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Children's Oral Health and Academic Performance: Evidence of a Persisting Relationship over the Last Decade in the United States

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Abstract

Objective—To assess the association between children's oral health and academic performance using the most recent US national data, a decade after the last assessment using similar prior data.

Study design—Data from the 2016–17 National Survey of Children's Health for 45,711 children aged 6–17 years were analyzed. Children's oral health measures were indicators of specific oral health problems and parent-rated oral health. Academic performance measures included problems at school and missing school days. Regression models were employed adjusting for relevant demographic, socioeconomic, and health characteristics and state effects. Analyses were also conducted stratifying by child's age, sex, household income, and type of health insurance.

Results—We found significant associations across all the evaluated academic outcomes and oral health measures. Children with oral health problems were more likely to have problems at school (OR=1.56, 95% CI: 1.32, 1.85), miss at least one school day (OR=1.54, 95% CI: 1.28, 1.85), and miss more than three or six school days (OR=1.39, 95% CI: 1.20, 1.61 and OR=1.39, 95% CI: 1.14, 1.69; respectively). These associations were generally larger when using the child's oral health rating. Poor oral health was consistently related to worse academic performance across age, sex, household income, and health insurance type subgroups.

Conclusion—Children's oral health status continues to be strongly linked to their academic outcomes. This evidence highlights the need for broad population-wide policies and integrated

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approaches to reduce academic deficits and promote children's health and development of which oral health is an important component.

Keywords

Dental Health; School Performance; Academic Achievement

Despite being largely preventable, oral health problems remain the leading chronic condition among children.¹ Nearly 621 million children have untreated caries in their deciduous teeth worldwide.² In the US, oral health problems in children and adolescents have persisted at high rates despite the increase in dental care utilization among children and some states implementing new prevention programs.^{3,4} In 2011–2014, 14% of children aged 2–8 years and 19% of children aged 5 to 19 years had untreated dental caries.^{5,6} Oral health problems in children may result in pain and discomfort; sleep and appetite issues; low self-esteem, confidence and social skills; and reduced academic performance.^{7–9}

Prior studies using US data have suggested worsening academic performance among children with oral health problems. A study using 2008 data from North Carolina showed that children with poor oral health had lower school grades and missed more school days due to dental pain or infection.¹⁰ Disadvantaged children with toothaches in Los Angeles had lower school grades, and those with unmet dental care needs missed more school days.¹¹ Another study using nationally representative data from 2007 found that children with oral health problems were more likely to have problems at school and to miss school, and were less likely to do all required homework, even after accounting for various relevant demographic, socioeconomic, and health characteristics.⁸ There is also similar evidence from other countries such as Brazil, Greece, Canada, and UK.^{12–16}

In this study, we examined the relationship between children's oral health status and their academic performance using the most recent nationally representative data in the US. This work provides an updated assessment using 2016–2017 data, nearly a decade from the 2007 nationally representative data previously examined for this question.⁸ We also evaluated the potential heterogeneity in this relationship across a range of demographic and socioeconomic factors. Providing an updated analysis is especially important to understand the dynamics between children's oral health status and academic performance given reported improvements in dental care utilization among children and dental treatment quality and the implementation or expansion of some state-level preventive strategies.^{3,17,18} Such strategies include reimbursement of fluoride varnish applications by non-dentist primary care providers, expansions of school-based dental sealant programs, and increased access to optimally fluoridated water. Furthermore, recently the Affordable Care Act mandated oral health risk assessments as essential preventive care at no out-of-pocket cost to children up to age 10 years and required dental services to be offered as essential health benefits under health insurance plans in marketplaces. Not only child learning outcomes are of great importance in their own right, they are also strongly tied to future labor market outcomes, economic performance, and other lifetime outcomes.^{19,20}

Methods

We analyzed data from the 2016 and 2017 waves of the National Survey of Children's Health (NSCH), the most recent nationally representative survey of children's health in the US. The NSCH obtains a new sample of children each wave (children are not followed over time). The NSCH measures different aspects of children's health, access to health care, and family, school, and neighborhood contexts. Data were collected from primary caregivers (mostly parents). In our main models, we combined data from 2016 and 2017 to increase power but we also did separate sensitivity analyses by year. The NSCH asked questions about academic performance of children aged 6–17 years. Of the 51,156 children in this age range, 45,711 had complete data on all model variables. More details about the NSCH can be found elsewhere.^{21,22}

Academic Performance Measures

The NSCH obtained data on two academic performance outcomes. The first question asked about whether the school reported that the child had problems at school during the past year. We coded this question into a binary outcome for any report of a problem at school. The second question was about the number of school days missed due to health issues during the past year (collected in categories). We coded this question into three binary outcomes including any missed days, missing more than three days, and more than 6 days.

