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A decade of change: unraveling the factors shaping untreated dental caries trends in U.S. children, 2011-2020

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A DECADE OF CHANGE: UNRAVELING THE FACTORS SHAPING UNTREATED DENTAL CARIES TRENDS IN U.S. CHILDREN, 2011-2020

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Abstract.

Objectives: This study evaluated whether the reduction in untreated dental caries among U.S. children aged 2–11 years over the past decade reflects meaningful oral health improvements. It also examined associations between the prevalence of untreated caries and factors such as socioeconomic status, dietary habits, access to care, and demographics.

Methods: Data from NHANES cycles 2011–2020 were analyzed, including 7,195 children aged 2–11. Untreated dental caries were defined as active, untreated lesions. Descriptive statistics summarized characteristics; bivariate analyses assessed associations, followed by multivariable logistic regression to identify independent predictors. Interaction terms evaluated time-based effect modification, and stratified analyses were conducted by age group. Survey weights were applied to account for NHANES complex design.

Results: Overall, 13.7% of children had untreated caries. Prevalence declined from 15.4%(2011–2012) to 12.2%(2015–2016), but rose slightly to 12.8%(2017–2020). Each successive cycle was associated with 10% reduction in odds of untreated caries (OR=0.9; 95%CI:0.83–1.06). Age modified trends: prevalence consistently declined among older children (21.5% to 14.1%) but fluctuated in younger children. Poverty strongly predicted untreated caries; children with income-to-poverty ratio<0.5 had fourfold higher odds (OR=3.7; 95%CI:2.3–5.89).

Uninsured children had 50% higher odds, while private insurance had 20% lower odds (OR=0.8, 95%CI:0.61–0.96). Children without a dental visit in over a year had 3.2 times higher odds (95% CI: 2.53–4.16).

Conclusions: Despite a 20% cumulative decline, the trend in untreated dental caries may be plateauing. Targeted, age-specific interventions are needed to reduce disparities and improve oral health among U.S. children.

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Introduction.

Dental care emerges as the foremost unmet health requirement among children in the United States. Dental caries stands out as the most prevalent chronic disease in the pediatric population,[1] significantly impacting oral health and overall well-being.[2] About 20% of children aged 5 to 11 have at least one untreated decayed tooth,[3] putting them at risk for pain, infection, and missed school days due to dental problems.[4] In fact, more than 51 million school hours are missed annually because of unplanned dental care needs.[5] The burden of this preventable disease is enormous, by mid-childhood, more than 50% of children have detectable caries, and by late adolescence, an overwhelming 80% have experienced dental decay.[6] Beyond its overall burden, the impact of dental caries is disproportionately borne by children from socioeconomically disadvantaged and minority backgrounds.[7]

Despite the increased implementation of preventive strategies, the prevalence of dental caries remains significantly high.[8] Socioeconomic disparities, limited access to dental care, and persistent unhealthy dietary habits continue to undermine the effectiveness of preventive measures.[9] These factors contribute to the continued high rates of dental caries, highlighting the challenges in achieving widespread reduction in caries prevalence despite advancements in prevention.[8–10] in fact, 17% of children from low-income families have untreated cavities in their primary teeth, a rate three times higher than that of children from higher-income families.[7] Furthermore, only 15% of children aged 6 years or older living at or below the federal poverty level (FPL) have at least one sealant, which is about one-third the rate seen in higher-income families.[7]

Age is a critical factor in understanding the prevalence of untreated dental caries among children. Although caries is more frequently observed in older children due to its time-dependent

nature, younger children are not exempt from risk and face unique barriers to prevention and treatment.[11] Notably, children under the age of five are less likely to receive dental care from general dentists, with several studies documenting a reluctance within the dental workforce to treat this age group.[12,13] This gap in care is further compounded by younger children's complete dependence on their parents or caregivers for access to dental services, which is strongly influenced by parental education, income, and oral health literacy.[14] In contrast, school-aged children are more likely to benefit from structured dental access points such as school-based programs.[15]

Previous literature has documented a decline in the prevalence of untreated dental caries among U.S. children. Among children aged 2 to 5 years, the prevalence decreased from 20.5% in 1999–2004 to 10.4% in 2011–2016.[16] Similarly, for children aged 6 to 11 years, untreated caries declined from 21.2% to 15.3% over the same period.[16,17] While these changes indicate progress, the overall burden of disease remains substantial and did not meet the Healthy People 2020 target of reducing the prevalence of untreated caries to 10.2%.[18] Moreover, persistent disparities remain, with children from low-income households continuing to bear a disproportionate burden of untreated dental caries.[17]

Most previous studies only documented changes in the overall prevalence of untreated dental caries and examined sociodemographic characteristics; however, they did not assess how behavioral and access-to-care factors interact to shape oral health outcomes over time.[17,19] Additionally, no study to date has examined trends over the most recent 10-year period, with existing analyses either relying on outdated data or covering shorter time spans.

This study aims to evaluate whether the reduction in untreated dental caries among children aged 2-11 years over the past decade reflects a meaningful improvement in oral health

outcomes. Additionally, it seeks to examine the effect of different demographics, socioeconomic, and behavioral predictors that may hinder this reduction. The first hypothesis is that the observed reduction in untreated dental caries among U.S. children aged 2–11 years over the past decade did not improve significantly. The second hypothesis is that socioeconomic, demographic, and access-to-care factors are significantly associated with untreated dental caries in children, thereby limiting further reductions in its prevalence.

