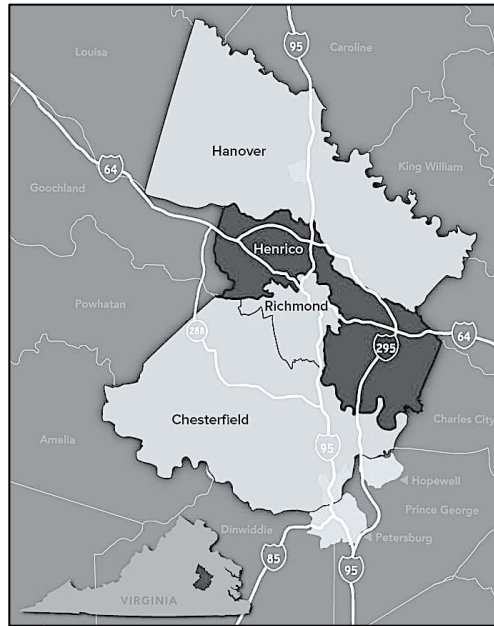


Figure 2: Henrico County, Virginia

Figure 2. Henrico County, Virginia³¹

East Henrico County is home to several areas defined as food deserts by the USDA and Figure 3 “Henrico County, Virginia Food Desert Map” defines these geographic areas based on 2019 survey data.³²

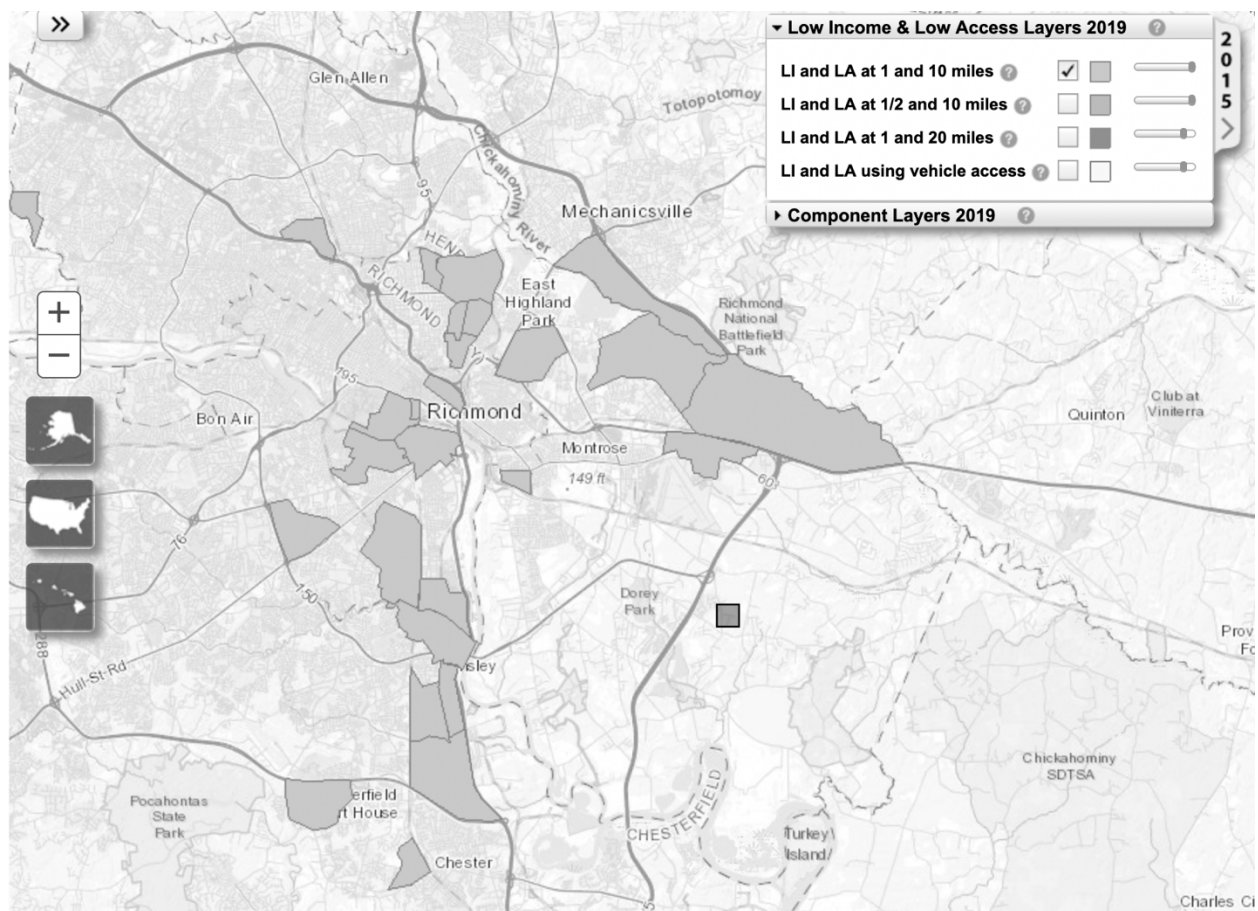


Figure 3: Henrico County, Virginia Food Desert Map

Figure 3. Henrico County, Virginia Food Desert Map³²

Methods

A community-academic partnership was initiated between transdisciplinary oral health researchers at Virginia Commonwealth University's iCubed Oral Health Core and the Henrico Student Wellness Coalition, a multi-stakeholder group. The goal of this partnership was to identify and address the psychological, social, and nutritional contexts of dental and overall health and to inform future innovative solutions for improving oral health and overall health outcomes for populations that are disproportionately affected by oral disease.³³

In 2021, the iCubed Oral Health Core Project conducted a survey of residents of the eastern Henrico community. This survey sought to better understand the health issues faced by residents, including the various factors that might affect resident's health and healthcare needs. Residents of the community were asked to complete the electronic survey.. Participants were asked about their neighborhoods, health status (medical, dental, behavioral), utilization of healthcare and community services, and preferences for potential school-based services. Portions of the study focused on a subset of items relating to children's health and well-being. This community survey was approved by the VCU Institutional Review Board for Human Subject (HM20015695).

This project utilized a secondary data analysis to examine the association between living in a food desert and dental problems in children, data from the iCubed Oral Health Core Project was analyzed. We hypothesized that living in a food desert in East Henrico County, with limited access to healthy foods, would lead to an increase in pediatric oral health problems. Therefore, the primary predictor was residing in a food desert. Due to the lack of information allowing

precise geographic location of family residences, a proxy was adopted in this study for children living in a food desert. The food desert proxy was determined by the response to the question: “To what extent do you agree that this neighborhood has access to affordable fresh produce/ healthy groceries?” Respondents were asked to select from the following options from a 5-point Likert scale: “Strongly agree,” “Agree,” “Neutral,” “Disagree,” “Strongly Disagree.” A response of “Disagree” or “Strongly Disagree” was considered to indicate that the respondent resided in a food desert. This was considered an influence at the community level.

The primary outcome variable was whether the child had experienced pain, which was measured with a binary “Yes” or “No” response. Control variables at the child and family levels were also considered. At the child level, whether the child had been to the dentist in the past 12 months, the child’s race, and their ethnicity were considered. At the family level, the caregiver’s gender, relationship status, and education level were considered.

Survey responses were first summarized with descriptive statistics (counts, percentages). After preliminary descriptive statistics, some response levels were combined to create larger group sizes more conducive to statistical analysis. Logistic regression was used to model the association between residing in a food desert and history of dental pain for the child. Variables with marginal statistical significance ($p\text{-value} \leq 0.10$) in the bivariate analysis were included and backwards elimination was used to reach a parsimonious model. Significance level was set at 0.05. SAS EG v.8.2 (SAS Institute, Cary, NC) for all analyses.

Results

The following is a summary of results from the iCubed Oral Health Core Project Study, including those pertaining to the hypothesized association between food desserts and pediatric oral health problems, as well as other pertinent findings from the study.

Of the 634 respondents who participated in the survey study, 374 reported having children *and* responded to the question regarding access to fresh produce/ healthy groceries. A complete demographic profile is presented in Table 1: Demographic Profile of Respondents (n=374). Approximately 20% of the households reported that their child's mouth was in fair or poor condition (22%) and that their child had experienced dental pain (20%). Seventy-six percent reported that their child completed a dental visit within the last 12 months. The majority of respondents were either Black (40%) or White (40%), and a further 28% identified as Hispanic ethnicity. Sixty-four percent of respondents were female. Thirty-two percent reported some college or trade/ vocational school, while a lesser 18% reported high school or less education. Additionally, 78% were partnered (married or living with partner). Fourteen percent of respondents disagreed or strongly disagreed that they had access to healthy produce and were categorized as living in a food desert.