Oral Health Measures

We employed 2 primary measures of oral health. The first measure was based on the survey respondent's rating of the child's current dental health status as excellent, very good, good, fair, or poor, which we coded a binary indicator for poor or fair versus good, very good, or excellent. The second measure captured whether the child had specific oral health problems over the past 12 months. In 2016–17, NSCH asked whether the child had any of the following problems: toothache, decayed teeth or cavities, or bleeding gums, which we coded into a binary indicator for reporting any of these problems. These measures were reported and not based on direct clinical assessment. However, parental reports of children's oral health are closely associated with children's unmet treatment needs and clinical measures and are considered valid indicators of children's oral health.^{23–25} Parental reports are also especially relevant given their influence on decisions about children's oral health and dental care use. In an additional model, we separated dental problems into whether toothache was reported or not in order to gauge the extent to which the associations with academic performance are due to pain versus other mechanisms.

Statistical analyses

We regressed the academic performance indicators on the oral health measures, one at a time, adjusting for several potential confounders. Specifically we adjusted for demographic characteristics (child's age, sex, race/ethnicity, birth order, number of children and adults in the household, and family structure); socioeconomic status (household poverty-level, highest level of education in the household, household employment status, and child's health insurance coverage); medical history (if the child had ever been diagnosed with learning disabilities, ADD/ADHD, conduct or behavior problem, autism, delayed development,

speech problem, hear/vision problem or depression/anxiety); and state fixed-effects (dummy variables for states) to capture differences between states. We estimated the models using logistic regression and the survey sampling weights to obtain nationally representative estimates. All models were estimated for the total sample and by school age groups: 6–11 years (elementary-school), 12–14 years (middle school), and 15–17 years (high-school) to assess if the associations of interest varied with age. Also, we estimated models stratified by sex, race (white versus non-White), household income (< 300% FPL versus >300% FPL), and type of health insurance (private versus public) to further evaluate potential heterogeneity.

Results

Table I (available at www.jpeds.com) lists the distribution of study variables in our analytical sample. Nearly 25% of children had problems at school and about 23% and 10% missed more than three and six school days, respectively. In terms of oral health status, over 15% of children had at least one dental problem (toothache, decayed teeth or cavities, or bleeding gums), and nearly 6% had their dental health rated as poor or fair.

Association between Oral Health and Academic Performance

Table 2 reports the odds ratios (ORs) and their 95% confidence intervals for the associations between the oral health measures and academic performance outcomes estimated from the adjusted logistic regressions combining all ages 6–17. As noted before, separate regressions were estimated for the two oral health measures (any dental problem and poor/fair rating). Across the evaluated academic outcomes and oral health measures, there were significant associations indicating worse academic performance with poorer oral health. Furthermore, the magnitude of these associations was meaningful. Specifically, children with at least one dental problem were more likely to have problems at school (OR = 1.56, 95% CI: 1.32, 1.85) and miss at least one school day (OR = 1.54, 95% CI: 1.28, 1.85) by nearly 50%. Also, they were more likely to miss more than three school days or more than 6 school days by 40% (OR = 1.39, 95% CI: 1.20, 1.61 and OR = 1.39, 95% CI: 1.14, 1.69; respectively). These associations were generally more pronounced when using the child's oral health rating. Specifically, children with poor/fair oral health were nearly 80% more likely to have problems at school (OR=1.77, 95% CI: 1.33,2.36), and more likely to miss more than three school days or more than six days by about 60% (OR=1.56, 95% CI: 1.23,1.99) and 90% (OR=1.93, 95% CI: 1.42,2.62), respectively.