By examining a nationally representative dataset over a 10-year period, this study seeks to fill gaps in understanding the persistent barriers to improving pediatric oral health despite preventive efforts.

Materials and Methods.

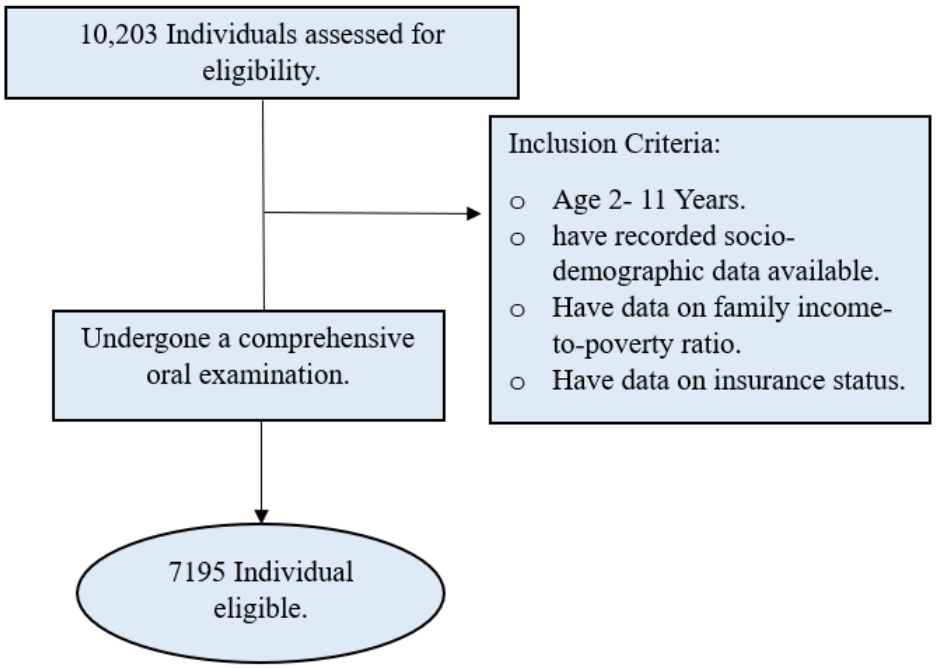
Data Source.

This study utilized data from four NHANES cycles spanning the years 2011 to 2020: NHANES 2011–2012, NHANES 2013–2014, NHANES 2015–2016, and NHANES 2017–2020. NHANES, conducted by the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention (CDC), employed stratified, multistage sampling methodologies to ensure a representative probability sample of the civilian, noninstitutionalized population of the United States.[20]

NHANES data were collected through in-home interviews and health examinations conducted in mobile examination centers (MECs). Interviews gathered sociodemographic and health information, including oral health. Calibrated, licensed dentists performed standardized oral exams in MECs to assess caries, restorations, and missing teeth. All data were anonymized and recorded using consistent coding across survey cycles.

To be considered for this study, participants were required to fulfill the following inclusion criteria *(Figure 1)*: (1) be aged between 2 and 11 years, (2) have recorded socio-demographic data available, (3) have data on family income-to-poverty ratio, (4) have data on insurance status, and (5) have undergone a comprehensive oral examination with at least one permanent or primary tooth present.

Figure 1. Participant Recruitment Flowchart



Study Population.

This study included 7,195 children aged 2–11 years who participated in NHANES cycles from 2011 to 2020. Participants were included in the analytical sample if they had complete data on all primary variables and had undergone an oral health examination.

The Primary Outcome: Is the prevalence of untreated dental caries, defined as the presence of active carious lesions in U.S. children aged 2-11 years.

Exposure and Covariates:

The primary exposure was time, defined by four NHANES survey cycles spanning 2011 to 2020. Covariates included demographic characteristics (age, gender, race/ethnicity), socioeconomic factors (family income-to-poverty ratio, insurance status), and behavioral factors (sugar intake and frequency of dental visits).

Variables.

Caries Definition.

In the caries assessment component of the oral examination, all teeth were examined using visual and tactile using a no. 23 explorer, hand mirror, and appropriate lighting. The examination followed a standardized order for each participant, and trained health technicians documented the presence of coronal caries and the affected surfaces.[21]

Participants in this study were defined as having decayed teeth if any tooth in their mouth displayed an active carious lesion. In this study, binary variables were employed to assess the presence or absence of dental caries.

Demographic and Socio-economic Variables.

Demographic variables included in this study are age, gender, race/ethnicity. Age was categorized into groups based on children's dentition status: primary dentition encompassed ages 2 to 5 years, while mixed dentition spanned ages 6 to 11 years. Race/ethnicity was classified into several categories: non-Hispanic White, non-Hispanic Black, Mexican American, Other Hispanic, Non-Hispanic Asian, and Others, which included individuals identifying as multiracial.

For the income-to-poverty ratio variable, children were classified into 5 categories: (<0.5), (0.5–1.0), (1.0–2.5), (2.5–4.0), and (≥4.0) to provide a more accurate representation of

the socioeconomic disparities. This allows for better identification of at-risk populations and a clearer understanding of how varying levels of income impact health outcomes, as opposed to broader classifications which may overlook significant variations within income groups.[22–24] The ratio was calculated by dividing the household income by the federal poverty threshold, where a ratio below 1 signified income falling below the federal poverty threshold.[25]

Two variables from the medical health insurance questionnaire were used: one indicating insurance status (insured vs. uninsured) and another identifying the type of coverage (public or private). These were combined to classify participants as uninsured, privately insured, or publicly insured.

Dietary Variables.

