Association Between Dental Caries and Socioeconomic Status Among One to Five-Year-Old Native American Children

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Abstract

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Background: The 2010 Indian Health Service (IHS) oral health basic screening survey (BSS) of oral health status for American Indian and Alaska Native (AI/AN) children ages 1 through 5 years nationwide found substantial differences in caries prevalence between different IHS service areas. The reasons for these differences are not well understood. Socioeconomic status (SES) may be a related factor, as it is well established that SES is a strong predictor of caries prevalence. However, it is possible that some IHS service areas have managed to achieve relatively low caries prevalence despite low SES.

Objective: This observational study examined associations between caries prevalence among preschool-aged AI/AN children and county-level SES to identify service areas in which caries prevalence was not well explained by SES.

Methods: Two sources of data were used for this study. Caries prevalence data among children ages 1 through 5 years from 76 study sites was drawn from the 2010 IHS BSS. Demographic, economic and social information describing the AI/AN population in the county for each of the 76 sites were selected from the American Community Survey. Associations between county SES

characteristics and study site caries prevalence were examined using correlation and linear regression analyses.

Results: Of the 76 study sites evaluated during the 2010 IHS BSS, caries outcomes and SES indicators varied widely. The percentage of children having experienced dental decay ranged from 14% to 88%, and percentage of children with untreated decay ranged from 0.5% to 74%. Percentage of decayed teeth overall ranged from 2.7% to 37.9%. Median annual income of the county ranged from $17,778 to $63,000; unemployment ranged from 6.4% to 32.9%, and percentage of the AI/AN population with a bachelor's degree ranged from 3% to 22.5%. Median income, unemployment, and educational all showed some correlation with caries prevalence. Linear regression analysis found that of the SES indicators studied, the SES indicator most predictive of caries prevalence was the percentage of the population having attained a bachelor's degree or a higher level of college education (part R^2 11% - 22%). Multivariate linear regression analysis adjusting for median income, % unemployment, and % bachelor's degree found that these three SES indicators taken together can explain 29% of the variation observed in percent of teeth with decay, 21% of the variation in any decay experience, and 16% of the variation in any untreated decay. For many study sites, caries prevalence was much higher or lower than what would be predicted based on SES indicators. Sites with the highest and lowest observed caries prevalence tended to also be the sites with highest and lowest observed-predicted values: the healthiest and least healthy areas remained the healthiest and least healthy even after accounting for SES.

Conclusions: Caries prevalence within the IHS BSS communities studied was not always well explained by SES, indicating that other factors may be contributing to caries prevalence. These

communities should be studied further to discover what factors may be more related to caries prevalence.

Table of Contents

page

List of Tables and Figures

I. INTRODUCTION

The 2010 Indian Health Service Oral Health Basic Screening Survey

The periodic Indian Health Service (IHS) basic screening survey (BSS) of oral health status for American Indian and Alaska Native (AI/AN) children ages 1 through 5 years (12-71 months) was conducted most recently in 2010. In 2010, the survey screened 8,461 AI/AN children in community settings at 63 IHS/tribal sites. It found that 54 percent of AI/AN children had decay experience, and 39 percent had untreated decay.[1] While these numbers represent nationwide averages, substantial variation in caries prevalence was found among the IHS service areas. For example, 85.9% of children in the Navajo area had caries experience, while 39.9% of children in the Oklahoma City area had caries experience.[1]

American Indian/Alaska Native children are at high risk of oral disease

AI/AN children have long been known to be at high risk for dental caries. A prior survey conducted from 1999-2002 found that more than 62% of AI/AN children ages 2-5 years had experienced dental caries compared with 42% of Mexican-American, 32% of African-American, and 25% of non-Hispanic white children.[2] A more recent study in 2007 found that the number of decayed and filled teeth (dft) was three times higher in AI/AN preschool children (mean dft=3.7) compared with the general US population (mean dft=1.2).[3]

Oral disease tends to begin at a very young age among AI/AN children. The 2010 survey found that by age two, 44% of AI/AN children already had dental caries.[1] A recent study that followed a cohort of 16-month old children from a Northern Plains Tribal community found that 31.9% had dental caries while an additional 29.3% had white spot (pre-carious) lesions.[4]

Impact of dental caries

Dental caries is a bacterial infection that transmits via saliva to other teeth in the same mouth as well as to other mouths, often from parents to children (vertical transmission)[5] or between children (horizontal transmission)[6]. When decay is not prevented or treated early, it can quickly spread and result in high rates of disease within a community.

Children are the most at-risk group to suffer from dental decay, are least able to care for their own oral health, and are least able to independently seek treatment. Dental caries is the most prevalent chronic disease currently affecting children worldwide.[7] Decay progresses quickly in primary teeth, which are softer and smaller than permanent teeth. Infections also spread quickly in children, both locally and systemically, and are deleterious to a child's development. In severe cases dental infections can be lethal.[8]

Untreated dental decay can become very painful and affect a child's health and quality of life. As dental infections grow, children become uncomfortable talking and breathing.[9] These children then have difficulty sleeping, concentrating, and learning.[9] Additionally, pain from dental caries results in decreased food intake, poor nutrition, limited growth, and impaired speech development.[9]

Poor oral health, especially dental caries, has been found to negatively impact children's school attendance and performance[10] and ability to engage in social relations.[11] Children suffering from dental caries experience chronic stress and depression, have reduced self-esteem, and are

reluctant to smile.[12-13] For adolescents, dental disease has been shown to be socially stigmatizing causing poor social acceptance.[14] The consequences are long-term: poor oral health during childhood and low SES during childhood have both been found to be predictors for poor adult oral health.[15]

Indian Health Service prevention efforts

The Indian Health Service (IHS) recognizes the impacts of high caries prevalence among AI/AN children and has implemented extensive prevention programs aimed at reducing caries prevalence among children. Among these is the Indian Health Service Early Childhood Caries (ECC) Collaborative. This is a national "multi-faceted program designed to enhance knowledge about early childhood caries prevention and early intervention among not only dental providers, but also all healthcare providers and the community."[16] IHS areas have their own Dental Support Centers (DSC) with experts who monitor local and site-specific programs. Objectives of DSCs are, for example, to "increase overall dental access, increase access for patients with diabetes, increase use of sealants, and increase use of topical fluoride treatments."[17] DSCs also assist programs with planning and evaluating Health Promotion/Disease Prevention (HP/DP) initiatives. One such local HP/DP program is the Puyallup Tribe's Early Childhood Caries prevention program, which follows mothers and children from pregnancy through early childhood with education and follow-up visits. Another HP/DP program is the Yellowhawk Tribe's Improving Access and Fluoride for Children ages 1-4.[18] Local efforts also include dental screenings and preventive services (fluoride and sealants) provided by clinic staff in community settings.

Indian Health Service (IHS) dental clinics serve about 56% of the AI/AN people in the United States. IHS services range from disease prevention efforts to treatment of disease by the clinics or by contracted providers when indicated. Health services in local facilities are available to all persons of AI/AN descent who belong to the local AI/AN community, and services are provided at no cost to eligible patients. Eligible patients include persons of AI/AN descent who are members, enrolled or otherwise, in an AI/AN Tribe or Group under federal supervision and who are residing within a service delivery area. A service delivery area usually encompasses the Reservation, trust land, and the counties that border the reservation.[19]

Despite national and local efforts of the IHS to reduce childhood caries, caries prevalence remains high and varies significantly between communities.[1] The reasons for these differences are not well understood, and may be related to socioeconomic status or other factors.

Dental caries and socioeconomic status

Dental caries is well known to have an inverse relationship with socioeconomic status (SES). Population groups with poorer SES tend to experience proportionately higher prevalence of dental caries.[20-21] The 2000 US Surgeon General's report on oral health highlighted this disparity.[22] The general definition of socioeconomic status takes into account the combination of income, education, and occupation/employment, as these factors tend to be interrelated. The association between SES and dental caries is especially strong in primary teeth.[23] Dental disease in children is better predicted by SES than by home care habits such as tooth brushing or extended use of a baby bottle.[24] A 2001 study of 6-7 year old children in Canada demonstrated that he relationship between dental caries and SES holds true even for a population with access

to publicly financed dental care.[25]

Study Aims

While SES might explain some of the variation in caries prevalence found between IHS communities, it is also possible that some IHS communities have managed to achieve relatively low caries prevalence despite poor SES. One aim of this study is to determine associations between community SES and caries prevalence for children in AI/AN communities, and which SES indicators are most predictive. Another aim of this study is to identify which, if any, communities were able to achieve lower caries prevalence despite having lower SES. These communities should be considered further to learn what factors are aiding in their success. Such information may help to guide future prevention efforts.

II. METHODS

Study Design

The study was an observational study using de-identified existing oral health data describing American Indian/Alaska Native children ages 1 through 5 years obtained from the 2010 HIS BSS and socioeconomic data describing income, employment, and education obtained from the American Community Survey. Approvals to conduct this study were obtained from both the University of Washington Institutional Review Board and the National Indian Health Service Institutional Review Board.

Oral Health Data

De-identified data from the 2010 Basic Screening Survey (BSS) was obtained from the Indian Health Service. The BSS screened 8,461 children ages 1 through 5 years from 76 study sites. The present study examines each of the 76 BSS study sites separately, even when multiple study sites exist for the same tribe. This approach differs from that of Phipps et al[1] who aggregated all sites for each tribe to create a total of 63 sites. These data contain the following information for each child screened during the 2010 BSS:

- Screening site (a community location such as a school or day care center)
- Age
- Gender
- Number of erupted teeth
- And the following measures of caries prevalence:
    - Number of decayed, missing, filled teeth (dmft)
    - Percentage of erupted teeth with a history of any decay
    - Whether a child had experienced any dental decay (yes/no)
    - Whether the child had any untreated dental decay (yes/no)

Socioeconomic Data

SES information for this study was obtained from the American Community Survey (ACS). The ACS is a nationwide survey conducted annually, beginning in 2005. It is designed to produce up-to-date demographic, social, economic and housing information for national and sub-national geography. It is integrally connected with the US Census 2010. ACS data are tabulated for a variety of different geographic areas and can be searched on the county level. ACS data is also

available for many different ethnic/racial groups and information about the AI/AN specific population for a county can be searched. For geographic areas with small populations, ACS 5-year estimates provide a more adequate sample size than single year estimates and increase statistical reliability. Five-year estimates include data collected over a 60-month period. Data from the ACS can be used as a reliable source for socioeconomic indicators.[24]

In the present study, socioeconomic (SES) data describing the American Indian/Alaska Native (AI/AN) population – specifically AI/AN alone or in combination with one or more other races – was obtained from the ACS for the county in which the screening site was located. Because IHS service delivery areas usually encompass the Reservation, trust land, and counties that border the reservation,[19] this study collected information based on counties as the defined geographical area. For screening sites that serve multiple counties, SES data were recorded for all relevant counties and the average was taken. For cases in which two study sites were located in the same county, the county data were used to describe each study site. The following SES data about the AI/AN population were obtained for each study site's county/area:

- Mean income
- Median income
- Percentage unemployment
- Percentage with a high school diploma or higher
- Percentage with a bachelor's degree or higher

Data Analysis:

Each of the measures of caries prevalence, as well as the average age and gender of the children screened, was summarized at the site level as a weighted mean using the sampling weights from the 2010 Basic Screening Survey (BSS). Associations between all measures of caries prevalence and the five SES variables were assessed using Pearson's correlation coefficient and linear regression. Standard errors and statistical significance were determined using methods for complex sample designs to account for the stratified and clustering sampling of the BSS. To facilitate the interpretation of the regression coefficient estimates, SES variables were mean centered and divided by the standard deviation among the sites. Hence, coefficient estimates for the SES variables indicate the predicted change in the caries outcome for a 1 standard deviation increase in the SES variable.

The results for dmft and percentage of decayed teeth were very similar, hence, only the results for percent decay are reported. Percent decay takes into account the number of erupted teeth, which is helpful for understanding the oral health of very young children with fewer teeth erupted. There was a strong correlation between the two SES variables mean income and median income ($r = 0.83$) and a moderate correlation between the percent of high school graduates and percent of bachelor's degrees ($r = 0.42$). In the final multivariate linear regression model mean income and percent of high school graduates were excluded, because median income and percent of bachelor's degrees showed stronger associations with caries prevalence. To identify sites where caries prevalence was not well predicted by the SES variables, the final multivariate linear regression was re-run omitting each site one at time and computing the difference between the observed and predicted caries outcomes. The ten sites with the largest over- and under-

predicted caries outcomes were identified and described. The data analysis was performed using IBM SPSS version 19 and SAS version 9.3 (SAS Institute, Carey, NC).

III: RESULTS

Data from two of the 76 study sites were excluded from analyses because one county lacked ACS SES data due to insufficient sample size in the county and one study site did not collect the same oral health data as the other study sites. After these two sites were removed, the total number of sites included in this study was 74 sites with a total of 8,271 children. The number of children screened at each site ranged from 13 to 425 with a mean of 111 children per site and standard deviation of 89. Breakdown of gender and age is described in Table 1.

The study sites showed a wide range in caries prevalence (Table 2) and in socioeconomic characteristics (Table 3). The percentage of children having experienced any dental decay ranged from 14% to 88%, and percentage of children with untreated decay ranged from 0.5% to 74%. The percentage of decayed teeth overall ranged from 2.7% to 37.9%. Median annual income of the counties ranged from $17,778 to $63,000; unemployment ranged from 6.4% to 32.9%; and percentage of the AI/AN population with a bachelor's degree ranged from 3% to 22.5%.

Median income and educational attainment (both high school and bachelor's degree) were significantly inversely correlated with all three measures of caries prevalence ($r = -0.30$ to -0.45). Percent decayed teeth and percent of children experiencing any decay increased with the age of the children screened ($r = 0.21$ and 0.38) and with the county's unemployment rate ($r = 0.34$ and

0.32), but children's age and county unemployment were not significantly associated with whether or not the child had untreated decay ($r = 0.16$ and 0.13; $p > 0.05$). (Table 4.)

Linear regression analysis results for each SES variables, adjusted for age and gender, are shown in Table 5. The strongest SES indicator for each of the caries indicators was the percentage of bachelor's degrees in a community (Part R^2, 11% to 34%). Median income was the second strongest SES indicator studied (Part R^2, 10% to 14%). The weakest SES indicator was mean income (Part R^2, 5% to 9%). SES variables tended to be more related to percentage of decayed teeth and percentage of children experiencing any decay than to whether the decay remained untreated.

After excluding the socioeconomic variables "mean income" and "% high school graduation", multivariate linear regression analyses adjusting for the three remaining SES variables together (median income, % unemployment, and % bachelor's degree) showed that, taken together, these three SES variables can explain 29% of the variation observed in percentage of decayed teeth, 21% of the variation in any decay experience, and 16% of the variation in any untreated decay. (Table 6.) Only the percentage of bachelor's degree remained significantly associated with all three caries outcomes in the multivariate regression models.

Regression analyses were re-run omitting each study site one at a time to identify which study sites' caries prevalence were farthest from those that would be predicted given their SES indicators. Table 7 summarizes the observed-predicted values. In Appendix A, Tables A1-A3 list the study sites with the observed-predicted values greater than 1 standard deviation above

and below the mean. This allows us to identify study sites that have higher or lower caries outcomes than would be predicted based solely on the SES factors considered in this study. Tables A4-A5 compare the study sites with highest and lowest caries prevalence before accounting for SES with study sites whose caries prevalence was farthest from what would be predicted based on SES. Many of the same study sites are on both lists, showing that the healthiest and least healthy areas remain the healthiest and least healthy even after accounting for SES. Figures 1A, 2A, and 3A show the distribution of observed caries prevalence compared with the observed-predicted values for the same measure of caries prevalence. The study sites with the lowest and highest observed caries prevalence are also the study sites whose caries prevalence is farthest from what is predicted based on SES. The healthiest and least healthy areas remain the healthiest and least healthy even after accounting for SES.

Figures 1B-D, 2B-D, and 3B-D show the distribution of observed caries outcomes compared with each SES variable. Caries prevalence was not well predicted by the SES of the study site, as sites with high or low caries outcomes are scattered across the SES spectrum.

IV: DISCUSSION

Caries outcomes often not explained by SES

The 2010 IHS BSS found high caries prevalence for AI/AN preschool aged children overall, but some of the IHS service areas exhibited much better oral health than others. The reasons for the disparities in oral health status between sites are not entirely understood, though to date the predominant assumption was that SES factors were mainly responsible.[1] After closer

examination of the BSS results and SES indicators, this study found caries prevalence at a number of IHS service areas was significantly higher or lower than what would be predicted based on SES. Even after accounting for SES, many of study sites with highest and lowest caries prevalence remained at the highest and lowest ends of the spectrum.

The findings of this study suggest that the caries prevalence experienced by AI/AN communities, while associated with SES to some extent, is often due to factors other than SES. Some communities experience lower caries prevalence despite poor SES indicators and some experience high caries prevalence despite high SES indicators.

Educational attainment strongest SES predictor of oral health

Of the SES indicators examined in this study, percentage of the population with a bachelor's degree was the strongest indicator of caries prevalence. Previous studies examining higher education and children's health also found that the education level of parents is predictive of children's health outcomes.[28] A 2006 study comparing education, income, and occupational class pointed out that each of these SES indicators relate to different causal mechanisms and each tends to predict different types of health outcomes.[29] The same study found that education is a stronger predictor of diabetes than is income, while income is a stronger predictor of mortality.[29] Given that education is strongly related to oral health related behaviors[30] and oral health related behaviors are a strong predictor of oral health status of children[31], prevention efforts focusing on continuing education of adults may be of value.

Alternative explanation for caries prevalence

While the IHS has implemented local and national efforts toward the prevention of dental caries, the type and implementation of these efforts varies widely. Clinics and prevention programs differ in their organization, methods, resources, and community involvement. For example, some tribes emphasize community outreach and education while some emphasize tribal leadership involvement in caries prevention meetings; some have school-based prevention programs, some have case manager model programs through early childhood. It is possible that some prevention efforts are more effective than others, which could account for greater reduction in caries prevalence for some communities. The specific prevention efforts of the more successful tribal sites should be studied further.

Limitations

SES factors for this study were taken from data for the county where the study site was located. Because IHS service delivery areas usually encompass the Reservation, trust land, and counties that border the reservation,[19] this study collected information based on counties as the defined geographical area. It is likely that most children screened during the 2010 BSS are residents of the county in which the study site was located. However, some IHS service areas extend beyond the county where the study site is located. SES values were not collected directly for each child studied from the 2010 BSS and it is possible that some of the SES data used in this study does not apply to each child screened during the 2010 BSS.

While the BSS and the ACS are both surveys meant to describe a population, they are not able to describe every individual in the population. While there is an inherent risk of error or

misrepresentation, both entities have made every effort to accurately describe their target populations.

Children screened during the 2010 IHS BSS were from a probability sample of IHS service units using a convenience sample of children from community settings within those service units. The number of children screened represented a total of 7% of the IHS user population of children ages 1 through 5 years.[1] While the population screened is a limited sample and the sampling error was not quantifiable, the IHS has no reason to believe that the remaining IHS population of that age group is any different from the screened population. [1] Variation in sampled numbers of children by service unit was addressed through analysis weighting but could still impact results from the BSS. [1]

The ACS acknowledges that errors, both sampling and nonsampling, are inevitable. The ACS makes every effort to improve data quality by recognizing and minimizing potential errors. A project of the US Census, the ACS conducts formal assessments to demonstrate that its data products meet the Census Bureau quality standards.[32]

This study accounts for SES but it does not account for other community-wide factors that may influence caries outcomes such as community water fluoridation. Fluoridation is difficult to account for on a county level because many counties are fluoridated in some water districts but not in others. It is difficult to determine which children in an area are exposed to community water fluoridation and which are not, making it impractical to account for water fluoridation in this study.

Next steps in research

Dental caries is a disease with many risk factors contributing to its prevalence. While SES is certainly a contributor to caries outcomes for children screened during the 2010 BSS, it is clear that other factors are influencing the oral health of AI/AN children. More research should be conducted to learn about those communities whose caries outcomes were farthest from what would be predicted from SES, especially those communities with lower caries prevalence than predicted. If it is found that prevention efforts in these communities are to credit for their success, these healthier communities can serve as examples for IHS oral health prevention efforts.

V: CONCLUSIONS

Caries prevalence correlated well overall with SES for most of the communities studied. However, some communities had caries outcomes much higher or lower than predicted based on SES indicators, indicating other factors than SES may be contributing to the caries prevalence. These communities should be studied further to discover what factors may be leading to their higher or lower caries prevalence.

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VII. Tables

Table 1: Age and gender of participants

		Gender			Age in years				
	Total	Male	Female	Unknown	Age 1	Age 2	Age 3	Age 4	Age 5
N	8271	4121	4127	23	865	1084	2344	2753	1225
%	100	49.8	49.9	0.3	10.5	13.1	28.3	33.3	14.8

Table 2: Measures of caries prevalence summarized at the site levels[1].

Measure of caries prevalence	Mean [SD]	Range
% Decayed Teeth[2]	17.5 [8.95]	2.7 – 37.9
% Any Decay Experience	53.2 [18.3]	14.0 – 88.0
% Any Untreated Decay	36.9 [15.3]	.05 – 74.0

[1]Each caries outcome was summarized at the site level as a weighted mean using the sampling weights from the 2010 Basic Screening Survey.
[2]Percentage of erupted teeth with a history of any decay

Table 3: Socioeconomic characteristics of the study sites.

	Mean [SD]	Range
Child's Gender (% Female)	51.3 [9.8]	23 – 76
Child's Age (years)	3.07 [0.41]	2 – 5
Mean Income (USD/year)	46,673 [13,854]	24,559 – 126,935
Median Income (USD/year)	35,772 [9,534]	17,778 – 63,000
% Unemployed	17.5 [6.1]	6.4 – 32.9
% High School Graduates	79.8 [7.2]	52.8 – 94.2
% Bachelor's Degree	12.2 [4.3]	3.0 – 22.5

[1]Gender and age was summarized at the site level as a weighted mean using the sampling weights from the 2010 Basic Screening Survey.

Table 4: Pearson correlation coefficients

	% Female (p-value)	Age (p-value)	Mean Income (p-value)	Median Income (p-value)	% Unemployed (p-value)	% HS graduate (p-value)	% Bachelor's degree (p-value)
% Decayed Teeth	.028 (.762)	.206** (.001)	-.283* (.025)	-.339* (.023)	.344** (.003)	-.301* (.032)	-.451** (<.001)
Any Decay Experience	.015 (.879)	.375** (<.001)	-.242* (.031)	-.316* (.013)	.317** (.001)	-.333** (.009)	-.324** (.002)
Any Untreated Decay	.042 (.667)	.165 (.379)	-.216 (.059)	-.291* (.021)	.127 (.290)	-.317* (.013)	-.317** (.007)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Linear regression results for the five SES variables against each caries outcome

Variables	% Decayed Teeth			Any Decay Experience			Any Untreated Decay		
	Regression Coefficient[3] [SE]	P-value	Part R^2	Regression Coefficient[3] [SE]	P-value	Part R^2	Regression Coefficient[3] [SE]	P-value	Part R^2
Age[1]	4.6 [1.3]	.001	4.3%	.17 [.032]	<.001	14.2%	.064 [.071]	.376	2.8%
Gender[1]	3.9 [9.0]	.667	0.1%	.074 [.18]	.682	0.2%	.085 [.145]	.563	0.3%
Median Income (SD)[2]	-3.3 [1.3]	.015	13.5%	-.069 [.023]	.004	14.0%	-.049 [.018]	.011	10.1%
Mean Income (SD)[2]	-2.6 [1.2]	.032	8.6%	-.049 [.022]	.032	7.2%	-.035 [.018]	.060	5.2%
% Unemployed (SD)[2]	3.2 [1.0]	.004	12.3%	.059 [.019]	.003	10.3%	.020 [.019]	.305	1.7%
% HS Graduate (SD)[2]	-2.7 [1.3]	.047	9.0%	-.062 [.028]	.029	21.3%	-.049 [.022]	.027	9.9%
% Bachelor's degree (SD)[2]	-4.3 [.84]	<.001	22.4%	-.067 [.016]	<.001	34.3%	-.051 [.017]	.003	11.0%

[1]With age and gender only in the linear regression model.
[2]Adjusted for age and gender.
[3]Regression coefficient estimate for change in the caries outcome for a 1 standard deviation increase in the SES variable.

Table 6: Multivariate linear regression results for selected SES variables against each caries outcome.

	% decayed teeth Regression Coefficient (SE)[1]	P-value	Any decay experience Regression Coefficient (SE) [1]	P-value	Any untreated decay Regression Coefficient (SE) [1]	P-value
Constant	1.16 (6.94)		-0.053 (0.116)		0.12 (0.20)	
Age (years)	5.5 (1.43)	<.001	0.19 (0.025)	<.001	0.08 (0.07)	0.214
Gender	-1.0 (8.51)	0.907	0.016 (0.166)	0.924	-0.02 (0.15)	0.889
Median Income (SD)	-1.1 (1.33)	0.407	-0.037 (0.025)	0.147	-0.04 (0.02)	0.047
% Unemployed (SD)	1.7 (0.92)	0.071	0.027 (0.018)	0.148	-0.01 (0.02)	0.514
% Bachelor's degree (SD)	-3.5 (1.03	0.001	-0.047 (0.022)	0.034	-0.04 (0.02)	0.042
Overall R^2	33.6%		35.6%		19.0%	
Part R^2 for SES variables	29.3%		21.1%		16.2%	

[1]Regression coefficient estimate for change in the caries outcome for a 1 standard deviation increase in the SES variable.

Table 7: Mean, standard deviation, minimum and maximum of observed-predicted values

	Mean	Standard Deviation	Minimum	Maximum
% Decayed Teeth	0.0	7.29	-18.2	14.98
% Any Decay Experience	0.1	14.68	-38.0	31.36
% Any Untreated Decay	0.1	13.73	-27.9	26.05

VIII. Figures

Figure 1: Plots showing observed mean of percent decayed teeth for each study site compared with: A) Observed-predicted percent decayed teeth for each study site, B) median income for each study site, C) percentage of the population with a bachelor's degree or higher level of education, and D) percentage of the population unemployed.

Figure 2: Plots showing observed mean of any decay experience for each study site compared with: A) Observed-predicted any decay experience for each study site, B) median income for each study site, C) percentage of the population with a bachelor's degree or higher level of education, and D) percentage of the population unemployed.

Figure 3: Plots showing observed mean untreated decay for each study site compared with: A) Observed-predicted untreated decay for each study site, B) median income for each study site, C) percentage of the population with a bachelor's degree or higher level of education, and D) percentage of the population unemployed.

Figure legend:

▲ Study sites with observed-predicted values >1 standard deviation above the mean, exhibiting more decay than predicted by SES.

○ Study sites with observed-predicted values within one standard deviation from the mean

▼ Study sites with observed-predicted values >1 standard deviation below the mean, exhibiting less decay than predicted by SES.

Figure 1

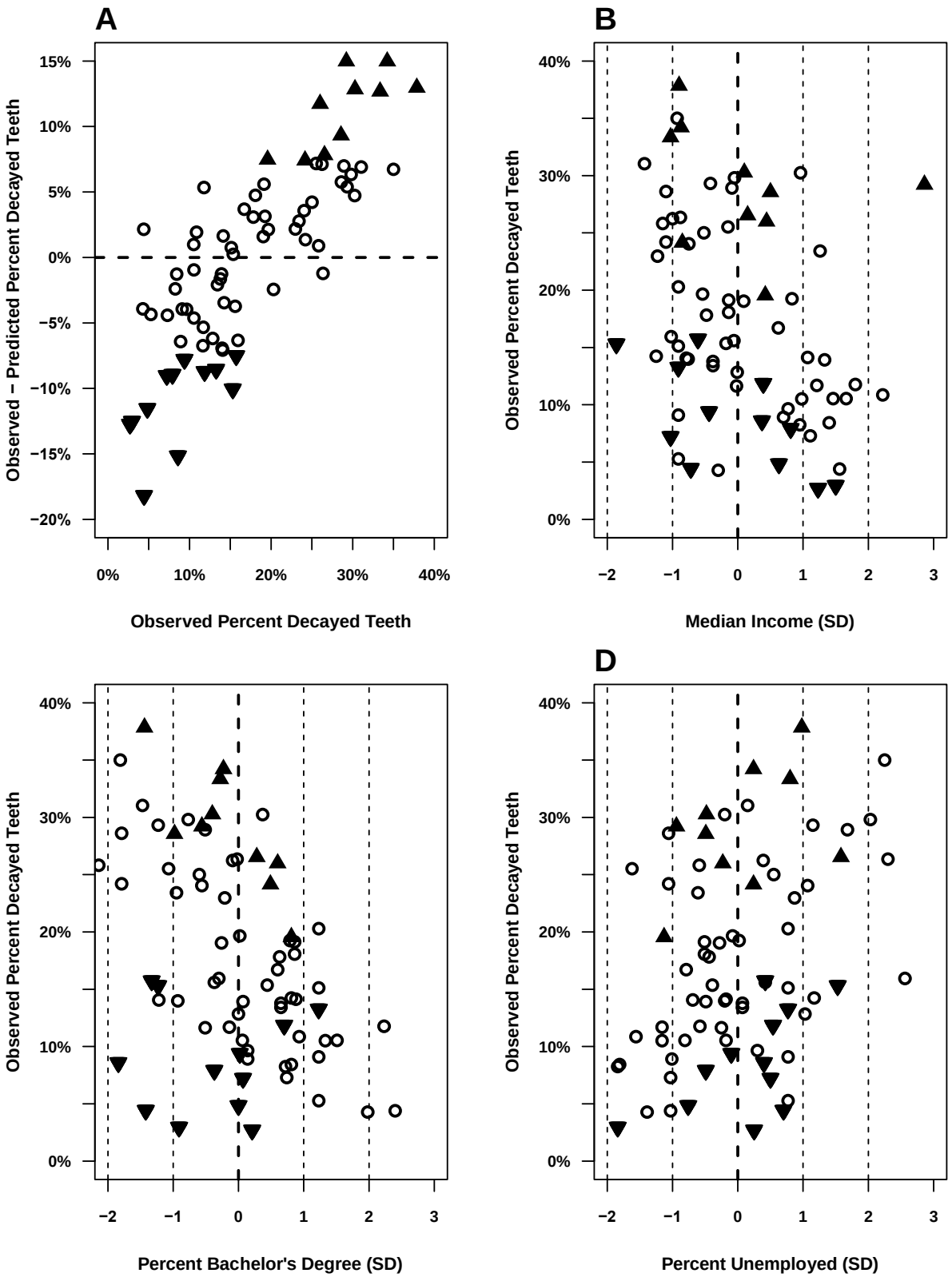

A
Observed − Predicted Percent Decayed Teeth
15%
10%
5%
0%
−5%
−10%
−15%
−20%
0%
10%
20%
30%
40%
Observed Percent Decayed Teeth
B
Observed Percent Decayed Teeth
40%
30%
20%
10%
0%
−2
−1
0
1
2
3
Median Income (SD)
Observed Percent Decayed Teeth
Percent Bachelor's Degree (SD)
D
Observed Percent Decayed Teeth
Percent Unemployed (SD)

Figure 2

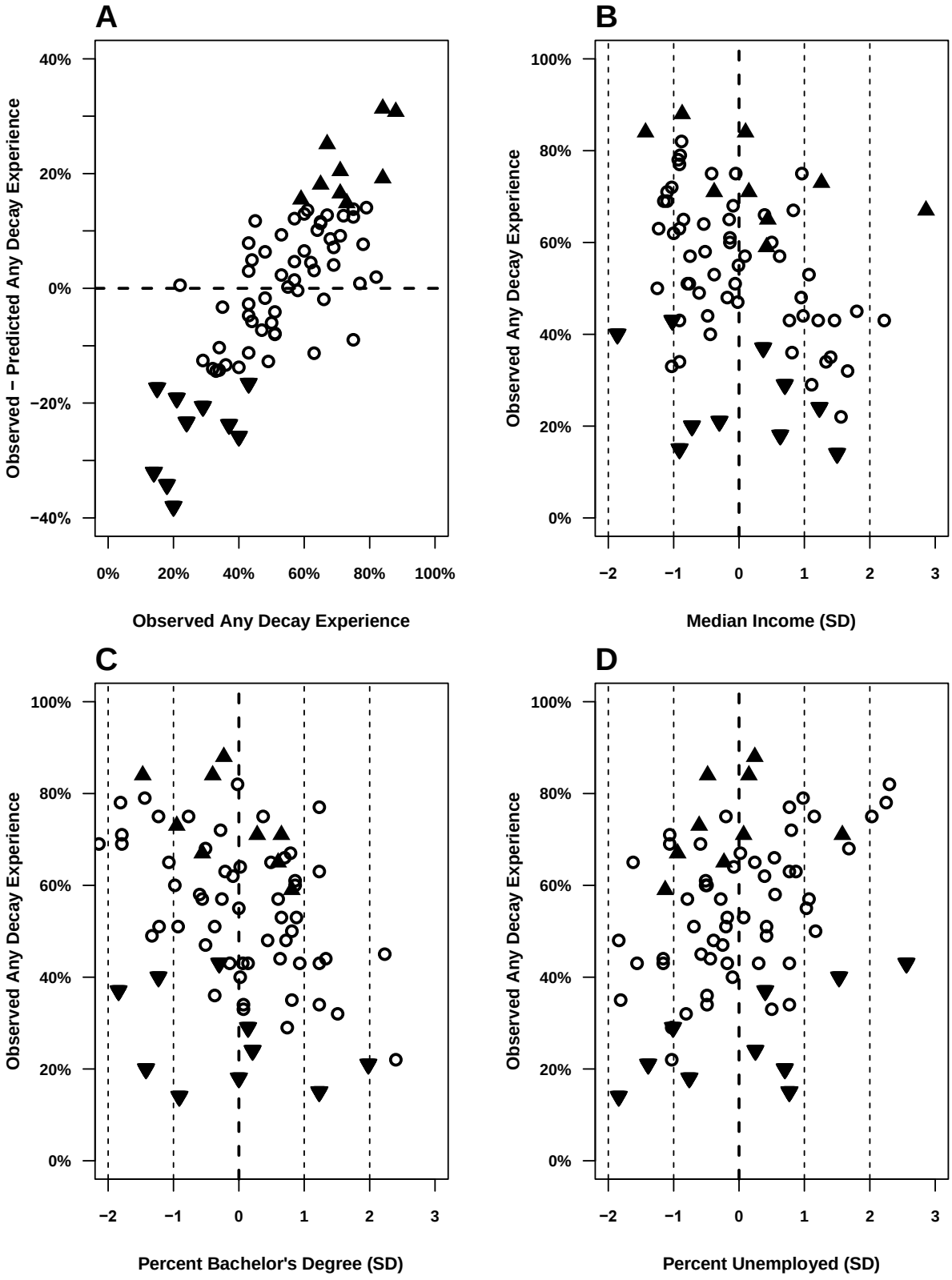
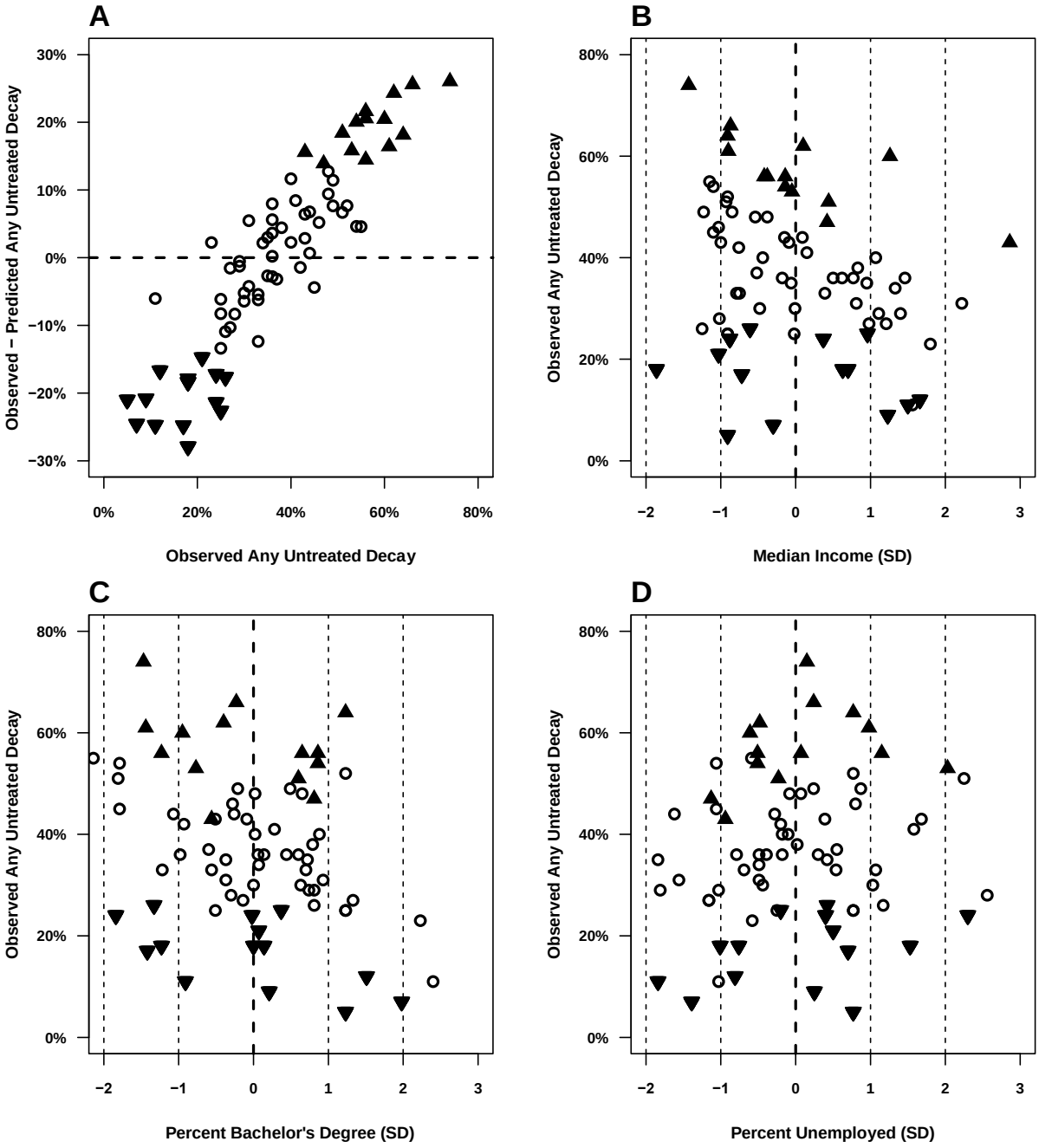

