ORIGINAL REPORT: EPIDEMIOLOGIC RESEARCH

School-Based Caries Prevention, Tooth Decay, and the Community Environment

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Abstract: *The school and community context can contribute to inequity in child oral health. Whether the school and community affect the effectiveness of school-based caries prevention is unknown. The association between the school and community environment and dental caries, as well as their moderating effects with school-based caries prevention, was assessed using multilevel mixed-effects regression. Data were derived from a 6-y prospective cohort study of children participating in a school-based caries prevention program. For the school and community, living in a dental-shortage area and the proportion of children receiving free or reduced lunch were significantly related to an increased risk of dental caries at baseline. Caries prevention was associated with a significant per-visit decrease in the risk of untreated caries, but the rate of total caries experience increased over time. Caries prevention was more effective in children who had prior dental care at baseline and in schools with a higher proportion of low socioeconomic status students. There was significant variation across schools in the baseline prevalence of dental caries and the effect of prevention over time, although effects were modest. The school and community environment have a direct impact on oral health and moderate the association between school-based caries prevention and dental caries.*

Knowledge Transfer Statement: *School-based caries prevention can be an effective means to reduce oral health inequity by embedding dental care within schools. However, the socioeconomic makeup of schools and characteristics of the surrounding community can affect the impact of school-based care.*

Keywords: oral health, dental caries, adolescent, dentistry, epidemiology, children

Introduction

Despite recent reductions in the prevalence of untreated dental caries in U.S. school-aged children, considerable disparities still persist in oral health and dental care utilization. Data from national surveillance studies show that sealant use is lowest among low-income children, that less than half of children aged 6 to 11 y from low-income families had a dental visit in the previous year (Griffin et al. 2016), and that the prevalence of untreated dental caries is highest among non-Hispanic black, Hispanic, and Asian children compared to whites (Dye and Thornton-Evans 2010; Dye et al. 2012). To improve access to dental services for vulnerable populations in medically underserved areas, multiple federal agencies, national institutes, and organizations recommend school-based caries prevention (Australian National Health and Medical Research Council 2007; Albert et al. 2005; Griffin et al. 2007; Center for Health and Health Care in Schools 2012).

Although school-based caries prevention programs may be effective in preventing dental caries (Gooch et al. 2009; Matsuyama et al. 2016; Cakar et al. 2017; Williams et al. 2017), the type of services provided, intensity of treatments (e.g., topical fluoride concentration), and frequency of care can be inconsistent across programs (Albert et al. 2005). This can result in disparate treatment effects (Hiiri et al. 2010; Williams et al. 2017). In addition to overall program-

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level variation, the complex relationship between oral health, the school environment, and the community may affect prevention effectiveness. For example, our previous work in school-based prevention showed that the baseline prevalence of caries in schools can be highly variable, ranging from 19% to as high as 54% (unpublished material), suggesting that school or community-level characteristics may affect oral health equity. It is also possible that prevention is mediated by individual characteristics within schools, such as age, which would have larger implications for the planning of prevention programs. Finally, recent evidence indicates that racial and ethnic disparities in oral health may be more pronounced in affluent schools than in poor ones (Matsuo et al. 2015). Thus, the effects of school-based prevention may be moderated by observable school and community characteristics.

The utility of existing caries prevention research in optimizing prevention programs is limited without considering the larger school and community factors that may contribute to disparities in child dental health. In this study, we explore the impact of the school and community environment on the effectiveness of caries prevention.

Methods

Design and Interventions

Data were derived from a longitudinal open cohort of children participating in a school-based caries prevention program conducted in rural and urban elementary schools in the Northeastern United States from 2004 to 2010, beginning with 4 elementary schools in 2004 and ending with 50 schools in 2008. Schools were included in analysis if they had at least 4 data collection periods and more than 50 children participating. All participating schools were designated as Title 1 as over half of enrolled students qualified to receive free or reduced-price meals. In each year of the program, students in participating schools were provided informed consent. Recruited children who had completed informed consent were followed longitudinally and treated twice yearly with caries prevention for as long as they were enrolled in the school. The average overall participation rate was approximately 15%, ranging from 10% to 30% across school. Subjects were included in analysis only if they were between the ages of 5 and 12 y.