Fast food consumption was classified into three categories: (1) no consumption per week, (2) once per week, and (3) twice or more per week. This variable was based on responses from the NHANES Diet Behavior & Nutrition questionnaire, which asked participants how many times they consumed fast food or pizza per week, with values ranging from 1 to 21. Due to the low frequency of responses above three times per week and in alignment with prior literature.[26] broader groupings were applied to enhance interpretability and analytic reliability.

Sugar intake, measured in grams per day, was assessed using data from the Dietary Interview – Total Nutrient Intakes, First Day. Intake levels were categorized into three groups; low (<76.9 g), moderate (76.9–109 g), and high (>109 g), based on intake percentiles (P25 and P75) reported in the ANIVA cohort study.[27] The breastfeeding variable was taken from the dietary interview and was based on the question asking whether the child was ever breastfed, with the responses classified as a binary variable: (yes/no).

Access to Care Variables.

The variables for the last dental visit were categorized as follows: (1) less than six months ago, (2) between 6 and 12 months ago, (3) more than one year ago, or (4) never. The oral health recommendation variable was classified as (1) see dentist at earliest convenience, or (2) continue regular care. Another variable assessed whether children needed care but were unable to receive it, represented as a binary value of yes or no.

Ethical Considerations.

This study was reviewed by the Boston University Medical Campus Institutional Review Board and deemed Not Human Subjects Research based on the use of publicly available, de-identified NHANES data (IRB Protocol #H-45286, October 6, 2024).

Statistical Analysis.

All statistical analyses were performed using SAS software (version 9.4). Descriptive analyses were conducted to examine the distribution of key demographic, socioeconomic, and behavioral characteristics across NHANES survey cycles. Analyses accounted for the complex sampling design, and differences in distributions within categories across cycles were assessed using Chi-square test.

The prevalence of untreated dental caries was calculated for each covariate across survey cycles to assess variation over time. Bivariate analyses were conducted to examine associations between untreated dental caries and individual variables, including sociodemographic, dietary, and access-to-care characteristics. Statistical differences in prevalence were evaluated using Chi-square tests, with corresponding p-values reported to determine significance.

Multivariable logistic regression was used to examine the association between untreated dental caries and selected covariates, including age, income-to-poverty ratio, insurance status, and frequency of dental visits. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported to assess the strength of associations. To evaluate trends over time, interaction terms between survey cycle and each covariate were also computed. Variables with statistically significant interaction terms were further examined using stratified multivariable logistic regression analyses to explore potential effect modification.

Survey sample weights were incorporated to account for the complex survey design and to provide nationally representative estimates. Statistical significance was determined at a p-value of <0.05.

Results.

The study included a total weighted sample of 7,195 children aged 2 to 11 years from four NHANES cycles (2011–2020). Overall, 60.6% of participants were aged 6 to 11 years, and the sex distribution was approximately equal *(Table 1)*. The racial and ethnic composition was predominantly non-Hispanic White (53.8%), followed by non-Hispanic Black (13.2%) and Mexican American (14.9%) children. Across the survey years, the distribution of age, sex, race/ethnicity, income-to-poverty ratio, and insurance status remained relatively stable, with no statistically significant variation observed.

Most children were either publicly insured (43.8%) or privately insured (50%), while only 6.2% were uninsured. Across the NHANES cycles from 2011 to 2020, the distribution of total sugar intake significantly differed ($p < 0.0001$), with the proportion of children in the high-intake group (>109 g/day) decreasing from 56.5% in 2011–2012 to 43.3% in 2017–2020, while

the proportion in the low-intake group (<76.9 g/day) increased from 19.2% to 29.2%. Despite increasing awareness, more than half of the children consumed fast food at least once per week, while only 23.8% reported no weekly fast-food consumption. Dental care access factors such as dental visit timing, inability to access care distribution, and oral health recommendations also did not differ significantly over time.

Table 1. Baseline Characteristics of the Study Population Using the National Health and Nutrition Examination Survey by Cycle (NHANES 2011–2020).

	Total		**2011–2012**	**2013–2014**	**2015–2016**	**2017–2020**	**P-Value**
Characteristic	n= 7195, %		n= 1852 (%)	n= 1629 (%)	n= 1588 (%)	n= 2126 (%)	
Age							
2 to 5 years	2879	39.4	41.2	38.8	37.6	39.6	0.3
6 to 11 years	4316	60.6	58.8	61.2	62.4	60.4	
Sex							
Male	3607	50.3	50.8	50.4	50.8	49.6	0.9
Female	3588	49.7	49.2	49.6	49.2	50.4	
Ethnicity							
Non-Hispanic White	2112	53.8	54.2	52.3	53.8	54.2	1.0
Non-Hispanic Black	1872	13.2	14.2	13.2	13.1	12.7	
Mexican American	1334	14.9	14.9	16.9	15.3	13.6	
Hispanic	747	8.3	8.6	7.7	8.5	8.3	
Non-Hispanic Asian	556	4.1	4.2	4.2	3.7	4.2	
Other	574	5.7	3.9	5.7	5.6	7	
Family income-to-poverty ratio:							
<0.5	1003	9.5	10.9	10	8.2	9.1	0.6
0.5– < 1.0	1469	15.9	17.2	18.2	13.6	15.2	
1.0– < 2.5	2494	31.7	33.3	31	34.7	29.4	
2.5– < 4.0	1076	19	16.4	17.2	21.9	19.9	
≥4.0	1153	23.9	22.2	23.6	21.6	26.4	
Insurance Coverage:							
Uninsured	476	6.2	8.4	5.5	5.8	5.3	0.7
Private	2786	50	47.5	50.6	52	50.1	
Public	3929	43.8	44.1	43.9	42.2	44.6	
Junk Food:							
No Junk food/week	894	23.8	27.2	24.4	22.9	21.9	0.09
1 time/ week	2097	50.9	43.5	52.9	52.2	53.5	

