Submitted: 25 May, 2023 Accepted: 04 July, 2023 Published: 03 January, 2024 DOI:10.22514/jocpd.2024.008

ORIGINAL RESEARCH

Journal of Clinical Pediatric Dentistry

Investigating the relationship between dental cavities and protective factors among children aged 0–5 years

Marlene Dontsop[1], Kyle Nwankwo[1], Riva Walker[1], Christianna Potter[1], Chau-Kuang Chen[2], Ruth Bol[1], Lisa Sherden[1], Pandu R Gangula[1], Cherae Farmer-Dixon[3,*]

[1]Department of Oral Diagnostic Sciences & Research, Meharry Medical College School of Dentistry, Nashville, TN 37208, USA
[2]School of Graduate Studies, Meharry Medical College, Nashville, TN 37208, USA
[3]Department of Dental Public Health, School of Dentistry, Meharry Medical College, Nashville, TN 37208, USA

***Correspondence**
cdixon@mmc.edu
(Cherae Farmer-Dixon)

Abstract

The purpose of this study was to determine the protective factors that contribute to the prevention of children aged 0–5 years from developing dental cavities. The oral hygiene practices of 266 children aged 0–5 years were assessed through surveys administered from 2019 to 2022 to identify clinical, dietary, social and parental factors. The Partial Least Squares (PLS) Regression and Artificial Neuron Networks (ANN) Models were used to determine protective factors associated with the prevention of dental cavities in children. The race distribution of the children as identified by caregivers is as follows: (1) Black or African-American (53.4%); (2) Asian (25.9%); (3) White (18.4%); and (4) Native American (2.3%). We found behavioral protective factors to significantly affect the oral health outcome (cavities) among children aged 0–5 years ($p < 0.05$). We also found that children whose parents/caregivers flossed their teeth were less likely to develop cavities. In addition, children were least likely to have cavities if their parents/caregivers used toothpaste and mouthwash, avoided sharing chewed food, and refrained from drinking 100% juice. In contrast, children were more likely to obtain cavities if their parents/caregivers had a lower education level, rarely cleaned their teeth, and often consumed marijuana, cow or goat milk, juice drinks and sugary beverages. The education level of parents, and on the contrary, oral hygiene practices of the family, play a significant role in influencing the prevalence of cavities in children aged 0–5 years.

Keywords

Dental caries; Protective factors; Pediatric dentistry

1. Introduction

Untreated dental caries was the most prevalent disease identified in the 2019 study of the Global Burden of Disease (GBD), with a larger percentage of untreated caries affecting children on a global scale [1]. Genetical and parent/child behavioral factors are two major risk factors for early childhood caries among 0–5 years old children [2]. Behavioral and food habits also play a crucial role in protecting teeth from cavities among this age group [2]. Findings from cross-sectional and prospective studies conducted among low-income African American children aged 0–5 years in Detroit, Michigan suggest children who consume more sugar-sweetened beverages are at increased risk of periodontal disease and dental caries [3]. Based on the 2019 data from the Centers of Disease Control and Prevention (CDC), roughly 33% of Mexican-American and 28% of non-Hispanic African-American children aged 2–5 years contracted cavities in the primary dentition, compared to 18% of non-Hispanic White children in the same age group [4]. Additionally, it is evident that family income plays a critical role in maintaining good oral health among these communities [4]. While dental caries in children is preventable, its prevalence among minority populations is high [4]. Untreated caries in young children can ultimately yield a negative outcome in the future because untreated caries can cause infection and pain, consequently affecting overall health [5]. The oral cavity is the gateway to the systemic body; thus, the development of cavities can affect and/or exacerbate health symptoms overall. Therefore, the treatment of cavities in young children can be beneficial not only for the health status of the mouth but also for that of the body.

Several factors are known to play a role in the development of carious lesions, such as race and ethnicity, maternal oral health, diet, socioeconomic status, parental education, oral hygiene practices and access to dental care/dental home. Parental behavior also plays an important role in the oral health of children and the development of caries. Studies have shown that this is because parental behavior impacts parental education, maternal diet, maternal oral health, toothbrushing practices at home, and family sugary food intake [6]. In Tennessee, oral diseases are among the most prevalent health problems that affect a significant number of children in every county [7]. However, studies showing the risk factors associated with dental caries among children aged 0–5 years

from families of low socioeconomic status are limited.

Therefore, we conducted this study to investigate the effects of several risk and protective factors that play a role in the development of dental cavities in children in the underserved, diverse and rural populations in Nashville, Tennessee. Our study is the first to evaluate the clinical, dietary, social and behavioral protective factors for both parents/caregivers and their children that attribute to the prevention of dental caries among children aged 0–5 years living in Davidson County. Specifically, we evaluated factors that contribute to the maintenance of caries/gum disease-free oral cavities and the child's oral health.