A
Observed − Predicted Any Decay Experience
40%
20%
0%
−20%
−40%
0%
20%
40%
60%
80%
100%
Observed Any Decay Experience
B
Observed Any Decay Experience
100%
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Median Income (SD)
C
Observed Any Decay Experience
100%
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Percent Bachelor's Degree (SD)
D
Observed Any Decay Experience
100%
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Percent Unemployed (SD)

Figure 3


A
Observed − Predicted Any Untreated Decay
30%
20%
10%
0%
−10%
−20%
−30%
0%
20%
40%
60%
80%
Observed Any Untreated Decay
B
Observed Any Untreated Decay
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Median Income (SD)
C
Observed Any Untreated Decay
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Percent Bachelor's Degree (SD)
D
Observed Any Untreated Decay
80%
60%
40%
20%
0%
−2
−1
0
1
2
3
Percent Unemployed (SD)

IX. Appendix

Table A1: Percent decayed teeth: study sites with observed-predicted values > 1 standard deviation from the mean (Observed-predicted values illustrated in figures 1A-D)

Percent decayed teeth – More decay than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % decayed teeth	Predicted % decayed teeth	Observed-predicted
4	63000	11.8	9.80	29.22	14.24	14.98
23	27317	18.9	11.2	34.23	19.25	14.98
29	26943	23.4	6.0	37.86	24.90	12.97
68	36606	14.6	10.5	30.28	17.43	12.85
36	25769	22.3	11.0	33.36	20.67	12.69
39	39797	16.1	14.8	26.00	14.26	11.75
72	40441	14.5	8.0	28.57	19.24	9.33
37	37083	27.0	13.4	26.55	18.73	7.82
52	39621	10.7	15.7	19.56	12.08	7.48
5	27500	18.9	14.3	24.16	16.74	7.42

Percent decayed teeth – Less decay than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % decayed teeth	Predicted % decayed teeth	Observed-predicted
31	28750	21.7	6.1	4.43	22.62	-18.19
74	39123	19.9	4.3	8.58	23.75	-15.17
14	47411	19.0	13.1	2.70	15.44	-12.74
17	50000	6.4	8.3	2.95	15.47	-12.52
53	41631	12.9	12.2	4.83	16.37	-11.54
54	17778	26.7	6.9	15.30	25.35	-10.05
26	25758	20.5	12.5	7.21	16.24	-9.03
30	43409	14.5	10.6	7.91	16.85	-8.94
25	39316	20.7	15.2	11.85	20.57	-8.72
21	26900	22.1	17.5	13.26	21.81	-8.55
42	31403	16.9	12.3	9.38	17.18	-7.80
13	29745	20.0	6.5	15.72	23.23	-7.51

Table A2: Percent with any decay experience: study sites with observed-predicted values > 1 standard deviation from the mean (Observed-predicted values illustrated in figures 2A-D)

Percent with any decay experience – higher than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % any decay	Predicted % any decay	Observed-predicted
68	36606	14.6	10.5	84	52.65	31.36
23	27317	18.9	11.2	88	57.22	30.78
4	63000	11.8	9.8	67	41.84	25.16
41	31956	17.9	15.0	71	50.53	20.47
10	21872	18.4	5.9	84	64.80	19.20
39	39797	16.1	14.8	65	46.91	18.09
37	37083	27.0	13.4	71	54.43	16.57
52	39621	10.7	15.7	59	43.50	15.50
27	47656	13.8	8.1	73	58.14	14.86