2 or more times/ week	1140	25.3	29.3	22.7	24.9	24.6	
Sugar: (g/day)							
Low (< 76.9)	2119	27.5	19.2	29.3	32.5	29.2	**<.0001**
Moderate (76.9 –109)	1937	26.7	24.3	27.3	27.8	27.5	
High (> 109)	3139	45.8	56.5	43.4	39.7	43.3	
Ever breastfed:							
Breastfed	2616	77.8	74.7	76.4	77.1	80.9	0.2
Never	974	22.2	25.3	23.6	22.9	19.1	
Untreated Dental Caries:							
Yes	1005	13.7	15.4	15	12.2	12.8	0.4
No	5438	86.3	84.6	85	87.8	87.2	
Oral Recommendations:							
At earliest Convenience	1266	15.9	17.3	15.1	11.8	17.7	0.08
Continuing regular care	5846	84.1	82.7	84.9	88.2	82.3	
Last dental visit:							
< 6 months	4442	64.9	61.3	66.8	64.1	66.7	0.1
Between 6-12 months	1132	13.9	15.4	13.5	13	13.5	
> 1 year	652	8.7	9.2	6.3	11.2	8.3	
Never	954	12.5	14.1	13.4	11.7	11.5	
Unable to access care:							
Yes	295	4.1	4.3	3.2	3.8	4.7	0.5
No	5940	95.9	95.7	96.8	96.2	95.3	

* Estimates are weighted to account for the complex survey design of NHANES and to provide nationally representative results.

†P-values are derived from chi-square tests and indicate whether the distribution of each characteristic differed significantly across NHANES cycles (2011–2020).

The overall prevalence of untreated dental caries among U.S. children aged 2 to 11 years was 13.7% across NHANES cycles from 2011 to 2020 *(Table 1)*. There was a cumulative 20% reduction in untreated dental caries over the 10-year-period *(Table 3)*, with a gradual decline in the overall prevalence of untreated dental caries from 2011-2012 (15.4%) to 2015-2016 (12.2%), followed by a slight increase to 12.8% in 2017-2020, indicating a potential plateau *(Table 1)*. This decline was not statistically significant but may have clinical significance.

When stratified by age, younger children (ages 2–5) exhibited a lower risk of untreated dental caries compared to older children (ages 6–11). Among younger children, the trend fluctuated, with a decline from 9.4% in 2011–2012 to 8.2% in 2015–2016, followed by a rebound to 10.7% in 2017–2020 (P = 0.6), indicating an inconsistent pattern. In contrast, older children demonstrated a more consistent decline in prevalence, from 21.5% in 2011–2012 to 14.1% in 2017–2020 (P = 0.07) *(Table 2)*. The interaction term between age group and survey cycle was statistically significant (P = 0.02), indicating that the trend in untreated dental caries over time differed by age group, with a more pronounced decline observed among older children *(Figure 2)*.

Patterns by socioeconomic and access-to-care variables also revealed notable disparities. A clear social gradient was observed; children from households with the highest income-to-poverty ratio (≥4.0) had the lowest prevalence of untreated dental caries (5.8%), compared to 24.6% among children living in extreme poverty (income-to-poverty ratio <0.5) (P = 0.05). Notably, while the prevalence remained relatively stable for the high-income group across cycles, the extreme poverty group showed persistent elevation over time, with minimal improvement. A similar trend was seen in relation to dental visits. Children who had not visited a dentist in more than one year consistently had higher prevalence across all survey cycles, reaching 33.7% in the most recent cycle—compared to 10% among those with a dental visit in the past six months (P = 0.002). These findings highlight how both socioeconomic status and delayed care contribute not only to disparities at a single time point but also to stagnation in oral health improvements over the decade.

Differences by sex, race/ethnicity, insurance type, breastfeeding history, and dietary factors such as sugar intake and junk food consumption were not statistically significant across

cycles *(Table 2)*. However, children who were publicly insured (17.2%) or uninsured (26.3%) consistently exhibited higher caries prevalence across NHANES cycles compared to those with private insurance (9.0%), reflecting persistent disparities in access to preventive services. The prevalence of untreated dental caries was highest among children with high total sugar intake (>109 g/day) at 16.1%, while it was notably lower and nearly identical among those with low and moderate intake, both at 13.1%. These differences were not statistically significant. Similarly, children who were never breastfed had a higher prevalence (15.5%) than those who were breastfed (9.8%), a pattern that remained relatively unchanged across cycles. Although these differences did not reach statistical significance, they may hold clinical relevance and highlight sustained inequities in early-life nutrition and access to oral health resources.

Table2. Prevalence of Untreated Dental Caries Among U.S. Children Aged 2–11 Years by Sociodemographic, Dietary, and Access-to-Care Characteristics Across NHANES Cycles (2011–2020).