At each observational period, children received oral examinations, prophylaxis, glass ionomer cement sealants placed on all teeth, interim therapeutic restorations placed on all teeth with carious lesions, fluoride varnish, toothbrush, toothpaste, and health education. Children were referred to local dentists for immediate follow-up care if needed. The study received institutional review board approval from the Forsyth Institute and the New York University School of Medicine and conformed with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research.

Data

Demographic data were collected from each participant for age at each examination, the total number of preventive visits received, sex, grade, and school. Recorded clinical data at each observation included the number of adult and primary teeth present; the number of decayed, missing, filled, or sealed teeth or surfaces (occlusal, lingual, buccal, mesial, and distal); and any evidence of previous dental care received outside of the school (e.g., preexisting sealants or restorations).

School indicators for school type (e.g., urban, suburban, rural), the proportion of students eligible for free or reduced-price lunch (FRL, included as a poverty indicator), and school size were obtained from the National Center for Education Statistics' (NCES) Common Core of Data. Prior to analysis, the percentage of FRL was standardized. Data for school-level race ethnicity and the pupil to teacher ratio were obtained from the NCES Elementary/Secondary Information System (E/Si). For analysis, race/ethnicity was defined as the proportion of students who were black or Hispanic.

Data for medically underserved populations/areas (MUPs/MUAs) and health professional–shortage areas (HPSAs) for dental and primary care providers were obtained from the Health Resources & Services Administration (HRSA) Data Warehouse and matched to participating schools using school mailing addresses. Medically underserved communities are defined by HRSA as geographic populations or areas with a lack of access to primary care services. For MUAs, shortages are classified for residents within a geographic area (e.g., county, census tracts). MUPs refer to specific subgroups of people living in a geographic area with a shortage of primary care services, such as homeless, low-income, or Medicaid-eligible persons. HPSAs are defined by HRSA as areas with health care provider shortages in primary care, dental health, or mental health. Shortages may be geographic, population, or facility based.

Data Collection, Calibration, and Standardization

At each observation for each participant, examining dentists dried tooth surfaces with gauze squares and performed clinical visual-tactile full-mouth oral examinations, including examination of all teeth and tooth surfaces for decayed, missing, filled, sound, or pulpal involvement. The exam also included an assessment of pain, swelling, infection, and abscess. Following the clinical examinations, which were conducted by a licensed dentist, dental hygienists delivered all preventive treatments.

Data collectors were calibrated by examining 10 students independently at baseline and discussing whether caries was present or not. Following this review, data collectors examined another 10 students independently and compared results ($\kappa = 0.75$). To standardize delivery of care, hygienists were trained to use Fuji IX glass ionomer in capsules prior to participating in the program. Following the start of the program, dentists and hygienists were standardized yearly but not calibrated. Each examiner recorded clinical data using a proprietary tablet-based software that was then securely uploaded to a data coordinating center.

Outcomes

Outcomes were derived for the presence of untreated caries on permanent teeth and the total observed caries experience (TOCE). Untreated caries was determined by the detection of any untreated carious lesion on any permanent tooth surface and used as a dichotomous outcome. TOCE was defined as the total number of primary or permanent teeth with untreated caries or restorations that were observed over the total study period and was used as a measure of total accumulated decay.

Statistical Analysis

Mixed-effects multilevel regression was used to assess the relationship between school and community variables, caries prevention, and study outcomes. Multilevel logistic regression was used for untreated caries and multilevel Poisson regression for TOCE. The multilevel data structure consisted of observations nested within children nested within schools. Schools were unique within geographic communities, and thus community effects (e.g., medically underserved areas) were included at the school level.

First, a series of bivariate multilevel models were conducted for each predictor of interest for each outcome. Variables included age, sex, evidence of prior dental care at baseline, school-level race ethnicity, pupil-teacher ratios, community water fluoridation status, the percentage of students receiving free or reduced lunch, and whether the school was located in a dental professional–shortage or medically underserved area. Variables with significant bivariate associations were included in multivariable analyses for further evaluation. Multivariable models also adjusted for the period in which a school entered the study. To explore variation across schools, random effects were included for baseline dental caries and the effects of caries prevention for each outcome. To address the possibly complex relationship between age and caries experience due to mixed dentition, a quadratic term for age was included in TOCE models. In addition, as a sensitivity analysis, multilevel models were stratified into TOCE for the primary and permanent dentition and analyzed separately.