2. Materials & methods

The surveys for this study were administered between 2019 and 2022.

2.1 Sample size

Surveys were presented to 266 aged 0–5 years old children's caregivers in Davidson County, Nashville, TN.

2.2 Inclusion criteria

The caregivers (18–60 years old) of children aged 0–5 years with diverse, vulnerable and underserved backgrounds were recruited. Pregnant women (18–60 years old) who already have children were also included in the study.

2.3 Exclusion criteria

Caregivers of children above five years old were excluded from the study.

2.4 Treatment providers

Predoctoral Pediatric General Dental students (third- and fourth-year) at Meharry Medical College were responsible for administering the surveys. Dental Clinical faculty oversaw the entire program. All data was stored in a coded manner and samples were de-identified. The Principal Investigator and Program Coordinator had access to identifiers that were locked in a file cabinet and secured office. Data analysis and all evaluation procedures were performed by a biostatistician in the Office of Institutional Research, Meharry Medical College, Nashville, TN.

2.5 Recruitment of participants

Parents and caregivers of children aged 0–5 years were recruited from the Metropolitan Action Commission Head Start Program of Nashville, Meharry Medical College School of Medicine's Pediatric Department, and Meharry Medical College School of Dentistry's Pediatric Department. Meharry Medical College has a long-standing partnership with these pediatric dental clinics in the Nashville, TN area where predoctoral dental students receive their training.

2.6 Questionnaire survey

A total of 266 surveys were administered to assess child's and caregiver's oral hygiene practices, current dental health, and access to a dental home. The survey questionnaire collected information on behavioral and dietary habits as well as perceptions related to oral/systemic health within the four domains of health (physical, social, dietary and psychological). Survey instruments were adopted from the American Dental Association (ADA) Caries Risk forms that are available online. Caregivers' health information was also recorded. Demographic information was collected for all participants (age, race, gender, socioeconomic status, household income, educational level and marital status).

2.7 Statistical analysis

The IBM Statistical Packages for Social Sciences (SPSS) software suite, version 27, provided by IBM in Chicago, IL, US, was used to perform data analysis. The Partial Least Squares (PLS) Regression model was used to determine the protective factors associated with the prevention of dental cavities in children, measured in a binary scale (Yes/No). PLS Regression is instrumental when dealing with survey data and dental records comprising a large number of variables, including the elucidation of multicollinearity or correlation among the protective factors. The variables with 95% confidence interval of Variable Importance in the Projection (VIP) containing a positive value, especially greater than one, were considered. In addition, the significant effects of the protective factors were determined based on the p-value of being less than the 0.05 significance level, *i.e.*, the 95% confidence interval of the regression coefficient not containing zero. The Artificial Neuron Network (ANN) model is particularly useful when the relationships among variables are nonlinear and difficult to model using traditional statistical techniques. The ANN was trained to identify patterns and nonlinear relationships among multidimensional variables. A normalized importance value of greater than 50% was considered the indicator of important variables. Both the PLS Regression and ANN models were used to make predictions in order to determine the likelihood of a child developing dental cavities based on the protective factors examined. The results of these predictions could be used to inform preventive measures and interventions to reduce the occurrence of dental cavities in children.

3. Results

A total of 266 children aged 0–5 participated in this study as their parents/caregivers completed the survey. The variables used in the analysis of protective factors and their correlation to the prevention of caries were obtained using the PLS and ANN models (Table 1). Categorical factors were the children's race, the education level of parent/guardian, and the household income. The remaining variables or predictors, contributed to the dependent variable (or outcome variable) that determined if the children in the study experienced cavities.

There were 122 girls (45.9%) and 144 boys (54.1%) in this study (Table 2). Most of the children surveyed identified as Black/African American (53.4%) (Table 2). The two

TABLE 1. Variables in the ANN and PLS models.

Variable Names	Variable Descriptions
what_is_the_childs_race	What is the child's race?
highest_degree_or_level_of_school	What is the highest degree or level of school you have completed?
household_income	What is your household income?
how_often_do_you_clean_teeth	How often do you clean your teeth?
use_toothpaste	Do you use toothpaste to clean your teeth?
use_dental_floss	Do you use dental floss?
use_mouthwash	Do you use mouthwash?
do_you_drink_cow_s_milk_or	Do you drink cow or goat milk?
do_you_drink_100_juice	Do you drink 100% juice?
do_you_drink_juice_drinks	Do you drink juice drinks?
do_you_drink_flavord_wate	Do you drink flavored water?
do_you_drink_sugared_bever	Do you drink sugared beverages?
cigarettes	How often do you smoke cigarettes?
marijuana	How often do you use marijuana?
drinks_per_day	During the past 30 days, on the days you drank alcohol, how many drinks do you usually drink per day?
are_you_overweight	Are you overweight?
heart_disease	Past medical history (Heart Disease)
high_blood_pressure	Past medical history (High Blood Pressure)
diabetes_mellitus	Past medical history (diabetes)
how_often_do_you_brush_yo	How often do you brush your teeth?
do_you_floss_your_child_s	Do you floss your child's teeth?
do_you_help_your_child_use	Do you help your child use mouth rinse?
do_your_children_share_foo	Do your children share food?
do_you_chew_food_and_then	Do you chew your food then share it with your child?
do_your_children_take_fluo	Do your children take fluoride supplements?
Dependent (Outcome) Variable	Have your children experienced cavities?

The outcome variables and the protective risk factors were evaluated in the parent and child surveys. The PLS Regression and ANN models to determine which protective factors have the most significant effect or greatest impact on the prevention of dental cavities. The protective factors include dietary habits (consumption of sugary or acidic foods and drinks); oral hygiene habits (regular brushing, flossing, and mouthwash use); socioeconomic status (income and education levels); and medical condition (heart disease, high blood pressure and diabetes).

TABLE 2. Socio-demographic characteristics of participants.

Categories	n	%
Child's gender identified by parents		
Female	122	45.9%
Male	144	54.1%
Child's race identified by parents		
Native American	6	2.3%
Asian	69	25.9%
Black or African American	142	53.4%
Caucasian	49	18.4%
Parent's marital status		
Single	64	34.8%
Married/Partnered	69	37.5%
Widowed	27	14.7%
Divorced	15	8.2%
Separated	9	4.9%
Parent's highest education level		
Less than high school	46	25.0%
High school diploma or General Educational Development Certificate (GED)	47	25.5%
Some college	42	22.8%
Associate degree	13	7.1%
Bachelor's degree	20	10.9%
Master's degree	12	6.5%
Doctorate	4	2.2%
Parent's household income		
Less than $20 K	64	35.0%
$20 K to $34 K	54	29.5%
$35 K to $49 K	21	11.5%
$50 K to $74 K	26	14.2%
$75 K to $99 K	8	4.4%
Over $100 K	10	5.5%

Characteristics of the participants were determined: the child's gender, ethnicity and race; parent's marital status; parent's highest education level; and parent's household income.

most common marital status of the parent/caregiver was married/partnered (37.5%) and single (34.8%) (Table 2). The most common highest level of education of parent/caregiver was a high school diploma or General Educational Development Certificate (GED) (25.5%), and the most common household income was less than $20k (35%) (Table 2).

Variables that were highly correlated with the presence of dental cavities in the children surveyed were marijuana usage, tooth-cleaning frequency, toothpaste usage, flossing of child's teeth, the level of education of parent/caregiver, drinking of sugary beverages, mouthwash usage, food sharing between parent/caregiver and child, drinking of juice drinks and 100% juice, and drinking of cow's milk (Fig. 1).

The PLS Regression model illustrates factors that are either positively or negatively associated with the development of cavities in the children surveyed ($p < 0.05$) (Table 3). The study found marijuana usage, food sharing between caregiver/parent and child, and consumption of certain types of drinks (cow or goat milk, juice drinks and sugary beverages) to be significantly associated with a higher risk of developing dental cavities. On the other hand, the highest education level of parent/caregiver, tooth-brushing frequency, toothpaste usage, mouthwash usage and flossing of the child's teeth were significantly associated with a lower risk of developing dental cavities. Taken together, our results revealed some behavioral protective factors that contribute to the prevention of dental cavities in children aged 0–5 years.

The ANN model revealed variables with a normalized importance greater than 50% to be the child's race, alcohol consumption of parent/caregiver, mouthwash usage, parent/caregiver with diabetes mellitus, fluoride supplementation in the child, flossing of child's teeth, the highest level of education of parent/caregiver, marijuana usage, toothpaste usage, sharing of food between parent/caregiver and child, and helping the child with mouth rinse (Fig. 2).

4. Discussion

Our survey data revealed the effectiveness of certain protective factors in lowering the prevalence of caries in children aged 0–5 years. Factors that play an important role in preventing childhood caries include the frequency at which a child brushes and flosses their teeth, the child's diet, food sharing between parent/caregiver and child, and the social habits of the parent. The income and education level of parents/caregivers also play a role in the development of caries in children.