	Total, %	**2011–2012**	**2013–2014**	**2015–2016**	**2017–2020**	**P-Value**
	n= 7195	n= 1852	n= 1629	n= 1588	n= 2126	
Variables	**Prevalence of Untreated Dental Caries, %**					
Age:						
2 to 5 years	9.9	9.4	10.8	8.2	10.7	0.6
6 to 11 years	16.4	21.5	18.3	14.6	14.1	0.07
Sex						
Male	14.5	17.1	15	12.7	13.8	0.5
Female	12.8	13.7	15.1	11.7	11.8	0.4
Ethnicity						
Non-Hispanic White	11.2	11	13.2	10.3	10.8	0.8
Non-Hispanic Black	17.3	21.9	16.8	17.9	13.7	0.07
Mexican American	18.5	21.4	20.6	14.2	18.3	0.5
Hispanic	15.7	22	17.6	13.8	12	0.1
Non-Hispanic Asian	14.2	19.2	13.7	9.5	14.1	0.3
Other	12.7	8.3	10.6	11.1	16	0.4
Family income-to-poverty ratio:						

<0.5	24.6	27.6	28.1	19.8	23	0.2
0.5– < 1.0	18	18.2	13.5	22.2	18.7	0.3
1.0– < 2.5	15.5	15.7	17.1	14.2	15.4	0.9
2.5– < 4.0	11.1	16.6	11	9.7	9.3	0.3
≥4.0	5.8	5.4	10.7	2.5	5.6	0.05
Insurance Coverage:						
Uninsured	26.3	35.6	23.8	22.2	20.8	0.1
Private	9	7.9	12.2	7.7	8.6	0.2
Public	17.2	19.3	17.1	16.3	16.5	0.7
Junk Food:						
No Junk food/week	11.9	10.9	12	11.7	12.8	1.0
1 time/ week	11.9	11.5	14.8	10.5	11.4	0.6
2 or more times/ week	14.5	17	12.7	12.8	14.6	0.7
Sugar: (g/day)						
Low (< 76.9)	13.1	15.4	14.7	10.5	13.2	0.4
Moderate (76.9 – 109)	13.1	13.9	15.8	11.8	11.9	0.6
High (> 109)	16.1	14.7	13.9	13.0	14.1	0.7
Breastfeeding:						
Breastfed	9.8	8.1	10.8	7.8	11.6	0.2
Never	15.5	17.4	12.2	14.8	16.7	0.7
Last dental visit:						
< 6 months	10.4	10.3	13.1	8.8	10	0.3
Between 6-12 months	17.2	20.5	20.7	25.4	17.2	0.3
> 1 year	32.2	45.5	28.7	21.9	33.7	0.002
Never	9.5	10.7	12.1	6.2	8.6	0.4
Unable to access care:						
Yes	41.4	48.8	48.1	44.8	33.5	0.6
No	13.1	15	14.5	11.7	12.2	0.4
Oral Recommendations:						
See dentist at earliest Convenience	80.4	80.3	97	94.3	66.5	<.0001
Continuing regular care	1.1	1.8	0.2	1.1	1.2	0.07
* Estimates are weighted to account for the complex survey design of NHANES and to provide nationally representative results.						

†P-values are derived from chi-square tests and indicate whether the prevalence of untreated dental caries within each group changed significantly across NHANES cycles (2011–2020).

In the multivariable logistic regression model *(table 3)*, a 10% reduction in the odds of untreated dental caries was observed with each successive NHANES cycle (OR = 0.9, 95% CI: 0.83–1.06), though this trend was not statistically significant. However, several covariates were significantly associated with the likelihood of untreated dental caries among U.S. Children aged 2–5 years had a 40% lower risk of untreated dental caries compared to older children (OR = 0.6, 95% CI: 0.45–0.71, P < .0001). Compared to children from high-income families (poverty ratio ≥4.0), children in extreme poverty (poverty ratio <0.5) had 3.7 times higher odds of untreated dental caries (OR = 3.7, 95% CI: 2.3–5.89, P < .0001). Uninsured children had 50% higher odds of untreated dental caries compared to those with public insurance (OR = 1.50, 95% CI: 1.14–2.08), while private insurance was protective (OR = 0.8, 95% CI: 0.61–0.96, P= 0.004). Delayed dental visits were strongly associated with untreated dental caries; children who had not seen a dentist in more than a year had more than threefold increased odds compared to those seen within six months (OR = 3.2, 95% CI: 2.53–4.16, P < .0001).

Interaction terms between survey cycles and all covariates were tested to assess whether the association between time and untreated dental caries varied across subgroups. A statistically significant interaction was only observed between age and cycle (P = 0.02), indicating that the decline in untreated dental caries over time was more pronounced among older children *(Figure 2)*. Based on this finding, a stratified multivariable logistic regression analysis was conducted to further evaluate age-specific associations between risk factors and untreated dental caries *(Table 4)*. Interestingly, among younger children (ages 2–5), demographic and socioeconomic factors had a stronger influence. Male children (OR = 1.4, 95% CI: 1.03–1.9, P = 0.03), Mexican

American ethnicity (OR = 1.6, 95% CI: 1.02–2.2), and Non-Hispanic Asian ethnicity (OR = 2.7, 95% CI: 1.6–4.4) were all significantly associated with higher odds of untreated caries. The impact of poverty was particularly evident in this group, with children in extreme poverty experiencing nearly four times the odds of untreated dental caries compared to those from high-income households (OR = 3.8, 95% CI: 1.7–8.8, P = 0.0008).