To assess the potential moderating effects of child and/or school and community variables on the relationship between prevention and caries, interaction terms were included for previous dental care, FRL, school-level race/ethnicity, and whether the school was located in a dental-shortage area. In addition, the mediating effect of child age on the relationship between caries prevention and caries was assessed using multilevel mediation analysis with bootstrapped confidence intervals. For mediation analyses, TOCE was used as a continuous variable.

For multilevel logistic models, the intraclass correlation coefficient (ICC) for the fully adjusted model was computed using the latent variable method (Merlo et al. 2006). Finally, area level variance for the school/community was expressed using median odds ratios (MORs) and median incident rate ratios (MIRRs) (Larsen and Merlo 2005; Merlo et al. 2006; Rabe-Hesketh and Skrondal 2008).

Analysis was conducted in Stata v14.0 (StataCorp LP). Statistical significance was set at 0.05.

Results

The analytic sample consisted of 17,498 visits in 6,584 participants across 34 schools. The mean baseline prevalence of untreated caries on any tooth was 33%, and the mean (standard deviation [SD]) TOCE was 2.19 (2.83) (Table 1). Most participants had 4 or fewer prevention visits, and 60% of the sample presented with evidence of receiving previous dental care at baseline. The mean (SD) age at baseline was 7.3 (1.71) y. Across all schools, the average proportion of students eligible for free or reduced lunch was 71%, and 47% of students were black or Hispanic. The sample was equally distributed by sex. Average follow-up time for children was 16 mo. Seventeen included schools were located in an area with community water fluoridation. Twenty-four schools were in dental professional–shortage areas, 17 in primary care–shortage areas, and 24 in medically underserved areas.

In unadjusted models (Table 2), age, previous dental care, water fluoridation, medically underserved areas, primary care–shortage, the percentage of minority students, and free/reduced lunch were significantly associated with increased rates of TOCE, while living in a dental-shortage area was associated with reduced rates. Age, the percentage of students receiving free/reduced lunch, and evidence of previous dental care were associated with an increased odds of untreated caries.

In multivariable models (Table 3), having received previous dental care (incident rate ratio [IRR], 3.18; 95% CI, 2.93–3.45) and increases in school-level poverty (IRR, 1.24; 95% CI, 1.14–1.34) were associated with an increased incident rate of TOCE. Similarly, each prevention visit was associated with a small increase in the incidence rate (IRR, 1.13; 95% CI, 1.12–1.15). Adjusting for previous dental care removed the significant effect for living in either a dental or primary care–shortage area. After further adjusting for poverty, the proportion of black and Hispanic students in the school was no longer significant. Random effects showed significant variability in TOCE across children (σ^2, 2.17; 95% CI, 2.05–2.31) and schools (σ^2, 0.07; 95% CI, 0.04–0.14), although school-level variation in unmet oral health need was small. A random slope for prevention visits across schools was also significant (SD, 0.11; 95% CI, 0.08–0.16), indicating that the effect for caries prevention was not consistent across schools. The school-level median incidence rate ratio (MIRR) associated with TOCE was 1.17.

When stratified by primary and permanent dentition (Appendix Table), model results demonstrate that the risk of total caries continued to significantly increase in each group, although the rate was slower for permanent teeth (IRR, 1.05; 95% CI, 1.02–1.07) compared to primary teeth (IRR, 1.17; 95% CI, 1.16–1.19). School poverty and evidence of

Table 1.
Descriptive Statistics for Variables at the Visit, Child, and School/Community Level.

	n	%
Observations (*n* = 17,498)		
1	6,584	37.42
2	5,108	29.03
3	2,592	14.73
4	1,776	10.09
5	844	4.8
6	458	2.6
7	136	0.77
Child (*n* = 6,484)		
Male	3,338	51.4
Had previous dental care	3,986	60.54
Untreated caries (any tooth)	2,211	33.58
Age (mean/SD), y	7.32	1.71
TOCE (mean/SD)	2.19	2.83
Free and reduced lunch (mean/SD)	71.1	0.25
Hispanic/black (mean/SD)	46.7	0.31
School and community (*n* = 34)		
Community water fluoridation	17	50.00
Dental professional–shortage area	24	76.47
Primary care–shortage area	17	50.00
Medically underserved area	24	76.47
Community type		
Suburb	24	70.69
City	6	17.65
Town	2	0.06
Other	2	0.06

TOCE, total observed caries experience.

previous care were similarly significant in either dentition, but there was a separate significant effect for sex in permanent teeth. The corresponding MIRRs were 1.17 and 1.36 for primary and permanent teeth, respectively.

For logistic model results, each preventive visit was significantly associated with reduced odds of untreated caries (OR, 0.67; 95% CI, 0.60–0.75). Living in a dental-shortage area (OR, 2.53; 95% CI, 1.42–4.50) was associated with increased odds (Table 3). The intraclass correlation for the fully adjusted multilevel logistic model was 0.55. The school-level median odds ratio (MOR) associated with untreated caries was 1.24.

At the child level, there was a significant interaction between prevention and evidence of previous dental care (IRR, 0.89; 95% CI, 0.87–0.91), suggesting that the rate of change in TOCE over time in children receiving prevention decreased at a faster rate for those who had received prior dental care compared to those who had not (Table 4). At the school level, the rate of TOCE decreased faster over time in schools with proportions of children receiving free or reduced-price lunch that were greater than the average across schools (IRR, 0.96; 95% CI, 0.92–0.99). The interaction between prevention over time and the percentage of black or Hispanic students was not significant (IRR, 0.98; 95% CI, 0.95–1.01). Similarly, interaction between prevention and schools being located in dental-shortage areas was also not significant (IRR, 1.01; 95% CI, 0.99–1.02).

Multilevel mediation results (Table 5) show that the indirect effect of caries prevention on the total observed caries experience through child age was statistically significant but of small magnitude (β, 0.04; 95% CI, 0.01–0.07). In contrast, the direct effect of prevention on total caries was statistically significant and accounted for 92% of the total effect (β, 0.46; 95% CI, 0.38–0.53).

Discussion

This study explored the interrelationship between oral health, school-based caries prevention, and the school and community environment. Overall findings indicated that school-level variation in untreated caries and TOCE at baseline was statistically significant but of small magnitude. In contrast, variation at the child level for both outcomes was large. In fully adjusted models, prevention over time was significantly associated with decreased odds of untreated caries in permanent teeth but a slight increase in the incidence rate of total observed caries, although incident rates were lower in permanent teeth. Increases in the proportion of children receiving free

Table 2.
Bivariate Associations with TOCE and Untreated Caries.

	TOCE			Untreated Caries		
	IRR	*P* Value	95% CI	OR	*P* Value	95% CI
Dental-shortage area	0.58	**<.001**	0.46–0.73	1.18	0.693	0.53–2.62
Sex	0.97	0.479	0.90–1.05	0.94	0.70	0.68–1.30
Pupil teacher ratio	1.07	0.058	0.99–1.14	1.08	0.49	0.87–1.34
Prevention over time	1.15	**<.001**	1.14–1.16	0.79	**<.001**	0.70–0.88
Medically underserved	1.41	**0.007**	1.10–1.82	1.38	0.44	0.61–3.13
Age	1.19	**<.001**	1.18–1.21	1.27	**<.001**	1.16–1.39
Primary care–shortage	1.69	**<.001**	1.34–2.14	1.14	0.75	0.50–2.59
Community water fluoridation	1.99	**<.001**	1.61–2.45	1.44	0.38	0.64–3.22
Minority percentage	2.81	**<.001**	1.95–4.06	2.62	0.15	0.71–9.61
Standardized FRL	1.39	**<.001**	1.27–1.52	1.51	**0.044**	1.01–2.25
Previous care	3.62	**<.001**	3.34–3.92	1.57	**0.009**	1.12–2.22

Coefficients in bold are significant at .05.
FRL, free or reduced-price lunch; IRR, incident rate ratio; TOCE, total observed caries experience.

Table 3.
Multilevel Model Results for TOCE and Untreated Caries.