Data from the PLS and ANN models of our study support the notion that tooth-brushing, flossing and the use of fluoride are beneficial in reducing the risk of dental cavities in children

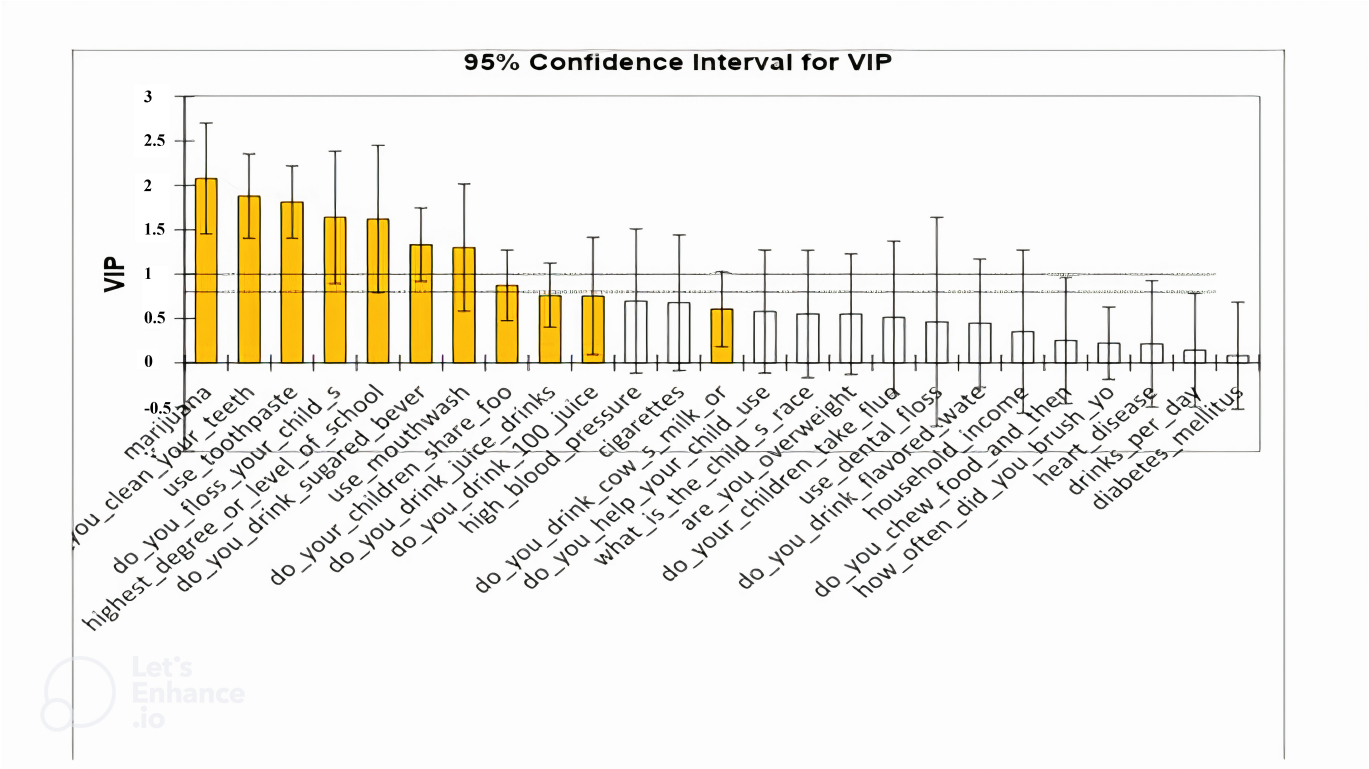

FIGURE 1. Variables indicative of the Variable Importance in the Projection (VIP). VIP measures the importance of individual variables in the model. Variables with high VIP scores are considered more important and have a greater impact on dental caries. Conversely, variables with low VIP scores are considered less important and have a lesser impact on dental caries. The graph shows the 95% confidence interval for the VIP scores, with grey-colored variables being more important and having a greater impact on dental cavities. The variables analyzed in this study include marijuana usage, frequency of tooth-cleaning, toothpaste usage, flossing of the child's teeth, the educational level of the parent/caregiver, consumption of sugary beverages, mouthwash usage, food sharing between the parent/caregiver and child, consumption of juice drinks and 100% juice, and consumption of cow's milk.

TABLE 3. Standardized coefficients in PLS regression model.

Variable	Coefficient	Lower Limit	Upper Limit
highest_degree_or_level_of_school*	−0.072	−0.110	−0.035
household_income	−0.016	−0.058	0.027
how_often_do_you_clean_your_teeth*	−0.084	−0.113	−0.055
use_toothpaste*	−0.081	−0.108	−0.054
use_dental_floss	0.021	−0.033	0.074
use_mouthwash*	−0.058	−0.092	−0.024
cigarettes	−0.030	−0.064	0.004
drinks_per_day	−0.006	−0.037	0.024
heart_disease	0.009	−0.023	0.042
high_blood_pressure	0.031	−0.006	0.068
diabetes_mellitus	0.004	−0.026	0.033
marijuana*	0.093	0.069	0.116
are_you_overweight	0.024	−0.007	0.056
what_is_the_child_s_race	−0.025	−0.058	0.009
how_often_did_you_brush_yo	0.010	−0.009	0.029
do_you_floss_your_child_s*	−0.073	−0.109	−0.037
do_you_help_your_child_use	0.026	−0.009	0.060
do_your_children_share_foo*	0.039	0.021	0.057
do_you_chew_food_and_then	0.011	−0.021	0.044
do_your_children_take_fluo	0.023	−0.017	0.063
do_you_drink_cow_s_milk_or*	0.027	0.011	0.043
do_you_drink_100_juice*	0.034	0.002	0.065
do_you_drink_juice_drinks*	0.034	0.013	0.055
do_you_drink_flavored_wate	0.020	−0.011	0.051
do_you_drink_sugared_bever*	0.059	0.040	0.079

**$p < 0.05$. Specific explanatory variables that may have an impact on children aged 0–5 years in contracting dental caries. The table displays standardized coefficients for each variable in the PLS Regression model for predicting dental cavities. Standardized coefficients indicate the strength and direction of the relationship between each variable and the development of dental cavities after accounting for the other variables in the model. Positive coefficients indicate a positive relationship with the development of dental cavities, while negative coefficients indicate a negative relationship. Significant variables are presented with their associated p-values. A coefficient is considered significant if $p < 0.05$.*

aged 0–5 years. In support of our findings, previous studies have shown that children aged 3 years and under should brush their teeth twice a day with a smear-sized amount of toothpaste, preferably after eating breakfast and before going to bed [8]. For children aged 0–5 years, parental guidance during tooth-brushing is crucial to the prevention of caries as the child may have difficulty aiming the toothbrush at certain areas, especially the posterior teeth. Toothpaste containing fluoride works best in preventing tooth decay as fluoride can prohibit demineralization of the teeth. Fluoride supplements can be given to children who drink fluoride-deficient water or do not use a fluoridated toothpaste [8]. After tooth-brushing, it is best not to rinse the mouth with water as this will remove the fluoride needed to protect the child's teeth [8]. Flossing is also effective in preventing caries as it is crucial to eliminate food debris interproximally in order to prevent incipient cavitated lesions. Flossing can begin when the child starts to have two teeth adjacent to each other [9]. Collectively, our study demonstrates that fluoride supplements coupled with flossing can protect children against dental caries.

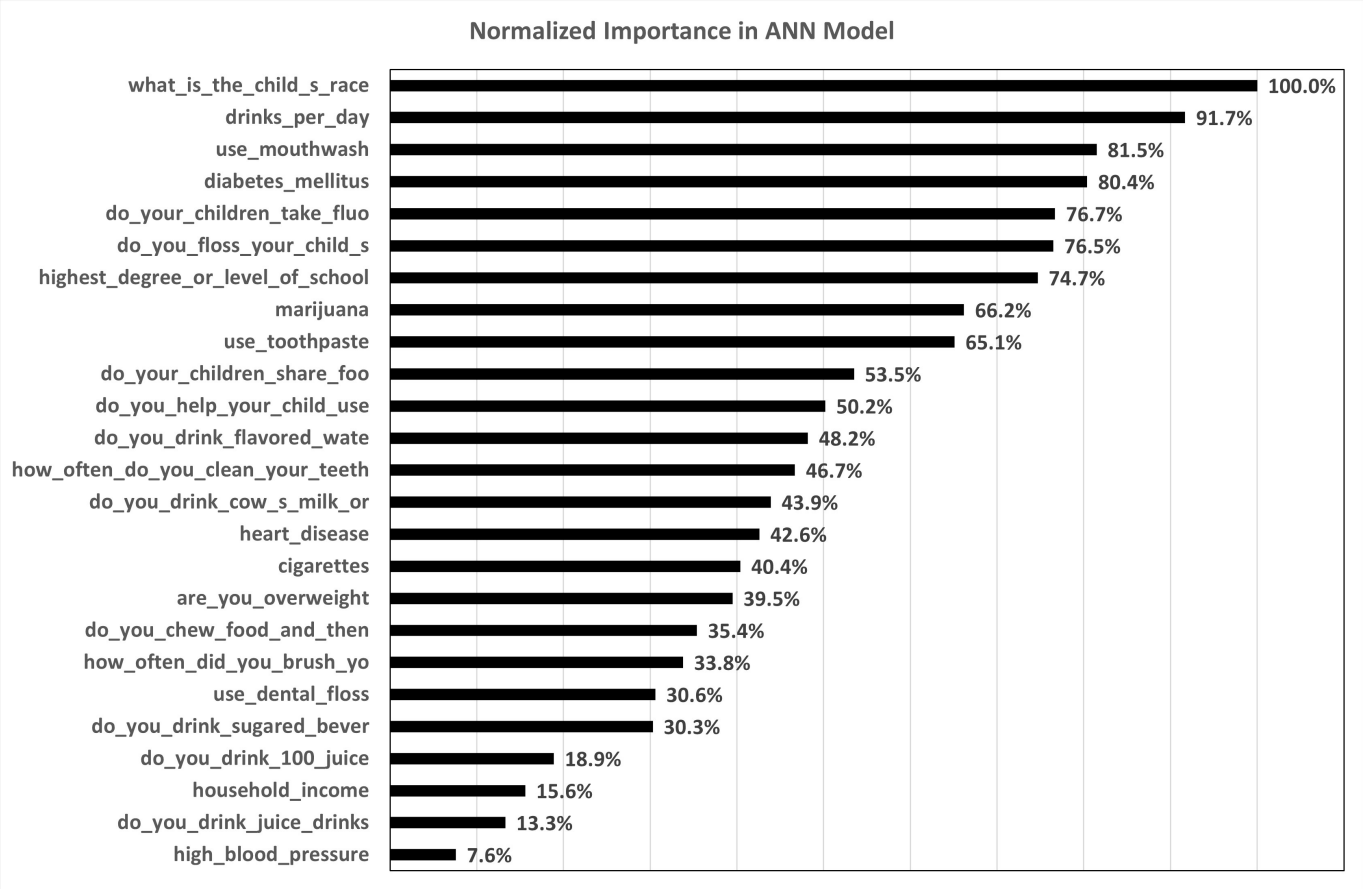

FIGURE 2. Several variables and their normalized importance % in the Artificial Neuron Network (ANN) Model. Normalized (relative) importance measures and ranks the importance of protective factors in relation to the prevention of dental cavities. The chart displays the normalized importance of protective factors in predicting the dental cavities for the development of targeted interventions to prevent dental cavities in children. The variables examined in this study include the child's race, alcohol consumption of the parent/caregiver, mouthwash usage, presence of diabetes mellitus in the parent/caregiver, fluoride supplementation in the child, flossing of the child's teeth, the highest educational level of the parent/caregiver, marijuana usage, toothpaste usage, sharing of food between the parent/caregiver and child, and assistance provided to the child with mouth rinse. ANN: Artificial Neuron Network.

Diet plays a significant role in the development of cavities in children. Similar to our findings, the consumption of cow's milk, goat's milk, sugary beverages, 100% juice and other juice drinks has been found to influence caries development in children aged 0–5 years [10]. The consumption of 100% juice not only leads to excess caloric intake, but also exacerbates the risk of caries development in children, especially when consumption is in excess [10]. The American Academy of Pediatric Dentistry (AAPD) recommends juice intake be limited to 4 oz daily for children aged 1–3 years and 4–6 oz daily for children aged 4–6 years [11]. Eliminating bottle-feeding of liquids such as fruit juice and cow milk at bedtime can prevent caries in infants. This is because bottle-feeding of these beverages at bedtime allows these sugar-containing liquids to stay on the teeth for a longer period of time.

Our data support the notion that food sharing is a risk factor for the development of caries in children aged 0–5 years. Parents may be prone to chewing food prior to sharing it with their children or sharing food from the same utensils, thus allowing the transmission of caries to their children [12]. Food sharing allows the introduction of bacteria to the child through the sharing of saliva [12]. The same concept applies to children sharing food with their siblings or other children.

Our survey results demonstrate that children with parents/caregivers with low household incomes are more likely to present with caries. Families with low socioeconomic status are more likely to consume sugary foods and drinks more often, pass caries to their children, and not have a dental home or access to proper oral hygiene care such as dental insurance [13]. Children from minority backgrounds are also more likely to have a low socioeconomic status, thus increasing their risk for developing dental caries [14]. In support of this notion, our study data also revealed a strong correlation between a child's race and the likelihood of caries in the child.

Our findings also revealed the impact of the education level of parent/caregiver on the likelihood of a child developing cavities. The education level of the parents/caregivers may affect their awareness of the oral health status of their children [15]. Parents/caregivers with lower education levels may not be as involved in their children's oral health regimen, nor may they understand the importance of oral hygiene or have access

to dental education [15]. Therefore, our studies suggest that the more educated the parents/caregivers are, the less likely their children will develop caries.

Similar to findings from other studies, our data support the notion that social activities of the parents/caregivers such as alcohol consumption and marijuana usage can also influence the prevalence of caries in their children [16]. Alcohol and tetrahydrocannabinol (THC, the active ingredient in marijuana) can cross the placenta and affect the dental health of the offspring in utero [16]. Our survey results show a high correlation between the presence of diabetes in the parent and caries development in the child. The presence of systemic diseases such as diabetes mellitus in the parents also increases the risk of caries in their children. Diabetes mellitus often presents with oral manifestations such as xerostomia, periodontal disease and increased caries risk [17]. Biological parents with diabetes mellitus can potentially pass down the disease to their offspring [18]. Collectively, the above studies suggest that oral health among children aged 0–5 years is dependent on the social activities and systemic health complications of their parents.

Our study is the first to evaluate how several factors contribute to the development of caries in children aged 0–5 years living in Davidson County, Nashville, TN, in areas of low-socioeconomic and underserved populations. Our study also determined the factors that pose a risk for caries in this same population, and our data are consistent with those from previous studies. However, there are currently no studies that highlight the underserved populations in Davidson County as well as their dental health and the factors that play a role in early childhood caries in this age group. Based on our findings from the PLS Regression and ANN models, we surmise that certain behavioral and environmental factors are significantly associated with a higher risk of dental cavities in children. These factors include marijuana usage, alcohol consumption of parent/caregiver, food sharing between caregiver/parent and child, and the consumption of certain types of drinks such as cow or goat milk, juice drinks and sugary beverages. Our study found certain oral hygiene behaviors and socio-demographic factors to be significantly associated with a lower risk of dental cavities in children. These factors include the highest education level of parent/caregiver, tooth-brushing frequency, toothpaste usage, mouthwash usage, flossing of the child's teeth, and fluoride supplementation in the child.

Our findings suggest that interventions aimed at reducing dental cavities in children should focus on promoting good oral hygiene behaviors such as regular tooth-brushing, flossing, and mouthwash usage, as well as reducing risk factors such as marijuana and alcohol use, food sharing, and consumption of sugary drinks. Furthermore, interventions should be tailored to address socio-demographic factors such as parental education level and racial issues. Collectively, our results from the PLS Regression and ANN models provide valuable insights into the factors that contribute to the development of dental cavities in children of low socioeconomic backgrounds and can inform the development of targeted interventions to reduce the incidence of this common dental condition among these children.

Our study had several limitations. The administration of surveys slowed down due to the COVID-19 pandemic and we were unable to achieve a sample size of 500 participants. Also, this study only recruited participants in Davidson County, Nashville, TN. In this study, the gender of the child was included as a socio-demographic characteristic of the study participants. However, we do not have enough information to ascertain if there are differences in gender with regards to the development of cavities in the children surveyed. Therefore, additional studies are warranted. Future studies should also utilize a longitudinal research approach by partnering with neighboring counties in Tennessee that also include underserved populations and families with inadequate access to dental care and education.

5. Conclusions

Based on our results, we conclude that there are several protective factors that aid in the prevention of dental cavities, as well as risk factors that contribute to the development of cavities in children aged 0–5 years. Our findings highlight the importance of early visits to the dentist for preventative measures and the establishment of a dental home by the age of one.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article.

AUTHOR CONTRIBUTIONS

KN, RW and CP—instrumented the surveys. RB—supervised the research team and also instrumented the surveys. LS—assisted with instrumenting surveys and data inclusion in RedCap. MD—wrote the manuscript. CK—analyzed the statistical data and assisted in the editing of the manuscript. PG—coordinated with the entire team during the research period and assisted in editing the manuscript. CFD—serves as the corresponding author and designed the research study as well as assisted in the editing of the manuscript. All authors read and improved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board, Meharry Medical College, Nashville, TN (IRB No. FWA00003675). This study complies with HIPAA standards and informed consent was obtained from all parents/caregivers along with verbal assent from the children.

ACKNOWLEDGMENT

We thank the Meharry Medical College School of Dentistry for supporting our research endeavors. We thank the Metropolitan Action Commission Head Start Program of Nashville and Meharry Medical College School of Medicine's Pediatric Department for allowing us to administer the surveys to caregivers. We also thank the Meharry Office of Scientific Editing and Publications (NIH grant S21MD000104) for editorial

assistance.

FUNDING

This research was funded by the HRSA Predoctoral Pediatric Training Grant (D85HP30825) and HRSA-COE Student Research Grant (D34HP00002) to Dr. Farmer-Dixon. This research was funded by the National Institute of Dental and Craniofacial Research (NIDCR), USA, Grant (U01DE033241).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Qin X, Zi H, Zeng X. Changes in the global burden of untreated dental caries from 1990 to 2019: a systematic analysis for the Global Burden of Disease study. Heliyon. 2022; 8: e10714.

[2] Ganesh A, Sampath V, Sivanandam BP, H S, Ramesh A. Risk factors for early childhood caries in toddlers: an institution-based study. Cureus. 2020; 12: e7516.

[3] Lim S, Tellez M, Ismail AI. Dental caries development among African American children: results from a 4-year longitudinal study. Community Dentistry and Oral Epidemiology. 2015; 43: 200–207.

[4] Centers for Disease Control and Prevention. Oral health surveillance report: trends in dental caries and sealants, tooth retention, and edentulism, United States, 1999–2004 to 2011–2016. 2019. Available at: https://www.cdc.gov/oralhealth/pdfs_and_other_files/Oral-Health-Surveillance-Report-2019-h.pdf (Accessed: 22 March 2023).

[5] U.S. Department of Health and Human Services. Section 2A: oral health across the lifespan: children. In US Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research (ed.) Oral Health in America: Advances and Challenges (pp. 2A1–98). National Institute of Dental and Craniofacial Research: Bethesda. 2021.

[6] Dumitrescu R, Sava-Rosianu R, Jumanca D, Balean O, Damian LR, Fratila AD, *et al*. The impact of parental education on schoolchildren's oral health—a multicenter cross-sectional study in Romania. International Journal of Environmental Research and Public Health. 2022; 19: 11102.

[7] TN Department of Health. Tennessee state oral health plan. 2022. Available at: https://www.tn.gov/health/health-program-areas/oralhealth/state-oral-health-plan.html (Accessed: 27 October 2022).

[8] American Academy of Pediatric Dentistry. Guideline on fluoride therapy. The Reference Manual of Pediatric Dentistry. American Academy of Pediatric Dentistry: Chicago, Ill. 2022: 317–320.

[9] American Academy of Pediatric Dentistry. Fast Facts. 2014. Available at: https://www.aapd.org/assets/1/7/fastfacts.pdf (Accessed: 27 October 2022).

[10] Kay MC, Welker EB, Jacquier EF, Story MT. Beverage consumption patterns among infants and young children (0–47.9 months): data from the feeding infants and toddlers study, 2016. Nutrients. 2018; 10: 825.

[11] American Academy of Pediatric Dentistry. Healthy beverage consumption in early childhood: recommendations from key national health and nutrition organizations: summary of oral health considerations. The Reference Manual of Pediatric Dentistry. American Academy of Pediatric Dentistry: Chicago, Ill. 2021: 565–568.

[12] Ramadugu K, Bhaumik D, Luo T, Gicquelais RE, Lee KH, Stafford EB, *et al*. Maternal oral health influences infant salivary microbiome. Journal of Dental Research. 2021; 100: 58–65.

[13] Vasireddy D, Sathiyakumar T, Mondal S, Sur S. Socioeconomic factors associated with the risk and prevalence of dental caries and dental treatment trends in children: a cross-sectional analysis of national survey of children's health (NSCH) data, 2016–2019. Cureus. 2021; 13: e19184.

[14] Ismail AI, Lim S, Sohn W, Willem JM. Determinants of early childhood caries in low-income African-American young children. Pediatric Dentistry. 2008; 30: 289–296.

[15] Ellakany P, Madi M, Fouda SM, Ibrahim M, AlHumaid J. The effect of parental education and socioeconomic status on dental caries among Saudi children. International Journal of Environmental Research and Public Health. 2021; 18: 11862.

[16] Auger N, Low N, Lee G, Ayoub A, Nicolau B. Prenatal substance use disorders and dental caries in children. Journal of Dental Research. 2020; 99: 395–401.

[17] Rohani B. Oral manifestations in patients with diabetes mellitus. World Journal of Diabetes. 2019; 10: 485–489.

[18] Pascon T, Barbosa AMP, Cordeiro RCL, Bussaneli DG, Prudencio CB, Nunes SK, *et al*. Prenatal exposure to gestational diabetes mellitus increases developmental defects in the enamel of offspring. PLOS ONE. 2019; 14: e0211771.

How to cite this article: Marlene Dontsop, Kyle Nwankwo, Riva Walker, Christianna Potter, Chau-Kuang Chen, Ruth Bol, *et al*. Investigating the relationship between dental cavities and protective factors among children aged 0–5 years. Journal of Clinical Pediatric Dentistry. 2024; 48(1): 60-68. doi: 10.22514/jocpd.2024.008.