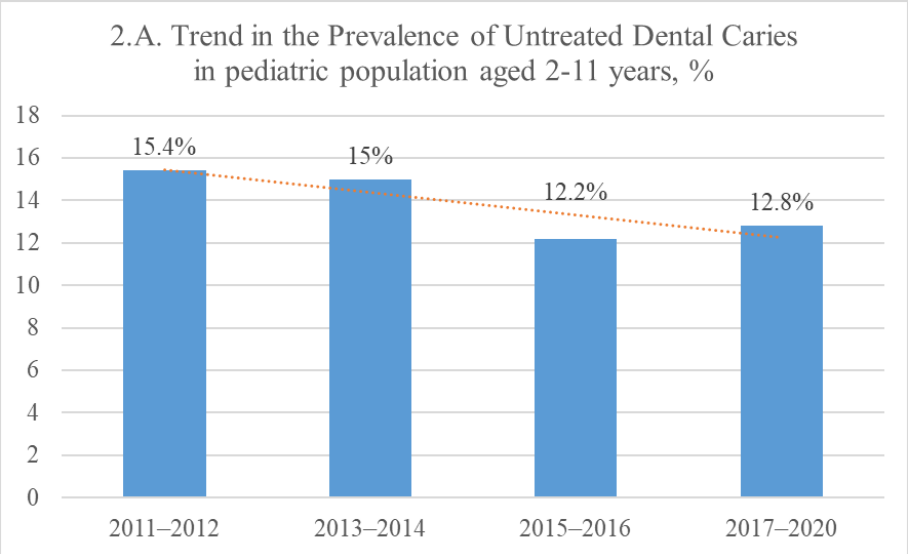
In contrast, older children (ages 6–11) showed stronger associations with behavioral and access-related factors. Delayed dental visits were the most influential predictors in this group. Those who had not visited the dentist in more than one year had over four times the odds of untreated caries (OR = 4.2, 95% CI: 3.1–5.6), and even those with a visit between 6–12 months had significantly increased odds (OR = 2.2, 95% CI: 1.6–3.1, P < .0001). Uninsured children were also associated with higher odds (OR = 1.5, 95% CI: 1.03–2.2, P = 0.04).

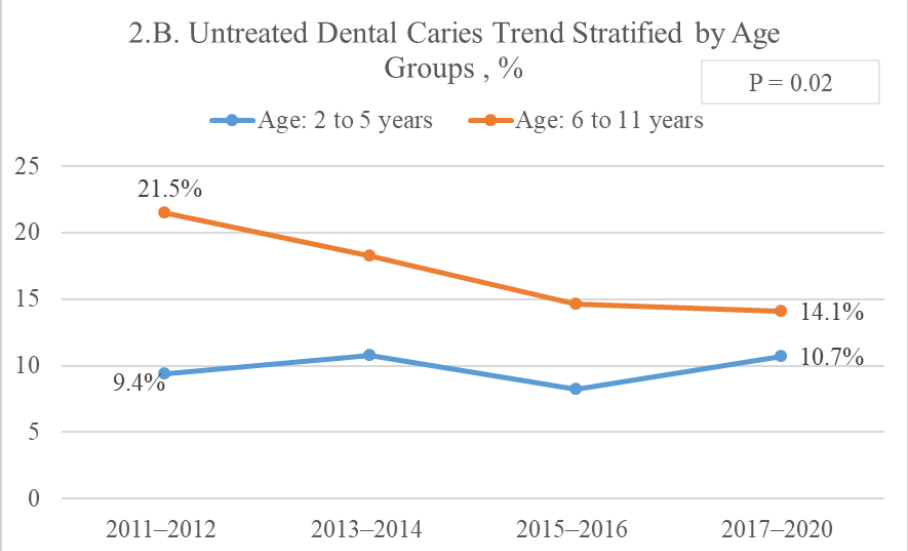
Table 3. Multivariable Logistic Regression Model Results Examining Determinants of Untreated Dental Caries Prevalence Among U.S. Children Aged 2-11 Years (NHANES 2011-2020).

Variable	Odds Ratio	Confidence Interval	P-Value
Cycle	0.9	(0.83 - 1.06)	0.3
Age: (ref. 6 to 11 yrs.)			
2 to 5 years	0.6	(0.45 - 0.71)	**<.0001**
Gender: (ref. female)			
Male	1.1	(0.94 - 1.32)	0.2
Ethnicity: (ref. Non-Hispanic White)			
Mexican American	1.2	(0.84 - 1.61)	0.2
Hispanic	1.1	(0.76 - 1.47)	
Non-Hispanic Black	1.1	(0.82 - 1.48)	
Non-Hispanic Asian	1.6	(1.12 - 2.3)	
Other	1.0	(0.6 - 1.56)	
Poverty: (ref. ≥4.0)			
<0.5	3.7	(2.3 – 5.89)	**<.0001**
0.5– < 1.0	2.4	(1.53 – 3.87)	
1.0– < 2.5	2.2	(1.35 - 3.55)	
2.5– < 4.0	1.7	(1.1 - 2.73)	
Insurance: (ref. Public)			
Uninsured	1.5	(1.14 - 2.08)	**0.004**

Private	0.8	(0.61 - 0.96)	
Sugar: (ref. high >109 g/day)			
Low (<76.9)	0.9	(0.77 - 1.14)	0.6
Moderate (76.9 – 109)	0.91	(0.71 - 1.16)	
Dental Visit: (ref. < 6 months)			
Between 6-12 months	1.9	(1.46 - 2.45)	**<.0001**
> 1 year	3.2	(2.53 - 4.16)	
Never	1.1	(0.78 - 1.53)	

Figure 2. Trends in the Prevalence of Untreated Dental Caries Among U.S. Children Aged 2–11 Years, NHANES 2011–2020.





‡ β coefficient and p-value represent the interaction term between age group and time (cycle).

