Associations of Ethnicity/Race and Socioeconomic Status with Early Childhood Caries Patterns

Walter J. Psoter, DDS, PhD; David G. Pendrys, DDS, Ph.D; Douglas E. Morse, DDS, PhD; Heping Zhang, PhD; Susan T. Mayne, PhD

Abstract

Objectives: *The purpose of this project was to evaluate ethnicity/race, household income and caregiver education level as predictors of 1) any early childhood caries, and 2) each of four proposed patterns of primary dentition caries.* ***Methods:*** *Between February 1994 and September 1995, five examiners visually examined Arizona pre-school children ages 5-59 months old. Self-reported demographic information including family income, caregiver education level and ethnicity/race were obtained at the time of examination. Multivariate analyses were conducted to assess the association of income, education and ethnicity/race with a child having any caries and with each of the proposed caries patterns seen in 3,850 examinations. Results: Income and education were inversely associated with: 1) any early childhood caries, and 2) the maxillary incisor caries pattern. A positive association between these caries patterns and minority ethnicity/race status was also identified. Three additional caries intraoral patterns demonstrated more varied associations with socioeconomic status (SES), ethnicity/race and income and education.* ***Conclusions:*** *This study supports the association of both ethnicity/race and social status with any early childhood caries. The patterns of caries were each found to be associated with specific and different socioeconomic-demographic indicators. The practical importance of these findings is that global measurement of ECC, without regard to specific caries pattern, leads to the potential for substantial non-differential misclassification of disease. The consequence of this is the potential for important ECC-SES-ethnicity/race associations to be masked. This, in turn, decreases the ability of surveys and investigations to accurately identify sub-groups of the population at greatest risk of developing ECC.*

Key Words: caries, caries patterns, primary dentition, ECC, early childhood, race, ethnicity, socioeconomic status

Introduction

The United States Surgeon General has stated that "dental caries is the most common chronic childhood disease" and that oral diseases represent "what amounts to a 'silent epidemic' affecting our most vulnerable citizens—poor children"(1). Caries in pre-school children, i.e. early childhood caries (ECC), has consistently demonstrated an inverse association with either mother's or family income (2). ECC has also exhibited tooth surface specific prevalences that differ in White, Black, Hispanic, and Chinese children (3). In addition, national and regional surveys have shown that the distributions of ECC varies by the ethnicity and race of the population under study (4-6).

ECC caries patterns have been proposed previously (7). Such patterns may reflect: 1) a spectrum of risk factors, 2) the effect of timing of exposure to risk factors, or 3) the effect of duration of exposure to these risk factors. Unbiased and precise risk estimates are dependent on valid and reliable case definitions (8). Four distinct patterns of ECC: 1) maxillary incisor caries, 2) occlusal caries of the 1st molars, 3) pit and fissure caries of the 2nd molars, and 4) smooth surface caries have been reported (9).

The purpose of this project was to evaluate ethnicity/race, household income and caregiver's education levels as predictors of 1) any early childhood caries ("any caries"), and 2) each of the four proposed ECC patterns in the primary dentition(9).

Methods

Study population. The sampled cohort of Arizona children and the methods of examination have been described elsewhere (5). Five examiners visually examined 5,171 Arizona pre-school children between February 1994 and September 1995. The children, 5-59 months old, were recruited from Head Start programs, WIC programs, health fairs and private day care centers. The private day care centers were localized in the Phoenix and Tucson areas, while other recruitment sites were located in these and 30 additional Arizona communities from the then six planning regions designated by the Arizona Department of Economic Security. The communities were stratified by population size for selection from the Arizona planning regions and each of the study communities had a minimum sample size of 25 children per age, year one through four.

Send correspondence and reprint requests to: Walter J. Psoter, DDS, PhD, Assistant Professor, New York University College of Dentistry, Department of Epidemiology & Health Promotion, 345 East 24th Street, New York, NY 10010. Phone: (212) 998-9217; Fax: (212) 995-4087. E-mail: wp9@nyu.edu. Dr. Psoter and Dr. Morse are affiliated with the New York University College of Dentistry, Department of Epidemiology and Health Promotion. Dr. Psoter is also affiliated with the School of Dentistry at the University of Puerto Rico, San Juan, Puerto Rico. Dr. Pendrys is affiliated with the University of Connecticut Health Center, School of Dental Medicine, Department of Behavioral Sciences & Community Health. Professor Zhang is affiliated with Yale University School of Medicine, Department of Epidemiology and Public Health, Division of Biostatistics. Professor Mayne is affiliated with Yale University School of Medicine, Department of Epidemiology and Public Health, Division of Chronic Disease Epidemiology. Manuscript received 7/05/04; returned to authors for revisions 1/14/05; final version accepted for publication 12/06/05.