Percent with any decay experience – lower than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % any decay	Predicted % any decay	Observed-predicted
31	28750	21.7	6.1	20	58.02	-38.02
53	41631	12.9	12.2	18	52.22	-34.22
17	50000	6.4	8.3	14	46.07	-32.07
54	17778	26.7	6.9	40	65.81	-25.81
74	39123	19.9	4.3	37	60.75	-23.75
14	47411	19.0	13.1	24	47.34	-23.34
40	42330	11.4	12.8	29	49.60	-20.60
8	32781	9.1	20.7	21	40.16	-19.16
18	26900	22.1	17.5	15	32.37	-17.37
66	25809	32.9	10.9	43	59.58	-16.58

Table A3: Percent with any untreated decay: study sites with observed-predicted values > 1 standard deviation from the mean (Observed-predicted values illustrated in figures 3A-D)

Percent with any untreated decay – higher than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % any untreated	Predicted % any untreated	Observed-predicted
10	21872	18.4	5.9	74	47.95	26.05
23	27317	18.9	11.2	66	40.41	25.59
68	36606	14.6	10.5	62	37.66	24.34
69	34311	14.4	15.9	56	34.37	21.63
41	31956	17.9	15.0	56	35.43	20.57
27	47656	13.8	8.1	60	39.52	20.48
28	34311	14.4	15.9	54	33.94	20.06
39	39797	16.1	14.8	51	32.55	18.45
19	26900	22.1	17.5	64	45.86	18.14
29	26943	23.4	6.0	61	44.57	16.44
70	35104	29.7	8.9	53	37.16	15.84
4	63000	11.8	9.8	43	27.40	15.60
1	31581	24.4	6.9	56	41.53	14.47
52	39621	10.7	15.7	47	33.08	13.92

Percent with any untreated decay – lower than predicted						
Site number	Median Income	% Unemployed	% Bachelor's degree	Observed % any untreated	Predicted % any untreated	Observed-predicted
54	17778	26.7	6.9	18	45.92	-27.92
31	28750	21.7	6.1	17	41.80	-24.80
17	50000	6.4	8.3	11	35.75	-24.75
8	32781	9.1	20.7	07	31.57	-24.57
46	44800	16.3	13.8	25	47.66	-22.66
67	27167	31.3	12.1	24	45.40	-21.40
18	26900	22.1	17.5	05	26.02	-21.02
14	47411	19.0	13.1	09	29.84	-20.84
53	41631	12.9	12.2	18	36.40	-18.40
40	42330	11.4	12.8	18	35.88	-17.88
13	29745	20.0	6.5	26	43.67	-17.67
74	39123	19.9	4.3	24	41.22	-17.22
34	51466	12.6	18.7	12	28.69	-16.69
26	25758	20.5	12.5	21	35.76	-14.76

Table A4: Comparison of sites with caries prevalence >1 standard deviation above the mean before and after accounting for SES

Percent Decayed Teeth				Any Decay Experience				Any Untreated Decay			
Sites >1 SD above mean before accounting for SES	% decayed teeth	Sites >1 SD above mean after accounting for SES	% decayed teeth	Sites >1 SD above mean before accounting for SES	% with any decay experience	Sites >1 SD above mean after accounting for SES	% with any decay experience	Sites >1 SD above mean before accounting for SES	% with any untreated decay	Sites >1 SD above mean after accounting for SES	%with any untreated decay
29	37.86	4	29.22	23	88	68	84	10	74	10	74
75	35.00	23	34.23	10	84	23	88	23	66	23	66
23	34.23	29	37.86	68	84	4	67	19	64	68	62
36	33.36	68	30.28	67	82	41	71	68	62	69	56
10	31.04	36	33.36	29	79	10	84	29	61	41	56
68	30.28	39	26.00	75	78	39	65	27	60	27	60
46	30.24	72	28.57	19	77	37	71	69	56	28	54
70	29.81	37	26.55	46	75	52	59	41	56	39	51
1	29.32	52	19.56	70	75	27	73	1	56	19	64
4	29.22	5	24.16	1	75			51	55	29	61
15	28.92			27	73			28	54	70	53
16	28.61			36	72			76	54	4	43
72	28.57			41	71			70	53	1	56
37	26.55			37	71			21	52	52	47
				16	71						

For percent decayed teeth, six study sites remain >1 SD above the mean both before and after accounting for SES.

For percent with any decay experience, five study sites remain >1 SD above the mean both before and after accounting for SES.

For percent with any untreated decay, eleven study sites remain >1 SD above the mean both before and after accounting for SES.

Table A5: Comparison of sites with caries prevalence >1 standard deviation below the mean before and after accounting for SES

Percent Decayed Teeth				Any Decay Experience				Any Untreated Decay			
Sites >1 SD below mean before accounting for SES	% decayed teeth	Sites >1 SD below mean after accounting for SES	% decayed teeth	Sites >1 SD below mean before accounting for SES	% with any decay experience	Sites >1 SD below mean after accounting for SES	% with any decay experience	Sites >1 SD below mean before accounting for SES	% with any untreated decay	Sites >1 SD below mean after accounting for SES	% with any untreated decay
14	2.70	31	4.43	17	14	31	20	18	05	54	18
17	2.95	74	8.58	18	15	53	18	8	07	31	17
8	4.28	14	2.70	53	18	17	14	14	09	17	11
58	4.39	17	2.95	31	20	54	40	17	11	8	07
31	4.43	53	4.83	8	21	74	37	58	11	46	25
53	4.83	54	15.30	58	22	14	24	34	12	67	24
18	5.27	26	7.21	14	24	40	29	31	17	18	05
26	7.21	30	7.91	6	29	8	21	53	18	14	09
6	7.29	25	11.85	40	29	18	15	40	18	53	18
30	7.91	21	13.26	34	32	66	43	54	18	40	18
59	8.25	42	9.38	26	33	31	20	26	21	13	26
12	8.43	13	15.72	20	34					74	24
				32	34					34	12
										26	21

For percent decayed teeth, six study sites remain >1 SD below the mean both before and after accounting for SES.

For percent with any decay experience, seven study sites remain >1 SD below the mean both before and after accounting for SES.

For percent with any untreated decay, nine study sites remain >1 SD below the mean both before and after accounting for SES.