Table 4. Multivariable Logistic Regression Model Results Examining Determinants of Untreated Dental Caries Prevalence Stratified by Age (2–5 Years vs. 6–11 Years), NHANES 2011–2020.

Variable	Young Children (2-5 yrs)			Older Children (6-11 yrs)		
	Odds Ratio	Confidence Interval	P-Value	Odds Ratio	Confidence Interval	P-Value
Cycle	1.1	(0.9, 1.3)	0.5	0.9	(0.8, 1.0)	0.07
Gender: (ref. female)						
Male	1.4	(1.03, 1.9)	**0.03**	1.0	(0.8, 1.3)	0.9
Ethnicity: (ref. Non-Hispanic White)						
Mexican American	1.6	(1.02, 2.2)		1.0	(0.6, 1.5)	
Hispanic	1.2	(0.7, 2.2)		1.0	(0.7, 1.4)	
Non-Hispanic Black	1.1	(0.7, 1.7)	**0.002**	1.1	(0.8, 1.5)	0.7
Non-Hispanic Asian	2.7	(1.6, 4.4)		1.2	(0.8, 1.9)	
Other	1.3	(0.7, 2.7)		0.8	(0.4, 1.4)	
Poverty: (ref. ≥4.0)						
<0.5	3.8	(1.7, 8.8)		3.4	(1.8, 6.5)	
0.5– < 1.0	2.2	(0.9, 5.2)	**0.0008**	2.5	(1.3, 4.6)	**0.008**
1.0– < 2.5	1.9	(0.8, 4.1)		2.3	(1.3, 4.1)	
2.5– < 4.0	1.0	(0.5, 2.3)		2.0	(1.1, 3.6)	
Insurance: (ref. Public)						
Uninsured	1.6	(0.9, 2.8)	0.1	1.5	(1.03, 2.2)	**0.04**
Private	0.7	(0.5, 1.0)		0.8	(0.6, 1.1)	
Sugar: (ref. high >109 g/day)						
Low (<76.9)	0.9	(0.6, 1.4)		0.9	(0.7, 1.2)	
Moderate (76.9 – 109**)**	0.9	(0.6, 1.3)	0.8	0.9	(0.5, 1.3)	0.9
Dental Visit: (ref. < 6 months)						
Between 6-12 months	1.3	(0.9, 1.9)		2.2	(1.6, 3.1)	
> 1 year	1.5	(0.8, 2.7)	0.1	4.2	(3.1, 5.6)	**<.0001**
Never	0.8	(0.5, 1.2)		1.8	(0.9, 3.5)	

Discussion.

This study evaluated national trends and associated predictors of untreated dental caries among U.S. children aged 2 to 11 years from 2011 to 2020 using NHANES data. Our hypothesis anticipated that the observed reduction in the prevalence of untreated dental caries would not demonstrate a significant improvement over time. The findings supported this hypothesis; while there was an overall 20% decline in untreated dental caries during the study period, this reduction was not statistically significant, suggesting a plateau in the later years (2017–2020). Nevertheless, the decline may still hold clinical significance, especially considering the potential implications for long-term oral health and policy planning.

Building on this, the study also examined our second hypothesis, to identify which covariates may have hindered further progress in reducing untreated dental caries. The multivariable logistic regression model revealed that several key barriers remain, younger age was associated with a lower likelihood of untreated caries, yet these children saw less improvement over time; poverty was a strong and persistent predictor, with children in extreme poverty having more than threefold higher odds of untreated caries; lack of insurance and infrequent dental visits further exacerbated the risk. These findings underscore the critical role of both structural and access-related determinants in shaping oral health outcomes for children.

An interesting observation emerged when trends in untreated dental caries were stratified by age. Older children (ages 6–11) demonstrated a more consistent decline in caries prevalence; from 21.5% in 2011–2012 to 14.1% in 2017–2020, whereas younger children (ages 2–5) showed fluctuating rates, declining from 9.4% in 2011–2012 to 8.2% in 2015–2016, but rebounding to 10.7% in 2017–2020 *(figure 2)*. This age-based divergence may be attributed to differences in access to structured preventive interventions. School-aged children are more likely to benefit

from school-based dental programs, such as sealant applications and topical fluoride treatments.[15] The Task Force on Community Preventive Services conducted a systematic review of published studies and found strong evidence that school-based sealant programs are highly effective, preventing up to 76% of cavities in the molars of school-aged children.[15] Similarly, fluoride varnish programs were shown to reduce the risk of caries initiation in permanent teeth by 33%, reinforcing the value of these interventions in reducing dental caries among older children.[15] In contrast, younger children typically rely entirely on parental engagement and caregiver access to dental services, which may be influenced by socioeconomic, cultural, or logistical barriers. Children's oral hygiene and oral health status have been shown to correlate with parents' educational and economic levels, as well as their health literacy and behaviors. [14] Notably, studies indicate low adherence to key recommendations for preschoolers, particularly the use of fluoride toothpaste in age-appropriate amounts, supervised brushing, and avoiding food after the last brushing, further contributing to inconsistent preventive care in this age group.[14]

Another key observation emerged when the multivariable logistic regression was stratified by age. Younger children (ages 2–5) were more affected by demographic and social determinants such as sex, race/ethnicity, and poverty level. These factors showed stronger associations with untreated dental caries in this group. In contrast, older children (ages 6–11) were more impacted by behavioral and access-related factors, including frequency of dental visits and insurance coverage. For instance, delayed dental visits and lack of insurance were significant predictors of untreated dental caries primarily among older children. This age-specific variation in risk factors highlights the importance of tailoring public health interventions based on developmental stage. Strategies aimed at younger children should prioritize addressing social

determinants; such as improving access to early preventive care in underserved communities, enhancing parental education, and targeting socioeconomic disparities.[14,15] Meanwhile, efforts for older children should focus on sustaining preventive behaviors and ensuring regular access to dental care.[28] This finding has been supported by previous literature, which emphasizes that age moderates the influence of social and behavioral risk factors on oral health outcomes in pediatric populations.[28] A study by Fisher-Owens et al. (2007) introduced a conceptual model highlighting how child-level, family-level, and community-level influences shift in impact as children grow older.[28] These insights should inform policymakers and oral health programs to adopt age-specific frameworks when designing interventions to reduce the burden of dental caries across childhood.