Table 3 (available at www.jpeds.com) shows separate estimates for 2016 and 2017. These results indicate significant and mostly comparable associations between the 2 years (with only one exception). Therefore, the estimates from the total sample pooled across 2016 and 2017 are not driven by one particular year.

Stratifications by Age, Race, Sex, Income, and Health Insurance Type

Stratifying by age (Table 4) revealed significant associations overall for all three age groups (6–11, 12–14, and 15–17 years). The estimates were largest for children aged 12–14, followed by children 15–17 years and the youngest group of 6–11. For children 12–14 years,

having dental problems or poor/fair rating of dental health was associated with doubled odds of having problems at school and missing more than 3 school days. Although a few estimates were statistically insignificant or only marginally significant in a few age subgroups, partly due to sample size reductions, these estimates overall showed remarkable consistency of poor oral health being related to worse academic performance across all ages.

Similarly, we observed mostly significant associations when stratifying by sex, race, household income, and type of health insurance (Table 5). Furthermore, there were generally no clear patterns for any subgroups consistently having larger or smaller associations across all evaluated outcomes and oral health measures, again indicating remarkable stability of these associations across important demographic/socioeconomic factors.

Associations with Toothache versus other Dental Problems

The results (Table 6) from the regressions simultaneously included 2 oral health indicators: whether toothache was reported (with or without other problems, 3.4% of analytical sample); and other dental problems (cavities or bleeding gums) were reported, but toothache was not reported (11.5% of analytical sample). Both groups were compared with no dental problems. We observed significant associations with academic performance for both groups, but toothache had larger associations than dental problems except for missing more than 6 school days. The largest difference was for school problems which had double odds with toothache. Yet these results indicate that the association between dental problems and academic performance is not entirely driven by pain.

Discussion

Using the most recent nationally representative survey data on children's health in the US, we provide evidence for the relationship between children's oral health and academic performance. Specifically, we find that worse oral health status, whether measured by reports of specific dental problems or overall rating of the child's dental health, is related to increased reporting of school problems and missing school days. The magnitudes of these associations are prominent, with 40–50% increase in likelihood of worse academic outcomes across most specifications in the total sample. These associations were observed across school ages but were most pronounced among children in intermediate school (12–14 years) for whom risk of school problems and missing school days nearly doubled. Furthermore, the associations were observed across subgroups defined by household income, health insurance type, and sex, suggesting that they are generalizable across demographic and socioeconomic characteristics and are not driven by a specific group. Similarly, significant associations were observed across groupings of dental problems depending on whether toothache was reported or not.

Findings from this study are similar to those from prior work using 2007 national data. Despite efforts and progress in improving children's oral health in the US over the past decade [greater access to dental care and less unmet needs among publicly insured children,²⁶ a decrease in children's caries experience in their permanent dentition (among 6–17 year-olds),²⁷ and a decline in untreated dental caries in primary dentition (among 2–8 year-olds)²⁸], more effort is needed in developing effective prevention programs and treatment access

policies to improve children's oral health and minimize the adverse impact of dental problems on children's academic outcomes and development. This issue remains relevant for health policy consideration with this new evidence of the persisting importance of oral health for children's academic success and healthy development. Our findings reinforce the evidence about the need for population-wide interventions focused on children's oral health assessment, prevention, and treatment. The US Department of Health and Human Services Oral Health Framework suggests several strategies such as integrating oral health into primary care training and practice, expanding community water fluoridation, promoting dental sealants delivery in schools, dental care homes, and exploring new care models for children at high risk for developing caries, amongst others.²⁹ Future evaluations of such programs and policy efforts should also include effects of oral health changes on children's academic outcomes in order to capture their full effects on children's wellbeing. The consistency of the associations between oral health and academic outcomes across demographic and socioeconomic subgroups suggests that this issue cuts across the population of children, further emphasizing the need for population-wide and public health interventions in addition to efforts that target children from lower poorer households such as ensuring adequate access to dental care for children in Medicaid.

The relationship between oral health and academic achievement is complex and likely involves multiple and intertwined pathways. For example, pain, discomfort, and associated eating and sleeping problems can reduce child's attention and ultimately their academic achievement. In addition, changes in functioning and dental esthetics may affect psychosocial factors such as self-esteem, confidence and social skills as suggested in prior work.⁸ Psychosocial status affects cognitive outcomes including the ability to learn.³⁰ In turn, psychosocial problems may reduce self-care including less attention to oral hygiene and healthy eating, which could adversely impact general and oral health. Furthermore, psychosocial and general health problems may exacerbate the effects of poor oral health on academic achievement. Children in early adolescence may be most vulnerable to psychosocial adjustment problems, which might partly explain the larger associations we observe for children 12–14 years. All of these pathways would suggest accumulating deficits in children's academic and overall development that may not just disappear after treating dental problems, emphasizing the need for holistic approaches to promote children's health and development of which oral health is one of multiple dimensions.

The study has several strengths including a nationally representative sample, recent data, multiple outcome and oral health measures, and numerous measures of potential confounders. Two limitations of the study are worth discussing. The first limitation is that we were unable to identify the underlying mechanisms connecting oral health and academic outcomes. We were able however to separate dental problems by whether pain was reported or not, which revealed that toothache was associated with larger odds of problems in school than dental problems without pain. Dental pain may reflect a more severe oral health condition and untreated dental decay problems. Pain can disrupt child's daily activities like sleeping, eating, playing, concentrating, and socializing all of which influence academic outcomes. Future studies examining mechanisms can provide further insights into the pathways connecting oral health and academic achievement including interplays through psychosocial status and general health. The second limitation is potential measurement error

in the parent/caregiver reports of oral health and academic indicators. Absent any theory for systematic reporting biases, such errors however would bias the associations toward the null (i.e. no association) if they are largely random. We observe consistent significant and large associations, suggesting that such a concern does not compromise our study conclusions (if anything the associations might be larger with less measurement error). Furthermore, our findings are consistent with other studies that have used clinical measures of oral health (based on dental examinations) and academic indicators based on school tests or other objective measures.^{11,12,31} Another measurement issue is that the academic variables available in the data were not specific cognitive and behavioral schooling outcomes, but rather general measures. However, these measures are broadly reflective of academic performance.

In summary, our findings suggest that children in the US with worse oral health status have poorer and academic outcomes, and that this relationship has persisted over the past decade. Furthermore, this association is consistent across subgroups defined by age, family income, health insurance type, and sex. These findings highlight the need for broad population-wide policies and integrated approaches to promote children's development and reduce academic deficits that include among other components initiatives to improve oral health through prevention and treatment access strategies. Further research should examine the mechanisms underlying these associations, and preferably employ longitudinal data with clinical measures of oral health and objective and standardized assessments of academic outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Weighted descriptive statistics for study variables

| Children 6–17 Years, N=45,711 | |
|---|--------------------|
| Variable | Percent (%) |
| <i>Academic Performance Measures</i> | |
| Problems in school | 24.7 |
| Any School Miss Day | 68.7 |
| >3 School Miss Days | 23.3 |
| >6 School Miss Days | 9.5 |
| <i>Oral Health Measures</i> | |
| Any dental problem | 15.8 |
| Toothaches | 3.4 |
| Cavities | 12.7 |
| Bleeding Gums | 2.2 |
| Poor or Fair Rated Oral Health | 6.1 |
| <i>Demographic Characteristics</i> | |
| Child's Age | |
| Age 6 | 8.1 |
| Age 7 | 8.3 |
| Age 8 | 8.5 |
| Age 9 | 8.5 |
| Age 10 | 8.3 |
| Age 11 | 8.3 |
| Age 12 | 8.3 |
| Age 13 | 8.3 |
| Age 14 | 8.3 |
| Age 15 | 8.4 |
| Age 16 | 8.4 |
| Age 17 | 8.3 |
| Child's Gender | |
| Male | 51.1 |
| Female | 48.9 |
| Race/Ethnicity | |
| Non-Hispanic White | 50.9 |
| Non-Hispanic Black | 13.8 |
| Non-Hispanic Others | 10.0 |
| Hispanic | 25.3 |
| Birth Order | |
| Only Child | 25.6 |
| Oldest Child | 36.6 |
| Second Oldest Child | 28.2 |
| Third Oldest Child | 8.2 |