Table 1: Demographic Profile of Respondents (n=374)

	n	%
Outcome variables		

Condition of the Mouth			
	Excellent/Very Good/Good	292	78%
	Fair/Poor	80	22%
Child Experienced Dental Pain			
	Yes	74	20%
	No	300	80%
Predictor Variables			
Child-Level Influences			
Child Visit Dentist w.in 12mo			
	Yes	275	76%
	No	89	24%
Race			
	American Indian/Alaska Native	24	7%
	Asian	2	1%
	Black/African American	148	40%
	Native Hawaiian or Pacific Islander	4	1%
	White	148	40%
	Multiracial	30	8%
	Other/No response	11	3%
Ethnicity			
	Hispanic	103	28%
	Non-Hispanic	234	65%
	I choose not to answer	25	7%
Family-Level Influences (Responding Parent/Guardian)			
Gender			
	Woman	240	64%
	Man	117	31%
	Other/No response	17	5%
Relationship Status			
	Single	62	17%
	Living with partner	27	7%
	Married	256	69%
	Separated	7	2%
	Divorced	11	3%
	Other/No response	8	2%
Education			
	None	1	0%
	1st to 8th Grade	4	1%
	Some High School	14	4%
	High School Graduate	36	10%
	GED	11	3%
	Some College	92	25%

Vocational Training (business, trade or technical school)	27	7%
Associates Degree (AA, AS)	27	7%
College degree	87	23%
Some Graduate School	31	8%
Graduate or Professional Degree	35	9%
Other/No response	9	2%
Community-Level Influences		
Neighborhood Access to Affordable Produce		
Strongly Agree/Agree	221	59%
Neutral	101	27%
Disagree/Strongly Disagree	52	14%

There was a significant bivariate association between a child having a dental visit within the last 12 months (p-value=0.0014), the child's ethnicity (p-value <0.0001), the guardian's education level (p-value<0.0001), and self-reporting a child experiencing dental pain. There was also a moderate association between access to affordable produce and experiencing dental pain (p-value=0.0504).

There was a significant bivariate association with perceived condition of the child's mouth and the guardian's gender (p-value=0.0005) and the guardian's self-reported relationship status (p-value=0.0257). There was also a moderately significant association between perceived condition of the child's mouth and the child having a dental visit within the last 12 months (p-value=0.0619), child's race (p-value=0.0596), and the guardian's education level (p-value=0.0810). The relationship between perceived condition of the mouth and access to affordable produce was not statistically significant (p-value=0.3249), however, those who reported not residing in a food desert were 1.5 times more likely to perceive their child's mouth condition as "Excellent," "Very Good," or "Good." Because the variable of interest did not

demonstrate statistical significance, further analysis of this outcome variable was not performed.

Complete bivariate analysis results are presented in Table 2.

Table 2: Bivariate Associations with Condition of the Mouth and Experiences with Dental Pain (Odds Ratio, 95% CI)

		Condition of the Mouth (E/VG/G)	P-value	Child Experienced Dental Pain (Y)	P-value
Child-Level					
Child Visit Dentist w.in 12mo			0.0619		0.0014
	Yes	Reference		3.8 (1.67-8.61)	
	No	1.9 (0.97-3.88)		Reference	
Race			0.0596		0.6041
	White	Reference		Reference	
	Black	1.7 (0.94-3.21)		0.8 (0.43-1.35)	
	Other/Multiracial	0.77 (0.40-1.48)		1.0 (0.51-1.96)	
Ethnicity			0.6521		<0.0001
	Hispanic	0.9 (0.50-1.55)		3.2 (1.84-5.70)	
	Non-Hispanic	Reference		Reference	
Family-Level Influences					
Gender (Responding Parent/Guardian)			0.0005		0.2502
	Female	1.3 (1.51-4.01)		1.4 (0.79-2.47)	
	Male	Reference		Reference	
Relationship Status			0.0257		0.5649
	Partnered	0.4 (0.19-0.90)		0.8 (0.50-1.53)	
	Single	Reference		Reference	
Education			0.0810		<0.0001
	College or Beyond	2.8 (1.00-7.86)		3.4 (1.49-7.60)	
	Some College or Trade	1.03 (0.53-2.01)		0.9 (0.42-1.85)	
	High School or Less	Reference		Reference	
Community-Level Influences					
Neighborhood Access to Affordable Produce			0.3249		0.0504
	Yes	Reference		Reference	
	No	1.5 (0.66-3.58)		2.0 (1.00-3.85)	

The variables found to be significant or moderately significant in the bivariate models were considered for the overall model of experiencing dental pain. At the child level, children who

had seen the dentist within the past 12 months were associated with a 3.4 times increased odds of having experienced dental pain (95% CI: 1.44-7.88, p-value=0.0050). Additionally, Hispanic children were 2.3 times more likely to have experienced dental pain than non-Hispanic (95% CI: 1.29-4.12, p-value=0.0049).

At the family level, the responding guardian's education level was significantly associated with experiences with dental pain (p-value=0.0021). The respondents' education levels were classified as those with a college degree or beyond, those with some college education or trade degree, and those with a high school degree or less. Guardians with a college degree or beyond were found to report that their child experienced dental pain with 2.8 times increased odds than those with a high school degree or less (95% CI: 1.18-6.74). Those with some college education or a trade degree had 0.92 times decreased odds of self-reported dental pain than those with a high school degree or less (95% CI: 0.42-2.02), but this difference was not statistically significant.

At the community level, those that lived in food deserts had 2.22 times increased odds of reporting dental pain for a child than those who were not considered to live in food deserts (95% CI: 1.07-4.62, p-value=0.0325). Complete model information is provided in Table 3.

Table 3: Overall Model of Child's Experience with Dental Pain based on Child, Family, and Community-Level Influences

:

Child Experienced Dental Pain (Y)			P-value
Child-Level			
Child Visit Dentist w.in 12mo	Yes	3.37 (1.44-7.88)	0.0050
	No	Reference	
Ethnicity	Hispanic	2.30 (1.29-4.12)	0.0049
	Non-Hispanic	Reference	
Family-Level Influences			
Education	College or Beyond	2.82 (1.18-6.74)	0.0021
	Some College or Trade	0.92 (0.42-2.02)	
	High School or Less	Reference	
Community-Level Influences			
Neighborhood Access to Affordable Produce	Yes	Reference	0.0325
	No	2.22 (1.07-4.62)	

Discussion

There appears to exist at least a moderate association between access to affordable produce and experiencing dental pain based on analysis of data collected in the iCubed Oral Health Project survey. After adjusting for influences at the child and family levels, guardians of children that live in perceived food deserts had a 2.22 times increased odds of reporting a child having experienced dental pain than those who were not considered to live in a food desert (95% CI: 1.07-4.62, p-value=0.0325). When considered alone, residing in a food desert was only marginally significantly associated with having a child experience dental pain.

As discussed previously, there exists a significant body of evidence to suggest a strong association between different social determinants of health, such as socioeconomic status, and higher incidence of pediatric dental caries and oral health problems. Similar associations are set forth in the Fisher-Owens model.⁶ There also exists an association between socioeconomic status and likelihood of residing in a food desert. While one might presume that there is a direct association between living in a food desert and higher incidence of pediatric oral health problems, there is a paucity of evidence to support a direct association. The results of this analysis indicate a direct association.

The importance of better understanding the relationship between food deserts and pediatric oral health problems cannot be understated. If a strong association between these two entities does in fact exist, a better understanding of this interaction could support the development of public

health policy and community-based oral health programs aimed at decreasing oral health disparities exacerbated by geographic residence. Intervention in the pediatric population has potential to have a significant positive impact on the burden of dental caries as these patients grow into adults, noting that “the best predictor of future caries is past caries.”³⁴

There were several other notable findings from the iCubed Oral Health Core survey analysis. These findings raise additional questions and may warrant future study. We have included those findings here, organized based on their relation to the Fisher-Owens model:

At the child level, children who had been seen by the dentist within the past 12 months were associated with 3.4 times increased odds of having experienced dental pain (95% CI: 1.44-7.88). It was also found that Hispanic children were noted to be 2.3 times more likely to have experienced dental pain than non-Hispanic (95% CI: 1.29-4.12, p-value=0.0049)

At the family level, the responding guardian’s education level was significantly associated with experiences with dental pain (p-value=0.0021). Guardians with a college degree or beyond were associated with reporting their child experienced dental pain with 2.8 times increased odds than those with high school degree or less (95% CI: 1.18-6.74). Although not statistically significant, guardians with some college or a trade degree have a 0.92 times decreased odds of self-reported dental pain experience than those with a high school degree or less (95% CI: 0.42-2.02).

This study is subject to several limitations. The population from which the respondents were drawn was self-selected and may not be representative of the entire population of East Henrico

County. The need to adopt a proxy indicator to represent residence in a food desert, as opposed to using exact postal address for the respondents, may bias or even underestimate findings derived from this variable. For future studies that assess whether or not a subject lives in a food desert, the home address of the subject would be needed to most accurately assess if they do, in fact, live in a food desert. Additionally, as the iCubed Oral Health Project survey is self-reported, responses may be subject to recall bias of the participant. Similar to research by Testa et al., future research using a calibrated, standardized dental examination would be beneficial to assess the degree and accuracy of the of oral health problems reported by the respondents.³⁵ It would also be beneficial to know how long the child had resided in a food desert to better understand the correlation between living in a food desert and experiencing oral health problems.

Conclusion

There does appear to be a direct association between living in a food desert and risk of pediatric dental problems, based on analysis of data from residents of East Henrico County, Virginia.

Additional population-based studies would be beneficial to improve our understanding of this association, which in turn could support the allocation of resources for targeted outreach and public health interventions.

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