An important finding of this study was the strong association between socioeconomic status, particularly poverty and the risk of untreated dental caries among children. Compared to children from high-income families, those living in extreme poverty had nearly four times higher odds of untreated dental caries. This pronounced disparity highlights the persistent impact of economic disadvantage on children's oral health. Limited financial resources can restrict access to preventive and restorative dental services, reduce the affordability of fluoride-containing products and nutritious food choices, and create competing priorities within households.[29] Studies found that food insecurity may partially explain the association between low socioeconomic status and increased risk of dental caries, underscoring the role of nutritional barriers in shaping oral health outcomes among disadvantaged children.[29]

Similarly, insurance status was a significant predictor of untreated dental caries. Uninsured children had 50% higher odds of untreated dental caries compared to those with public insurance, while those with private insurance had 20% lower odds. These differences

reflect persistent access barriers and disparities in the utilization of preventive services across insurance types. Despite eligibility, the U.S. Government Accountability Office (GAO) has highlighted that children on public insurance often face challenges such as provider shortages, low Medicaid reimbursement rates, and administrative burdens, factors that collectively hinder access to timely dental care and reduce dentist participation in Medicaid programs.[30]

Another significant factor associated with untreated dental caries in this study was the timing of the last dental visit. Children who had not visited a dentist in over a year had more than three times the odds of having untreated dental caries compared to those who had seen a dentist within the past six months. Addressing these systemic and socioeconomic barriers requires a comprehensive public health approach. Enhancing Medicaid and CHIP dental provider networks and improving reimbursement rates could incentivize more providers to serve low-income populations.[31] Integrating oral health into primary care settings, particularly within Federally Qualified Health Centers (FQHCs), offers a promising strategy to expand access through medical-dental integration models.[32] Although the percentage of FQHCs offering dental services rose to 81.1% in 2021 from 76.3% in 2012, only 20.8% of their patients received any oral health care, underscoring ongoing disparities in service utilization despite broader availability.[32]

The limitations of the study include the reliance on cross-sectional data from NHANES restricts the ability to establish causal relationships between variables and limits the assessment of temporality in exposure-outcome associations. Additionally, the self-reported nature of several variables, including dietary habits and dental visits, introduces potential recall and reporting biases. Dental caries assessment was based on visual-tactile examinations without radiographic confirmation, which may underestimate true prevalence. While efforts were made to control for confounding variables, the influence of unmeasured or residual confounders cannot be ruled out.

The study offers several strengths. It utilizes nationally representative NHANES data across a 10-year span, enabling the assessment of trends in untreated dental caries among U.S. children with robust generalizability. This analysis accounted for a wide range of demographic, socioeconomic, and behavioral factors, providing a comprehensive view of the multifactorial determinants of untreated dental caries. The use of survey-weighted logistic regression methods allowed for accurate population-level estimates and adjustment for complex survey design. Moreover, stratified analyses and interaction testing provided insights into how caries trends differ by age, enhancing the nuance of interpretation and policy relevance. The identification of persistent disparities by poverty, insurance status, and access to care offers actionable targets for public health interventions aiming to reduce childhood oral health inequities.

Conclusion.

Untreated dental caries remains a prevalent and persistent public health challenge among U.S. children aged 2 to 11 years. Although there was a 20% overall decline in prevalence from 2011 to 2020, the reduction did not reach statistical significance, suggesting that progress has plateaued in recent years. Notably, age emerged as a key modifier in both prevalence trends and associated risk indicators. Older children experienced a more consistent decline, likely benefiting from school-based preventive interventions, whereas younger children showed fluctuating rates and greater vulnerability to demographic and socioeconomic disparities. Poverty, lack of insurance, and infrequent dental visits were strongly associated with higher odds of untreated caries, underscoring the critical need to address structural barriers to care. Tailored strategies that consider age-specific risk profiles, such as enhancing caregiver-focused programs for younger children and expanding school-based care for older children, are essential to achieving equitable and sustained improvements in children's oral health.

List of Abbreviated Journal:

1. **Am J Prev Med** — *American Journal of Preventive Medicine*
2. **Am J Public Health** — *American Journal of Public Health*
3. **BMC Oral Health** — *BMC Oral Health*
4. **Br Dent J** — *British Dental Journal*
5. **Clin Cosmet Investig Dent** — *Clinical, Cosmetic and Investigational Dentistry*
6. **Eur J Clin Nutr** — *European Journal of Clinical Nutrition*
7. **Front Endocrinol** — *Frontiers in Endocrinology*
8. **Int J Environ Res Public Health** — *International Journal of Environmental Research and Public Health*
9. **J Am Dent Assoc** — *Journal of the American Dental Association*
10. **J Public Health Dent** — *Journal of Public Health Dentistry*

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Curriculum Vitae: