

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

Carol Cristina Guarnizo-Herreño, DDS, PhD<sup>1,2</sup>, Wei Lyu, MS<sup>3</sup>, and George L. Wehby, PhD<sup>3,4</sup>

**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 previous data.

**Study design** Data from the 2016-2017 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 also were 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 1 school day (OR 1.54, 95% CI 1.28-1.85), and miss more than 3 or 6 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.

**Conclusions** 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 approaches to reduce academic deficits and promote children's health and development, of which oral health is an important component. (*J Pediatr* 2019; ■:1-7).

Despite being largely preventable, oral health problems remain the leading chronic condition among children.<sup>1</sup> Nearly 621 million children have untreated caries in their deciduous teeth worldwide.<sup>2</sup> In the US, oral health problems in children and adolescents have persisted at high rates despite the increase in dental care use among children and some states implementing new prevention programs.<sup>3,4</sup> In 2011-2014, 14% of children aged 2-8 years and 19% of children aged 5-19 years had untreated dental caries.<sup>5,6</sup> 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.<sup>7-9</sup>

Previous 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.<sup>10</sup> Disadvantaged children with toothaches in Los Angeles had lower school grades, and those with unmet dental care needs missed more school days.<sup>11</sup> 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.<sup>8</sup> There is also similar evidence from other countries such as Brazil, Greece, Canada, and the United Kingdom.<sup>12-16</sup>

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.<sup>8</sup> 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 use among children and dental treatment quality and the implementation or expansion of some state-level preventive strategies.<sup>3,17,18</sup> Such strategies include reimbursement of fluoride varnish applications by nondentist primary

From the <sup>1</sup>Departamento de Salud Colectiva, Facultad de Odontología, Universidad Nacional de Colombia, Bogotá, Colombia; <sup>2</sup>Department of Epidemiology and Public Health, University College London, London, United Kingdom; <sup>3</sup>Department of Health Management and Policy, College of Public Health, University of Iowa, Iowa City, IA; and <sup>4</sup>National Bureau of Economic Research, Cambridge, MA

Supported by National Institutes of Health/National Institute of Dental and Craniofacial Research (NIDCR) (1R03DE026224-01A1). The NIDCR had no role in study design or reviewing the findings. The authors declare no conflicts of interest.

0022-3476/\$ - see front matter. © 2019 Elsevier Inc. All rights reserved.  
<https://doi.org/10.1016/j.jpeds.2019.01.045>

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.<sup>19,20</sup>

## 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 healthcare, 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.<sup>21,22</sup>

### Academic Performance Measures

The NSCH obtained data on 2 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 3 binary outcomes including any missed days, missing more than 3 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 vs good, very good, or excellent. The second measure captured whether the child had specific oral health problems over the past 12 months. In 2016-2017, 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.<sup>23-25</sup> 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 to gauge the extent to which the associations with academic performance are due to pain vs 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, greatest 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, attention deficit disorder/attention deficit-hyperactivity disorder, conduct or behavior problem, autism, delayed development, speech problem, hearing/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/ethnicity (non-Hispanic whites vs other race/ethnicity), household income ( $\leq 300\%$  federal poverty level vs  $>300\%$  federal poverty level), and type of health insurance (private vs public) to further evaluate potential heterogeneity.

## Results

**Table I** (available at [www.jpeds.com](http://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 3 and 6 school days, respectively. In terms of oral health status, more than 15% of children had at least 1 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 II** reports the ORs and their 95% CIs for the associations between the oral health measures and academic performance outcomes estimated from the adjusted logistic regressions combining all ages 6-17 years. As noted before, separate regressions were estimated for the 2 oral health measures (any dental problem and poor/fair rating). Across the evaluated academic outcomes and oral health measures, there were significant associations

**Table II. Associations between oral health status and academic performance of children aged 6-17 years using 2016-2017 NSCH**