Data collection. Caregivers reported demographic and socioeconomic (SES) information using a self-administered questionnaire that was available in English and Spanish. The demographic and SES variables included the child's gender, age, and ethnicity/race (Native American, Black, Hispanic, White (non-Hispanic), Other), as well as household income (< $10,000, $10-<20,000, $20-<30,000 and >= $30,000, 1994 dollars), and caregiver's highest education level (no high school, some high school, complete high school, at least some college). Complete information on the variables of tooth surface status, ethnicity/race, household income and caregiver's education was available for 3,850 subjects; this cohort was used for the primary regression analyses.

Dental caries was defined as a visual break in the enamel surface, pit and fissure discoloration with adjacent opacity, evidence of marginal ridge undermining, or anterior shadowing on transillumination. Paired inter-examiner caries reliability was good (kappa =0. 97); additional reliability assessment was not conducted. All tooth surfaces were classified as caries/sound, with caries originally having been scored as decayed, missing due to caries, or filled surfaces (dmfs).

Caries pattern determinations. The caries data were previously analyzed by multidimensional scaling analysis to detect any underlying data structure, i.e. caries patterns. The analyses suggested the following patterns: 1) maxillary incisor caries, 2) occlusal caries of the 1st molars, 3) pit and fissure caries of the 2nd molars (occlusal, mandibular facial pit and maxillary lingual surfaces), and 4) smooth surfaces, other than maxillary incisor caries. Each intraoral pattern was scored as present or absent for each subject, i.e. a subject could have none, one or several patterns (9).

Data analysis. The Chi Square statistic was used to test for potential differences in age (years) and gender between the analyzed sample with complete SES data and the subjects missing data for ethnicity/race, education or income. The correlation between household income and caregiver's education was assessed for potential multicollinearity in the subsequent modeling procedures, and are presented below.

Associations of the SES variables with the outcomes of interest, that is, each of the proposed intraoral patterns as well as with a child having "any caries," were determined using logistic regression. Unconditional multivariate logistic regression modeled each of the patterns or "any caries" as the dependent (dichotomous) variable regressed on the independent variables of ethnicity/race (entered as a dummy variable), income and education level (entered as dummy and ordinal, scored 1-4, variables). The models initially controlled for child's age (years), gender, number of erupted teeth, those caries patterns (dichotomized) other than the dependent variable pattern, and the interaction terms of age (years) by income, education, and each of the caries intraoral patterns exclusive of that pattern modeled as the current dependent variable. Additionally, a crown restoration variable (any crowns present or not) was used to assess whether the

TABLE 1
Descriptive statistics of the primary analysis sample and subjects with incomplete SES (ethnicity/race, education, income) data

		Analyzed Sub-Sample*			Sample Missing SES Data		
Age (months)		n	Mean	Std. Deviation	n	Mean	Std. Deviation
		3850	36.5	15.7	1,319	36.4	15.5
			N	%	N	%	chi-square¶
Age (years)	0		293	7.6	90	6.8	0.754
	1		743	19.3	252	19.1	
	2		715	18.6	262	19.9	
	3		947	24.6	329	24.9	
	4		1152	29.9	386	29.3	
	Total		3850	100.0	1319	100.0	
Gender	Female		1844	47.9	625	47.4	0.908
	Male		2004	52.1	693	52.5	
	Total		3848	99.9	1318	99.9	
	Missing		2	0.1	1	0.1	
	Total		3850	100.0	1319	100.0	
Ethnicity/race	N.A.†		196	5.1			
	Black		278	7.2			
	Hispanic		1731	45.0			
	White		1538	39.9			
	Other		107	2.8			
	Total		3850	100.0			
Education (highest grade of caregiver)	no HS‡		352	9.1			
	some HS		662	17.2			
	completed HS		1375	35.7			
	some college		1461	37.9			
	Total		3850	100.0			
Income (self-reported household income)	<$10,000		1898	49.3			
	$10-<20,000		990	25.7			
	$20-<30,000		437	11.4			
	>=$30,000		525	13.6			
	Total		3850	100.0			

NB. Percentages may not add to 100% due to rounding
* Complete ethnicity/race, income and education data.
† NA – Native American.
‡ (HS) High school.
¶ Chi-square probability between analyzed sample and subjects with incomplete SES data.

presence or absence of crown restored teeth confounded parameter estimates of the SES and ethnicity/race variables via a treatment effect. Age, SES and race/ethnicity variables, number of erupted teeth, caries patterns and age/pattern interaction terms were forced into the final models for all caries pattern analyses, regardless of their statistical significance.

In order to assess the possible influence of the missing data for the full population, the independent variables in the final model were reanalyzed utilizing imputed household income and caregiver education levels for subjects missing these data. To accomplish a degree of homogeneity for income and education within each of the recruitment site types was assumed.

Subjects without income or education data were assigned the rounded (up) grouped median for their recruitment site type. This resulted in an income level 3 ($20-<30,000) assignation for subjects recruited from private day care centers, and a level 2 ($10-<20,000) for all others. For education, subjects recruited from private day care centers were assigned a level 4 (at least some college) for education, and all others a level 3 (completed high school).