| Children 6–17 Years, N=45,711 | |
|--------------------------------------|--------------------|
| Variable | Percent (%) |
| Fourth Oldest Child | 1.4 |
| Number of Kids in Household | |
| 1 | 25.6 |
| 2 | 38.7 |
| 3 | 22.7 |
| 4 or More | 13.0 |
| Number of Adults in Household | |
| 1 | 9.3 |
| 2 | 68.6 |
| 3 or More | 22.2 |
| Family Structure | |
| Two Parents, Biological/Adoptive | 65.4 |
| Two Parents, Stepfamily | 8.8 |
| Single Mother Family | 17.9 |
| Other | 7.8 |
| <u>Socioeconomic Status</u> | |
| Highest education level in Household | |
| Less than High School | 10.0 |
| High School Graduate | 20.7 |
| More than High School | 69.3 |
| Poverty Level | |
| 100% FPL | 21.1 |
| >100% FPL & 133% FPL | 8.3 |
| >133% FPL & 150% FPL | 3.5 |
| >150% FPL & 185% FPL | 7.2 |
| >185% FPL & 200% FPL | 3.1 |
| >200% FPL & 300% FPL | 15.0 |
| >300% FPL & 400% FPL | 11.5 |
| 400 FPL | 30.3 |
| Any Employment in Household | 94.3 |
| Any Health Insurance Coverage | 93.5 |
| Public Health Insurance | 57.5 |
| Private Health Insurance | 34.8 |
| <u>Medical History</u> | |
| Learning Disabilities | 8.7 |
| ADD/ADHD | 11.6 |
| Conduct or Behavior Problem | 10.2 |
| Autism | 3.3 |
| Delayed Development | 6.6 |
| Speech Problem | 7.8 |
| Hear/Vision Problem | 3.2 |

| Children 6–17 Years, N=45,711 | |
|--------------------------------------|--------------------|
| Variable | Percent (%) |
| Depression/Anxiety | 11.4 |

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Table 2.

Associations between Oral Health Status and Academic Performance of Children Aged 6–17 Years using 2016–2017 NSCH

| Academic Performance | N | OR | P-Value | 95% CI |
|--------------------------------|-------|---------------------|---------|-------------|
| <u>Any Oral Health Problem</u> | | | | |
| Problems in school | 44690 | 1.56 ^{***} | (0.000) | [1.32,1.85] |
| Any School Miss Day | 44754 | 1.54 ^{***} | (0.000) | [1.28,1.85] |
| >3 School Miss Days | 44754 | 1.39 ^{***} | (0.000) | [1.20,1.61] |
| >6 School Miss Days | 44754 | 1.39 ^{***} | (0.001) | [1.14,1.69] |
| <u>Poor Rated Oral Health</u> | | | | |
| Problems in school | 45648 | 1.77 ^{***} | (0.000) | [1.33,2.36] |
| Any School Miss Day | 45711 | 1.28 [*] | (0.059) | [0.99,1.67] |
| >3 School Miss Days | 45711 | 1.56 ^{***} | (0.000) | [1.23,1.99] |
| >6 School Miss Days | 45711 | 1.93 ^{***} | (0.000) | [1.42,2.62] |

Notes: The ORs were obtained from logit regressions adjusting for all covariates listed in Supplementary Table 1 and using NSCH sampling weights. 95% confidence intervals are in brackets and p-values are in parentheses. A separate regression was estimated for each academic performance outcome and oral health measure.

* Significant at 10 percent level

** significant at 5 percent level

*** significant at 1 percent level.

Table 3.

Associations between Oral Health Status and Academic Performance of Children Aged 6–17 Years using 2016 and 2017 NSCH Separately

| Academic Performance | Any Oral Health Problem | | | | Poor Rated Oral Health | | | |
|---------------------------|-------------------------|---------------------|---------|-------------|------------------------|---------------------|---------|-------------|
| | N | OR | P-Value | 95% CI | N | OR | P-Value | 95% CI |
| Panel A: 2016 NSCH | | | | | | | | |
| Problems in school | 30994 | 1.45 ^{***} | (0.000) | [1.21,1.75] | 31718 | 1.40 ^{**} | (0.035) | [1.02,1.92] |
| Any School Miss Day | 31041 | 1.46 ^{***} | (0.000) | [1.18,1.80] | 31763 | 1.58 ^{***} | (0.005) | [1.15,2.17] |
| >3 School Miss Days | 31041 | 1.45 ^{***} | (0.000) | [1.22,1.72] | 31763 | 1.57 ^{***} | (0.002) | [1.18,2.09] |
| >6 School Miss Days | 31041 | 1.43 ^{***} | (0.004) | [1.12,1.82] | 31763 | 1.74 ^{***} | (0.003) | [1.21,2.50] |
| Panel B: 2017 NSCH | | | | | | | | |
| Problems in school | 13696 | 1.69 ^{***} | (0.000) | [1.29,2.20] | 13930 | 2.18 ^{***} | (0.001) | [1.39,3.42] |
| Any School Miss Day | 13713 | 1.68 ^{***} | (0.000) | [1.26,2.23] | 13948 | 1.06 | (0.775) | [0.72,1.56] |
| >3 School Miss Days | 13713 | 1.35 ^{***} | (0.009) | [1.08,1.70] | 13948 | 1.55 ^{**} | (0.017) | [1.08,2.22] |
| >6 School Miss Days | 13713 | 1.36 ^{**} | (0.039) | [1.02,1.82] | 13948 | 2.12 ^{***} | (0.001) | [1.36,3.29] |

Notes: The ORs were obtained from logit regressions adjusting for all covariates listed in Supplementary Table 1 and using NSCH sampling weights. 95% confidence intervals are in brackets and p-values are in parentheses. A separate regression was estimated for each academic performance outcome, oral health measure, and NSCH wave.

* Significant at 10 percent level

** significant at 5 percent level

*** significant at 1 percent level.

Table 4. Associations between Oral Health Status and Academic Performance of Children Stratified by Age using 2016–2017 NSCH

| Academic Performance | Any Oral Health Problem | | | | Poor Rated Oral Health | | | |
|---------------------------|-------------------------|---------|---------|-------------|------------------------|---------|---------|-------------|
| | N | OR | P-Value | 95% CI | N | OR | P-Value | 95% CI |
| Panel A: Age 6–11 | | | | | | | | |
| Problems in school | 18902 | 1.31** | (0.021) | [1.04,1.65] | 19281 | 1.45* | (0.067) | [0.97,2.16] |
| Any School Miss Day | 18941 | 1.37** | (0.012) | [1.07,1.74] | 19320 | 1.18 | (0.359) | [0.83,1.67] |
| >3 School Miss Days | 18941 | 1.22** | (0.044) | [1.01,1.49] | 19320 | 1.45** | (0.022) | [1.05,2.00] |
| >6 School Miss Days | 18941 | 1.31* | (0.069) | [0.98,1.74] | 19320 | 1.60** | (0.043) | [1.02,2.52] |
| Panel B: Age 12–14 | | | | | | | | |
| Problems in school | 11549 | 2.07*** | (0.000) | [1.55,2.78] | 11792 | 2.31*** | (0.002) | [1.37,3.91] |
| Any School Miss Day | 11552 | 1.97*** | (0.000) | [1.43,2.73] | 11791 | 1.70* | (0.057) | [0.98,2.92] |
| >3 School Miss Days | 11552 | 1.99*** | (0.000) | [1.50,2.63] | 11791 | 2.39*** | (0.000) | [1.47,3.87] |
| >6 School Miss Days | 11552 | 1.60*** | (0.007) | [1.14,2.26] | 11791 | 3.78*** | (0.000) | [2.27,6.31] |
| Panel C: Age 15–17 | | | | | | | | |
| Problems in school | 14239 | 1.85*** | (0.000) | [1.33,2.59] | 14575 | 2.29*** | (0.001) | [1.40,3.74] |
| Any School Miss Day | 14261 | 1.76*** | (0.001) | [1.25,2.49] | 14600 | 1.36 | (0.174) | [0.87,2.13] |
| >3 School Miss Days | 14261 | 1.42** | (0.014) | [1.07,1.89] | 14600 | 1.41 | (0.115) | [0.92,2.16] |
| >6 School Miss Days | 14261 | 1.40* | (0.053) | [0.99,1.97] | 14600 | 1.79** | (0.023) | [1.08,2.94] |

Notes: The ORs were obtained from logit regressions adjusting for all covariates listed in Supplementary Table 1 and using NSCH sampling weights. 95% confidence intervals are in brackets and p-values are in parentheses. A separate regression was estimated for each academic performance outcome and oral health measure.

* Significant at 10 percent level
 ** significant at 5 percent level
 *** significant at 1 percent level.

Table 5.

Associations between Oral Health Status and Academic Performance of Children Stratified by Income, Insurance Type, Race and Gender using 2016–2017 NSCH

| | Any Oral Health Problem | | | | Bad Rated Oral Health | | | |
|-------------------------------|-------------------------|---------------------|---------|-------------|-----------------------|---------------------|---------|-------------|
| | N | OR | P-Value | 95% CI | N | OR | P-Value | 95% CI |
| Problems in school | | | | | | | | |
| Low Income (<300% FPL) | 17544 | 1.69 ^{***} | (0.000) | [1.35,2.12] | 17863 | 1.88 ^{***} | (0.000) | [1.35,2.63] |
| High Income (300% FPL) | 27146 | 1.36 ^{***} | (0.003) | [1.11,1.67] | 27785 | 1.65 ^{**} | (0.028) | [1.06,2.59] |
| Private Insurance | 34115 | 1.47 ^{***} | (0.000) | [1.23,1.76] | 34887 | 1.93 ^{***} | (0.000) | [1.36,2.74] |
| Public Insurance | 8824 | 1.92 ^{***} | (0.000) | [1.45,2.55] | 8971 | 1.88 ^{***} | (0.005) | [1.21,2.90] |
| White | 31823 | 1.34 ^{***} | (0.001) | [1.13,1.59] | 32516 | 1.58 ^{***} | (0.003) | [1.17,2.12] |
| Non-White | 12867 | 1.78 ^{***} | (0.000) | [1.36,2.34] | 13132 | 1.93 ^{***} | (0.002) | [1.27,2.93] |
| Male | 22844 | 1.47 ^{***} | (0.000) | [1.20,1.79] | 23350 | 1.61 ^{***} | (0.002) | [1.19,2.18] |
| Female | 21846 | 1.71 ^{***} | (0.000) | [1.32,2.22] | 22298 | 2.01 ^{***} | (0.002) | [1.29,3.11] |
| Any School Miss Day | | | | | | | | |
| Low Income (<300% FPL) | 17574 | 1.52 ^{***} | (0.000) | [1.21,1.91] | 17893 | 1.28 [*] | (0.095) | [0.96,1.72] |
| High Income (300% FPL) | 27180 | 1.72 ^{***} | (0.000) | [1.35,2.18] | 27818 | 1.54 ^{**} | (0.050) | [1.00,2.37] |
| Private Insurance | 34165 | 1.65 ^{***} | (0.000) | [1.33,2.04] | 34935 | 1.17 | (0.429) | [0.79,1.73] |
| Public Insurance | 8838 | 1.57 ^{***} | (0.004) | [1.15,2.12] | 8986 | 1.69 ^{***} | (0.006) | [1.16,2.47] |
| White | 31862 | 1.51 ^{***} | (0.000) | [1.24,1.85] | 32553 | 0.94 | (0.694) | [0.68,1.30] |
| Non-White | 12892 | 1.57 ^{***} | (0.001) | [1.19,2.06] | 13158 | 1.50 ^{**} | (0.024) | [1.05,2.12] |
| Male | 22875 | 1.45 ^{***} | (0.002) | [1.15,1.83] | 23381 | 1.19 | (0.271) | [0.88,1.60] |
| Female | 21879 | 1.63 ^{***} | (0.000) | [1.25,2.12] | 22330 | 1.27 | (0.239) | [0.85,1.89] |
| >3 School Miss Days | | | | | | | | |
| Low Income (<300% FPL) | 17574 | 1.31 ^{***} | (0.006) | [1.08,1.59] | 17893 | 1.59 ^{***} | (0.001) | [1.20,2.11] |
| High Income (300% FPL) | 27180 | 1.60 ^{***} | (0.000) | [1.31,1.94] | 27818 | 1.44 ^{**} | (0.047) | [1.01,2.06] |
| Private Insurance | 34165 | 1.49 ^{***} | (0.000) | [1.26,1.77] | 34935 | 1.55 ^{***} | (0.009) | [1.12,2.15] |
| Public Insurance | 8838 | 1.31 ^{**} | (0.032) | [1.02,1.67] | 8986 | 1.54 ^{**} | (0.013) | [1.09,2.17] |
| White | 31862 | 1.57 ^{***} | (0.000) | [1.34,1.83] | 32553 | 1.72 ^{***} | (0.000) | [1.31,2.26] |
| Non-White | 12892 | 1.24 | (0.103) | [0.96,1.60] | 13158 | 1.44 [*] | (0.060) | [0.99,2.10] |
| Male | 22875 | 1.41 ^{***} | (0.000) | [1.17,1.71] | 23381 | 1.67 ^{***} | (0.000) | [1.25,2.23] |
| Female | 21879 | 1.35 ^{***} | (0.006) | [1.09,1.68] | 22330 | 1.34 | (0.118) | [0.93,1.95] |
| >6 School Miss Days | | | | | | | | |
| Low Income (<300% FPL) | 17574 | 1.32 ^{**} | (0.028) | [1.03,1.70] | 17893 | 1.91 ^{***} | (0.000) | [1.33,2.72] |
| High Income (300% FPL) | 27180 | 1.62 ^{***} | (0.001) | [1.22,2.15] | 27818 | 2.18 ^{***} | (0.002) | [1.34,3.54] |
| Private Insurance | 34165 | 1.40 ^{***} | (0.006) | [1.10,1.78] | 34935 | 1.71 ^{***} | (0.008) | [1.15,2.54] |
| Public Insurance | 8838 | 1.28 | (0.107) | [0.95,1.73] | 8986 | 1.82 ^{***} | (0.004) | [1.21,2.76] |