	TOCE		Untreated Caries	
Direct Effects	IRR	95% CI	OR	95% CI
Sex	0.97	0.90–1.05	0.84	0.62–1.12
Prevention over time	**1.13**	1.12–1.15	**0.67**	0.60–0.75
Standardized FRL	**1.24**	1.14–1.34	1.33	0.99–1.78
Previous care	**3.18**	2.93–3.45	1.14	0.84–1.56
Age	**1.35**	1.24–1.47	**0.75**	0.68–0.83
Quadratic age	**0.98**	0.98–0.99		
Dental-shortage area			**2.53**	1.42–4.50
Random effects (intercepts)	**σ^2**	**95% CI**	**σ^2**	**95% CI**
Child	2.17	2.05–2.31	4.06	3.14–5.25
School	0.07	0.04–0.14	0.18	0.05–0.64

Coefficients in bold are significant at .05. Models further adjusted for the period in which schools entered the study and total duration enrolled (effects not shown).
FRL, free or reduced-price lunch; IRR, incident rate ratio; OR, odds ratio; TOCE, total observed caries experience.

or reduced-price lunch in a school was associated with increased TOCE, and schools located in dental-shortage areas had significantly higher risks of untreated permanent caries. Furthermore, the effect of school-based caries prevention was moderated by school factors and significantly varied across schools.

Median odds ratios and median incident rate ratios in multilevel analysis are defined as the median values of the odds ratio and incident rate ratio between the area at highest risk and the area at lowest risk, and they reflect the added individual risk of the outcome

Table 4.
Interactions between Child and School/Community Factors and Caries Prevention Predicting TOCE.

	IRR	95% CI
Child		
Previous dental care	**0.89**	0.87–0.91
School and community		
Standardized FRL	**0.96**	0.92–0.99
Percent black/Hispanic	0.98	0.95–1.01
Dental-shortage area	1.01	0.99–1.02

Coefficients in bold are significant at .05.
FRL, free or reduced-price lunch; IRR, incident rate ratio; TOCE, total observed caries experience.

Table 5.
Multilevel Mediation Results of Caries Prevention and Total Observed Caries Experience through Child Age at Examination.

	β	95% CI
Indirect effects	**0.04**	0.01–0.07
Direct effects	**0.46**	0.38–0.53
Total effects	**0.49**	0.41–0.56

that can be expected when an individual moves to higher risk areas (Larsen and Merlo 2005; Merlo et al. 2006). In this study, the MOR and MIRR estimates for the median case were equal to 1.24 and 1.17, respectively. Thus, school-level residual heterogeneity can increase the odds of untreated dental caries by 1.24 and the incident rate of total caries by 1.17. In other words, moving to a school with a higher probability of untreated caries can increase the individual risk of caries by 24%. When stratified by dentition type, the incident rate for TOCE would be expected to increase by 36% for caries in permanent teeth and 17% in primary teeth. While these effects are modest, residual heterogeneity for study outcomes are comparable in magnitude to other child and school/community effects and are thus relevant to understanding variation in the risks of tooth decay.

In educational and psychological research, the school or community environments are often found to influence the effects of academic or psychosocial interventions (Conduct Problems Prevention Research Group 2010; McCormick et al. 2015). In particular, the community context, such as demographic characteristics and economic conditions, can influence how community-based programs are implemented and assessed (Kegler et al. 2011). Notably, much of the existing research on school-based caries prevention has not considered the potential impact of the school or community environment (Devlin and Henshaw 2011; Monse et al. 2012; Muller-Bolla et al. 2016). School factors such as administrative culture or teacher buy-in, for example, can result in greater student participation rates. Alternatively, the overall distribution of race and socioeconomic status or the unequal variability of dental and medical services in the surrounding community could influence the effects of caries prevention programs. Thus, understanding the characteristics of the surrounding school and community environment can yield more realistic expectations of the anticipated impact of caries prevention.

This study showed that children who attended schools with high populations of students from low socioeconomic backgrounds or lived in areas with a shortage of community dental providers were associated with increased risks of untreated caries. This finding is in concordance with other research into child dental health (US Department of Health and Human Services 2000; Naughton 2014; Piovesan et al. 2014; Schwendicke et al. 2015). In addition, random effects for baseline caries prevalence and prevention over time were statistically significant across schools, which remained significant following adjustment for potential school-level confounders such as race/ethnicity and socioeconomic status. These findings suggest that variation in the effects of school-based prevention may depend, in part, on other unknown child, school, or community variables. Further study of the potential causes of this variation can help understand the anticipated benefits of school-based caries prevention.

For children receiving prevention, the rate of change in total observed caries experience over time was lower if they presented at baseline with evidence of receiving previous dental care (e.g., sealants present or evidence of having received a restoration). While previous care could be a proxy indicator for socioeconomic status (e.g., access and ability to pay for care), this may also reflect an added benefit of prevention for children who have previously had dental caries and could suggest a potential cumulative effect over time. Furthermore, the rate of change in TOCE over time was significantly reduced in schools receiving caries prevention if they had larger populations of low socioeconomic status (SES) students. This suggests that prevention may reduce or offset the effect of low SES on dental health over time, particularly as the proportion of low SES children within a school increases, which may contribute to overcoming socioeconomic disparities in oral health. When considering the implementation of a school-based caries prevention program, clinicians, policy makers, and school administrators should thus consider these larger school and community contexts when setting goals and standards determining what constitutes program effectiveness.

Despite a significant mediating effect of child age on the relationship between prevention and the total observed caries experience, most of the overall effect was still directly attributable to prevention itself. While there may be differential treatment effects by age, it can thus be assumed that effects of school-based prevention are directly experienced, regardless of age level of the child.

There are a number of limitations with this study. First, while analysis used the best available measures for school and community factors, variables such as school-level race/ethnicity and socioeconomic status were aggregated at the school level and are not as explanatory as individual-level data would be. The remaining significant variation in baseline caries is further evidence that there may be other unmeasured confounders relevant to understanding oral health inequities. There are also unresolved questions as to the mediating effects of low SES and race/ethnicity. Due to methodological limitations in the presented analysis, these higher-level school and community variables could not be explored as potential mediators of the effects of prevention on dental caries. Future studies on school-based caries prevention should collect student-level demographic data to support a more robust mediation analysis. Finally, data for this study were derived from an open longitudinal cohort where all participating children with informed consent received care. As such, there was no control group, and student participation rates were modest. As this study was primarily concerned with the interrelationship between school-based care, oral health, and the school and community environment, this is a minor limitation. However, results would be strengthened by adding in different types of caries prevention programs, which would also provide greater variation in school and community variables.

Conclusion

The effectiveness of school-based caries prevention in preventing childhood caries in part depends on a complex interrelationship between existing child inequities in oral health, the school, and the community. Future research should continue to explore the effects of alternative individual, school, and community variables and incorporate data from multiple caries prevention programs.

Author Contributions

R.R. Ruff, contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript; R. Niederman, contributed to conception, design, and data acquisition, critically revised the manuscript. Both authors gave final approval and agree to be accountable for all aspects of the work.

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References

Albert DA, McManus JM, Mitchell DA. 2005. Models for delivering school-based dental care. J Sch Health. 75(5):157–161.

Australian National Health and Medical Research Council. 2007. National Health and Medical Research Council (Australia) review of the efficacy and safety of fluoridation [accessed July 7, 2017]. https://www.nhmrc.gov.au/guidelines-publications/eh41.

Cakar T, Harrison-Barry L, Pukallus ML, Kazoullis S, Seow WK. 2017. Caries experience of children in primary schools with long-term tooth brushing programs: a pilot Australian study. Int J Dent Hyg. [epub ahead of print 26 Mar 2017] in press. doi: 10.1111/idh.12275.

Center for Health and Health Care in Schools. 2012. School-based oral health services: a select bibliography [accessed July 7, 2017]. http://www.healthinschools.org/issue-areas/school based-dental-health/bibliography/#sthash.V5oQz04W.dpbs.

Conduct Problems Prevention Research Group. 2010. The effects of a multiyear universal social-emotional learning program: the role of student and school characteristics. J Consult Clin Psychol. 78(2):156–168.

Devlin D, Henshaw M. 2011. Improving access to preventive dental services through a school-based dental sealant program. J Dent Hyg. 85(3):211–219.

Dye BA, Li X, Thorton-Evans G. 2012. Oral health disparities as determined by selected Healthy People 2020 oral health objectives for the United States, 2009–2010. NCHS Data Brief. (104):1–8.

Dye BA, Thornton-Evans G. 2010. Trends in oral health by poverty status as measured by Healthy People 2010 objectives. Public Health Rep. 125(6):817–830.

Gooch BF, Griffin SO, Gray SK, Kohn WG, Rozier RG, Siegal M, Fontana M, Brunson D, Carter N, Curtis DK, et al. 2009. Preventing dental caries through school-based sealant programs. J Am Dent Assoc. 140(11):1356–1365.

Griffin SO, Regnier E, Griffin PM, Huntley V. 2007. Effectiveness of fluoride in preventing caries in adults. J Dent Res. 86(5):410–415.

Griffin SO, Wei L, Gooch BF, Weno K, Espinoza L. 2016. Vital signs: dental sealant use and untreated tooth decay among U.S. school-aged children. MMWR Morb Mortal Wkly Rep. 65(41):1141–1145.

Hiiri A, Ahovuo-Saloranta A, Nordblad A, Makela M. 2010. Pit and fissure sealants versus fluoride varnishes for preventing dental decay in children and adolescents. Cochrane Database Syst Rev. (3):CD003067.

Kegler MC, Rigler J, Honeycutt S. 2011. The role of community context in planning and implementing community-based health promotion projects. Eval Program Plann. 34(3):246–253.

Larsen K, Merlo J. 2005. Appropriate assessment of neighborhood effects on individual health: integrating random and fixed effects in multilevel logistic regression. Am J Epidemiol. 161(1):81–88.

Matsuo G, Rozier RG, Kranz AM. 2015. Dental caries: racial and ethnic disparities among North Carolina kindergarten students. Am J Public Health. 105(12):2503–2509.

Matsuyama Y, Aida J, Taura K, Kimoto K, Ando Y, Aoyama H, Morita M, Ito K, Koyama S, Hase A, et al. 2016. School-based fluoride mouth-rinse program dissemination associated with decreasing dental caries inequalities between Japanese prefectures: an ecological study. J Epidemiol. 26(11):563–571.

McCormick MP, Cappella E, O'Connor EE, McClowry SG. 2015. Context matters for social-emotional learning: examining variation in program impact by dimensions of school climate. Am J Community Psychol. 56(1–2):101–119.

Merlo J, Chaix B, Ohlsson H, Beckman A, Johnell K, Hjerpe P, Rastam L, Larsen K. 2006. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. J Epidemiol Community Health. 60(4):290–297.

Monse B, Heinrich-Weltzien R, Mulder J, Holmgren C, van Palenstein Helderman WH. 2012. Caries preventive efficacy of silver diammine fluoride (SDF) and art sealants in a school-based daily fluoride toothbrushing program in the Philippines. BMC Oral Health. 12:52.

Muller-Bolla M, Pierre A, Lupi-Pegurier L, Velly AM. 2016. Effectiveness of school-based dental sealant programs among children from low-income backgrounds: a pragmatic randomized clinical trial with a follow-up of 3 years. Community Dent Oral Epidemiol. 44(5):504–511.

Naughton DK. 2014. Expanding oral care opportunities: direct access care provided by dental hygienists in the United States. J Evid Based Dent Pract. 14(Suppl):171–182.e171.

Piovesan C, Tomazoni F, Del Fabro J, Buzzati BC, Mendes FM, Antunes JL, Ardenghi TM. 2014. Inequality in dental caries distribution at noncavitated and cavitated thresholds in preschool children. J Public Health Dent. 74(2):120–126.

Rabe-Hesketh S, Skrondal A. 2008. Multilevel and longitudinal modeling using Stata. 2nd ed. College Station (TX): Stata Press.

Schwendicke F, Dorfer CE, Schlattmann P, Foster Page L, Thomson WM, Paris S. 2015. Socioeconomic inequality and caries: a systematic review and meta-analysis. J Dent Res. 94(1):10–18.

US Department of Health and Human Services. 2000. Oral health in America: a report of the Surgeon General. Rockville (MD): US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health.

Williams R, Rogo EJ, Gurenlian JR, Portillo KM. 2017. An evaluation of a school-based dental sealant programme. Int J Dent Hyg. [epub ahead of print 24 Aug 2017] in press. doi: 10.1111/idh.12303.