Academic performances	N	OR	P value	95% CI
<b>Any oral health problem</b>				
Problems in school	44 690	1.56*	(.000)	[1.32-1.85]
Any school miss day	44 754	1.54*	(.000)	[1.28-1.85]
>3 school miss days	44 754	1.39*	(.000)	[1.20-1.61]
>6 school miss days	44 754	1.39*	(.001)	[1.14-1.69]
<b>Poor rated oral health</b>				
Problems in school	45 648	1.77*	(.000)	[1.33-2.36]
Any school miss day	45 711	1.28†	(.059)	[0.99-1.67]
>3 school miss days	45 711	1.56*	(.000)	[1.23-1.99]
>6 school miss days	45 711	1.93*	(.000)	[1.42-2.62]

The ORs were obtained from logit regressions adjusting for all covariates listed in Table I and using NSCH sampling weights. 95% CIs 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 1% level.

†Significant at 10% level.

indicating worse academic performance with poorer oral health. Furthermore, the magnitude of these associations was meaningful. Specifically, children with at least 1 dental problem were more likely to have problems at school (OR 1.56, 95% CI 1.32-1.85) and miss at least 1 school day (OR 1.54, 95% CI 1.28-1.85) by nearly 50%. Also, they were more likely to miss more than 3 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 3 school days or more than 6 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 III (available at [www.jpeds.com](http://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 IV) revealed significant associations overall for all 3 age groups (6-11, 12-14, and 15-17 years). The estimates were largest for children aged 12-14 years, followed by children 15-17 years and the youngest group of 6-11 years. 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/ethnicity, household income, and type of health insurance (Table V). 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.

**Table IV. Associations between oral health status and academic performance of children stratified by age using 2016-2017 NSCH**

Academic performances	Any oral health problem				Poor-rated oral health			
	N	OR	P value	95% CI	N	OR	P value	95% CI
<b>Panel A: Age 6-11 y</b>								
Problems in school	18 902	1.31*	(.021)	[1.04-1.65]	19 281	1.45†	(.067)	[0.97-2.16]
Any school miss day	18 941	1.37*	(.012)	[1.07-1.74]	19 320	1.18	(.359)	[0.83-1.67]
>3 school miss days	18 941	1.22*	(.044)	[1.01-1.49]	19 320	1.45*	(.022)	[1.05-2.00]
>6 school miss days	18 941	1.31†	(.069)	[0.98-1.74]	19 320	1.60*	(.043)	[1.02-2.52]
<b>Panel B: Age 12-14 y</b>								
Problems in school	11 549	2.07‡	(.000)	[1.55-2.78]	11 792	2.31‡	(.002)	[1.37-3.91]
Any school miss day	11 552	1.97‡	(.000)	[1.43-2.73]	11 791	1.70†	(.057)	[0.98-2.92]
>3 school miss days	11 552	1.99‡	(.000)	[1.50-2.63]	11 791	2.39‡	(.000)	[1.47-3.87]
>6 school miss days	11 552	1.60‡	(.007)	[1.14-2.26]	11 791	3.78‡	(.000)	[2.27-6.31]
<b>Panel C: Age 15-17 y</b>								
Problems in school	14 239	1.85‡	(.000)	[1.33-2.59]	14 575	2.29‡	(.001)	[1.40-3.74]
Any school miss day	14 261	1.76‡	(.001)	[1.25-2.49]	14 600	1.36	(.174)	[0.87-2.13]
>3 school miss days	14 261	1.42*	(.014)	[1.07-1.89]	14 600	1.41	(.115)	[0.92-2.16]
>6 school miss days	14 261	1.40†	(.053)	[0.99-1.97]	14 600	1.79*	(.023)	[1.08-2.94]

The ORs were obtained from logit regressions adjusting for all covariates listed in Table I and using NSCH sampling weights. 95% CIs 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 5% level.

†Significant at 10% level.

‡Significant at 1% level.

**Table V.** Associations between oral health status and academic performance of children stratified by income, insurance type, race/ethnicity, and sex using 2016-2017 NSCH

Academic performance by subgroups	Any oral health problem				Bad-rated oral health			
	N	OR	P value	95% CI	N	OR	P value	95% CI
<b>Problems in school</b>								
Low income (<300% FPL)	17 544	1.69*	(.000)	[1.35-2.12]	17 863	1.88*	(.000)	[1.35-2.63]
High income (≥300% FPL)	27 146	1.36*	(.003)	[1.11-1.67]	27 785	1.65†	(.028)	[1.06-2.59]
Private insurance	34 115	1.47*	(.000)	[1.23-1.76]	34 887	1.93*	(.000)	[1.36-2.74]
Public insurance	8824	1.92*	(.000)	[1.45-2.55]	8971	1.88*	(.005)	[1.21-2.90]
Non-Hispanic whites	31 823	1.34*	(.001)	[1.13-1.59]	32 516	1.58*	(.003)	[1.17-2.12]
Other race/ethnicity	12 867	1.78*	(.000)	[1.36-2.34]	13 132	1.93*	(.002)	[1.27-2.93]
Male	22 844	1.47*	(.000)	[1.20-1.79]	23 350	1.61*	(.002)	[1.19-2.18]
Female	21 846	1.71*	(.000)	[1.32-2.22]	22 298	2.01*	(.002)	[1.29-3.11]
<b>Any school miss day</b>								
Low income (<300% FPL)	17 574	1.52*	(.000)	[1.21-1.91]	17 893	1.28‡	(.095)	[0.96-1.72]
High income (≥300% FPL)	27 180	1.72*	(.000)	[1.35-2.18]	27 818	1.54†	(.050)	[1.00-2.37]
Private insurance	34 165	1.65*	(.000)	[1.33-2.04]	34 935	1.17	(.429)	[0.79-1.73]
Public insurance	8838	1.57*	(.004)	[1.15-2.12]	8986	1.69*	(.006)	[1.16-2.47]
Non-Hispanic whites	31 862	1.51*	(.000)	[1.24-1.85]	32 553	0.94	(.694)	[0.68-1.30]
Other race/ethnicity	12 892	1.57*	(.001)	[1.19-2.06]	13 158	1.50†	(.024)	[1.05-2.12]
Male	22 875	1.45*	(.002)	[1.15-1.83]	23 381	1.19	(.271)	[0.88-1.60]
Female	21 879	1.63*	(.000)	[1.25-2.12]	22 330	1.27	(.239)	[0.85-1.89]
<b>&gt;3 school miss days</b>								
Low income (<300% FPL)	17 574	1.31*	(.006)	[1.08-1.59]	17 893	1.59*	(.001)	[1.20-2.11]
High income (≥300% FPL)	27 180	1.60*	(.000)	[1.31-1.94]	27 818	1.44†	(.047)	[1.01-2.06]
Private insurance	34 165	1.49*	(.000)	[1.26-1.77]	34 935	1.55*	(.009)	[1.12-2.15]
Public insurance	8838	1.31†	(.032)	[1.02-1.67]	8986	1.54†	(.013)	[1.09-2.17]
Non-Hispanic whites	31 862	1.57*	(.000)	[1.34-1.83]	32 553	1.72*	(.000)	[1.31-2.26]
Other race/ethnicity	12 892	1.24	(.103)	[0.96-1.60]	13 158	1.44‡	(.060)	[0.99-2.10]
Male	22 875	1.41*	(.000)	[1.17-1.71]	23 381	1.67*	(.000)	[1.25-2.23]
Female	21 879	1.35*	(.006)	[1.09-1.68]	22 330	1.34	(.118)	[0.93-1.95]
<b>&gt;6 school miss days</b>								
Low income (<300% FPL)	17 574	1.32†	(.028)	[1.03-1.70]	17 893	1.91*	(.000)	[1.33-2.72]
High income (≥300% FPL)	27 180	1.62*	(.001)	[1.22-2.15]	27 818	2.18*	(.002)	[1.34-3.54]
Private insurance	34 165	1.40*	(.006)	[1.10-1.78]	34 935	1.71*	(.008)	[1.15-2.54]
Public insurance	8838	1.28	(.107)	[0.95-1.73]	8986	1.82*	(.004)	[1.21-2.76]
Non-Hispanic whites	31 862	1.68*	(.000)	[1.37-2.07]	32 553	1.86*	(.000)	[1.35-2.55]
Other race/ethnicity	12 892	1.08	(.694)	[0.74-1.56]	13 158	2.12*	(.002)	[1.31-3.46]
Male	22 875	1.50*	(.001)	[1.17-1.92]	23 381	1.60†	(.012)	[1.11-2.30]
Female	21 879	1.27	(.106)	[0.95-1.71]	22 330	2.09*	(.001)	[1.33-3.29]

FPL, federal poverty level.

The ORs were obtained from logit regressions adjusting for all covariates listed in Table I and using NSCH sampling weights. 95% CIs 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 1% level.

†Significant at 5% level.

‡Significant at 10% level.

### Associations with Toothache vs Other Dental Problems

The results (Table VI) 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

**Table VI.** Associations between different dental problems and academic performance of children aged 6-17 years using 2016-2017 NSCH

Academic performances	Toothache				Bleed gum/cavities (but no toothache reported)		
	N	OR	P value	95% CI	OR	P value	95% CI
Problems in school	44 671	2.09*	(.000)	[1.54-2.84]	1.44*	(.000)	[1.18-1.75]
Any school miss day	44 735	1.72*	(.002)	[1.22-2.42]	1.55*	(.000)	[1.27-1.90]
>3 school miss days	44 735	1.49*	(.004)	[1.13-1.95]	1.38*	(.000)	[1.18-1.62]
>6 school miss days	44 735	1.20	(.302)	[0.85-1.70]	1.48*	(.000)	[1.19-1.83]

The ORs were obtained from logit regressions adjusting for all covariates listed in Table I and using NSCH sampling weights. 95% CIs 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 1% level.

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.

Findings from this study are similar to those from previous 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,<sup>26</sup> a decrease in children's caries experience in their permanent dentition [among 6-17 year-olds],<sup>27</sup> and a decline in untreated dental caries in primary dentition [among 2-8 year-olds]<sup>28</sup>), 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, among others.<sup>29</sup> Future evaluations of such programs and policy efforts also should include effects

of oral health changes on children's academic outcomes to capture their full effects on children's well-being. 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 previous work.<sup>8</sup> Psychosocial status affects cognitive outcomes including the ability to learn.<sup>30</sup> 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 observed for children aged 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, 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 (ie, 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.<sup>11,12,31</sup> 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. ■

Submitted for publication Dec 12, 2018; last revision received Jan 17, 2019; accepted Jan 29, 2019.

Reprint requests: George L. Wehby, PhD, Professor, University of Iowa, Departments of Health Management and Policy, Economics, and Preventive & Community Dentistry, and Public Policy Center, PhD Program Director, Department of Health Management and Policy, Research Associate, National Bureau of Economic Research, 145 N Riverside Dr, 100 College of Public Health Bldg, Room N250, Iowa City, IA 52242-2007. E-mail: [george-wehby@uiowa.edu](mailto:george-wehby@uiowa.edu)

## References

1. FDI World Dental Federation. Oral Health Worldwide: a report by FDI World Dental Federation, 2015. [https://www.fdiworlddental.org/sites/default/files/media/documents/2015\\_wohd-whitepaper-oral\\_health\\_worldwide.pdf](https://www.fdiworlddental.org/sites/default/files/media/documents/2015_wohd-whitepaper-oral_health_worldwide.pdf). [Accessed 1 September 2018].
2. Kassebaum NJ, Bernabe E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res* 2015;94:650-8.
3. Nasseh K, Vujicic M. Dental care utilization rate continues to increase among children, holds steady among working-age adults and the elderly. Health Policy Institute Research Brief, 2015. [http://www.ada.org/~media/ADA/Science%20and%20Research/HPI/Files/HPIBrief\\_1015\\_1.ashx](http://www.ada.org/~media/ADA/Science%20and%20Research/HPI/Files/HPIBrief_1015_1.ashx). [Accessed 1 September 2018].
4. Dye BA, Li X, Beltrán-Aguilar ED. Selected oral health indicators in the United States, 2005-2008. Washington (DC): US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2012.
5. National Center for Health Statistics (US). Health, United States, 2016: with chartbook on long-term trends in health. Hyattsville (MD): National Center for Health Statistics (US); 2017.
6. Fleming E, Afful J, Frenk SM. QuickStats: prevalence of untreated dental caries in primary teeth among children aged 2-8 years, by age group and race hispanic-origin National Health and Nutrition Examination Survey, 2011-2014. *Morbidity and Mortality Weekly Report (MMWR)* 2017;66:261.
7. Sheiham A. Dental caries affects body weight, growth and quality of life in pre-school children. *Br Dent J* 2006;201:625-6.
8. Guarnizo-Herreno CC, Wehby GL. Children's dental health, school performance, and psychosocial well-being. *J Pediatr* 2012;161:1153-9.
9. Watt RG, Mathur MR, Aida J, Bonecker M, Venturelli R, Gansky SA. Oral health disparities in children: a canary in the coalmine? *Pediatr Clin North Am* 2018;65:965-79.
10. Jackson SL, Vann WF Jr, Kotch JB, Pahel BT, Lee JY. Impact of poor oral health on children's school attendance and performance. *Am J Public Health* 2011;101:1900-6.
11. Seirawan H, Faust S, Mulligan R. The impact of oral health on the academic performance of disadvantaged children. *Am J Public Health* 2012;102:1729-34.
12. Paula JS, Lisboa CM, de Castro Meneghim M, Pereira AC, Ambrosano GM, Mialhe FL. School performance and oral health conditions: analysis of the impact mediated by socio-economic factors. *Int J Paediatr Dent* 2016;26:52-9.
13. Paula JS, Ambrosano GM, Mialhe FL. Oral disorders, socioenvironmental factors and subjective perception impact on children's school performance. *Oral Health Prev Dent* 2015;13:219-26.
14. Petridou E, Athanassouli T, Panagopoulos H, Revinthi K. Sociodemographic and dietary factors in relation to dental health among Greek adolescents. *Community Dent Oral Epidemiol* 1996;24:307-11.
15. Muirhead V, Marcenes W. An ecological study of caries experience, school performance and material deprivation in 5-year-old state primary school children. *Community Dent Oral Epidemiol* 2004;32:265-70.
16. Muirhead VE, Locker D. School performance indicators as proxy measures of school dental treatment needs: a feasibility study. *J Public Health Dent* 2006;66:269-72.
17. Kranz AM, Duffy E, Dick AW, Sorbero M, Rozier RG, Stein BD. Impact of Medicaid policy on the oral health of publicly insured children. *Matern Child Health J* 2019;23:100-8.
18. Griffin SO, Wei L, Gooch BF, Weno K, Espinoza L. Vital signs: dental sealant use and untreated tooth decay among U.S. school-aged children. *MMWR Morb Mortal Wkly Rep* 2016;65:1141-5.
19. Levin HM. More than just test scores. *Prospects* 2012;42:269-84.
20. Heckman JJ, Stixrud J, Urzua S. The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *J Labor Econ* 2006;24:411-82.
21. Data Resource Center for Child and Adolescent Health. The National Survey of Children's Health, 2018. <https://childhealthdata.org/learn-about-the-nsch/NSCH>. [Accessed 9 October 2018].
22. Chau KW, Lennon HTC. Let the buyer or seller beware: measuring lemons in the housing market under different doctrines of law governing transactions and information. *J Law Econ* 2011;54:S347-65.
23. Sohn W, Taichman LS, Ismail AI, Reisine S. Caregiver's perception of child's oral health status among low-income African Americans. *Pediatr Dent* 2008;30:480-7.
24. Filstrup SL, Briskie D, da Fonseca M, Lawrence L, Wandera A, Inglehart MR. Early childhood caries and quality of life: child and parent perspectives. *Pediatr Dent* 2003;25:431-40.
25. Pahel BT, Rozier RG, Slade GD. Parental perceptions of children's oral health: the Early Childhood Oral Health Impact Scale (ECOHS). *Health Qual Life Outcomes* 2007;5:6.
26. Shariff JA, Edelstein BL. Medicaid meets its equal access requirement for dental care, but oral health disparities remain. *Health Aff (Millwood)* 2016;35:2259-67.
27. Slade GD, Sanders AE. Two decades of persisting income-disparities in dental caries among U.S. children and adolescents. *J Public Health Dent* 2018;78:187-91.
28. Dye BA, Mitnik GL, Iafolla TJ, Vargas CM. Trends in dental caries in children and adolescents according to poverty status in the United States from 1999 through 2004 and from 2011 through 2014. *J Am Dent Assoc* 2017;148:550-65 e557.