| | Any Oral Health Problem | | | | Bad Rated Oral Health | | | |
|-----------|-------------------------|---------|---------|-------------|-----------------------|---------|---------|-------------|
| | N | OR | P-Value | 95% CI | N | OR | P-Value | 95% CI |
| White | 31862 | 1.68*** | (0.000) | [1.37,2.07] | 32553 | 1.86*** | (0.000) | [1.35,2.55] |
| Non-White | 12892 | 1.08 | (0.694) | [0.74,1.56] | 13158 | 2.12*** | (0.002) | [1.31,3.46] |
| Male | 22875 | 1.50*** | (0.001) | [1.17,1.92] | 23381 | 1.60** | (0.012) | [1.11,2.30] |
| Female | 21879 | 1.27 | (0.106) | [0.95,1.71] | 22330 | 2.09*** | (0.001) | [1.33,3.29] |

Notes: The ORs were obtained from logit regressions adjusting for all covariates listed in Supplementary Table 1 and using NSCH sampling weights. 95% confidence intervals are in brackets and p-values are in parentheses. A separate regression was estimated for each academic performance outcome and oral health measure.

* Significant at 10 percent level

** significant at 5 percent level

*** significant at 1 percent level.

Table 6. Associations between Different Dental Problems and Academic Performance of Children Aged 6–17 Years using 2016–2017 NSCH

| Academic Performance | N | Toothache | | | Bleed Gum/Cavities (but no Toothache Reported) | | |
|----------------------|-------|-----------|---------|-------------|--|---------|-------------|
| | | OR | P-Value | 95% CI | OR | P-Value | 95% CI |
| Problems in school | 44671 | 2.09*** | (0.000) | [1.54,2.84] | 1.44*** | (0.000) | [1.18,1.75] |
| Any School Miss Day | 44735 | 1.72*** | (0.002) | [1.22,2.42] | 1.55*** | (0.000) | [1.27,1.90] |
| >3 School Miss Days | 44735 | 1.49*** | (0.004) | [1.13,1.95] | 1.38*** | (0.000) | [1.18,1.62] |
| >6 School Miss Days | 44735 | 1.20 | (0.302) | [0.85,1.70] | 1.48*** | (0.000) | [1.19,1.83] |

Notes: The ORs were obtained from logit regressions adjusting for all covariates listed in Supplementary Table 1 and using NSCH sampling weights. 95% confidence intervals are in brackets and p-values are in parentheses. A separate regression was estimated for each academic performance outcome; both indicators for dental problems were simultaneously included in the regression.

* Significant at 10 percent level

** significant at 5 percent level

*** significant at 1 percent level.