29. US Department of Health Human Services Oral Health Coordinating Committee. US Department of Health and Human Services Oral Health Strategic Framework, 2014–2017. *Public Health Rep* 2016;131:242-57.
30. Jones DE, Greenberg M, Crowley M. Early social-emotional functioning and public health: the relationship between kindergarten social competence and future wellness. *Am J Public Health* 2015;105:2283-90.
31. Pongpichit B, Sheiham A, Pikhart H, Tsakos G. Time absent from school due to dental conditions and dental care in Thai schoolchildren. *J Public Health Dent* 2008;68:76-81.

**Table I. Weighted descriptive statistics for study variables**

Variables	Children 6-17 years, N = 45 711	
	Percent	
Academic performance measures		
Problems in school		24.7
Any school miss day		68.7
>3 school miss days		23.3
>6 school miss days		9.5
Oral health measures		
Any dental problem		15.8
Toothaches		3.4
Cavities		12.7
Bleeding gums		2.2
Poor or fair rated oral health		6.1
Demographic characteristics		
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 sex		
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
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
Socioeconomic status		
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 and ≤133% FPL		8.3
>133% FPL and ≤150% FPL		3.5
>150% FPL and ≤185% FPL		7.2
>185% FPL and ≤200% FPL		3.1
>200% FPL and ≤300% FPL		15.0
>300% FPL and ≤400% FPL		11.5
>400% FPL		30.3

(continued)

**Table I. Continued**

Variables	Children 6-17 years, N = 45 711	
	Percent	
Any employment in household		94.3
Any health insurance coverage		93.5
Public health insurance		57.5
Private health insurance		34.8
Medical history		
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
Depression/anxiety		11.4

ADD/ADHD, attention deficit disorder/attention deficit-hyperactivity disorder; FPL, federal poverty level.

**Table III.** Associations between oral health status and academic performance of children aged 6-17 years using 2016 and 2017 NSCH separately

Academic performances	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	30 994	1.45*	(.000)	[1.21-1.75]	31 718	1.40 <sup>†</sup>	(.035)	[1.02-1.92]
Any school miss day	31 041	1.46*	(.000)	[1.18-1.80]	31 763	1.58*	(.005)	[1.15-2.17]
>3 school miss days	31 041	1.45*	(.000)	[1.22-1.72]	31 763	1.57*	(.002)	[1.18-2.09]
>6 school miss days	31 041	1.43*	(.004)	[1.12-1.82]	31 763	1.74*	(.003)	[1.21-2.50]
Panel B: 2017 NSCH								
Problems in school	13 696	1.69*	(.000)	[1.29-2.20]	13 930	2.18*	(.001)	[1.39-3.42]
Any school miss day	13 713	1.68*	(.000)	[1.26-2.23]	13 948	1.06	(.775)	[0.72-1.56]
>3 school miss days	13 713	1.35*	(.009)	[1.08-1.70]	13 948	1.55 <sup>†</sup>	(.017)	[1.08-2.22]
>6 school miss days	13 713	1.36 <sup>†</sup>	(.039)	[1.02-1.82]	13 948	2.12*	(.001)	[1.36-3.29]

The ORs were obtained from logit regressions adjusting for all covariates listed in [Table I](#) and using NSCH sampling weights. 95% CIs 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 1% level.

<sup>†</sup>Significant at 5% level.