Additional models were constructed to analyze each ECC pattern, valued as present or absent only if at least one of the caries patterns' defining teeth were erupted, otherwise being scored as missing data. These models were limited to 2,674 cases with complete data. The excluded cases (due to missing data i.e. no erupted eligible teeth) included substantial numbers of primarily maxillary incisor pattern cases (50% of all such cases). Smooth surface and 1st molar patterns were additionally impacted, missing 28% and 47% respectively of their cases. This loss of cases was a function of: 1) the age range, i.e., the later erupting 2nd molars being present at only older ages, and 2) the models employed, i.e. forcing all patterns as dependent or independent variables.

Results

Demographics of the analyzed sample are presented in Table 1. Eighty-five percent of the analyzed sample were White (non-Hispanic) or Hispanic. Over 73% of the caregivers had completed high school or some college and 75% of the households had reported incomes of less than $20,000. Comparing the analyzed sample having complete SES data with those children missing data on ethnicity/race, education or income, neither age or gender distributions were statistically different. The mean age and standard deviations of both these groups were essentially identical (Table 1).

The Spearman rank correlation between income and education was r=0.406 (p≤0.001) before and 0.405 (p≤0.001) after controlling for child's age (years). Although significant, the limited correlation of 0.4 supported retaining both income and education in the regression models. Subsequent analyses demonstrated that the remaining SES parameter estimate (household income or caregiver's education) had no meaningful change when either education or income, respectively were removed from the logistic regression models.

The results of the final logistic regression models are presented in Table 2 for the "any caries" outcome and Table 3 for each of the four caries patterns. Gender and the interaction terms for age (year) by income and by education were not statistically significant and dropped from the models. No model demonstrated a statistically significant change in deviance when income and education were modeled as dummy variables compared to the models with these variables treated as ordinal values, i.e. there was no deviation from linearity. The final model treated these two variables as ordinal measures. The presence or absence of crowned teeth did not alter the results in terms of statistical significance or confound (a 10% or greater change in beta esti-

TABLE 2
Logistic regression adjusted* odds ratios and 95% confidence intervals for any childhood caries as a function of demographic variables among Arizona pre-school children

Any caries	Adjusted OR*	Adjusted 95% CI*
Age (year 1-4)	1.67	1.50-1.86
Income†	test for trend p=0.0009	
< $10,000 ¶	1	
$10,000-<$20,000	0.91	0.75-1.10
$20,000-<$30,000	0.56	0.42-0.76
≥$30,000	0.50	0.37-0.69
Education‡	test for trend p=0.0009	
no high school¶	1	
some high school	0.87	0.64-1.18
completed high school	0.77	0.58-1.02
some college	0.61	0.45-0.82
Number of erupted teeth	1.24	1.17-1.31
Ethnicity/race		
White¶	1	
Native American	3.57	2.50-5.09
Black	1.41	1.02-1.96
Hispanic	1.87	1.53-2.28
Other	1.94	1.19-3.18

*Each variable is adjusted for all of the other variables in the table.
†Caregiver's self-reported household income (< $10,000, $10,000-<$20,000, $20,000-<$30,000 and ≥ $30,000)
‡Caregiver's self-reported highest education level (no high school, some high school, completed high school, at least some college)
¶ Referent group

TABLE 3
Logistic regression adjusted* odds ratios and 95% confidence intervals for four hypothesized caries intraoral patterns as a function of demographic variables among Arizona pre-school children

Maxillary Incisor Caries	Adjusted OR*	Adjusted 95% CI*	Smooth Surface Caries	Adjusted OR*	Adjusted 95% CI*
Age (year 1-4)	0.96s	0.80-1.14	Age (year 1-4)	2.48	1.70-3.61
Income†	test for trend p=0.009		Income†	test for trend p=0.99	
< $10,000¶	1		< $10,000¶	1	
$10,000-<$20,000	0.87	0.67-1.11	$10,000-<$20,000	1.23	0.88-1.71
$20,000-<$30,000	0.49	0.31-0.77	$20,000-<$30,000	0.94	0.54-1.63
≥$30,000	0.37	0.22-0.63	≥ $30,000	0.89	0.50-1.58
Education‡	test for trend p=0.023		Education‡	test for trend p=0.009	
no high school¶	1		no high school¶	1	
some high school	0.94	0.65-1.36	some high school	0.59	0.35-0.98
completed high school	0.77	0.54-1.09	completed high school	0.56	0.35-0.88
some college	0.69	0.47-1.01	some college	0.48	0.29-0.79
Number of erupted teeth	1.2	1.13-1.29	Number of erupted teeth	1.01	0.89-1.16
Ethnicity/race			Ethnicity/race		
White¶	1		White¶	1	
Native American	3.23	2.06-5.06	Native American	0.95	0.54-1.69
Black	1.92	1.23-2.99	Black	0.53	0.29-0.97
Hispanic	2.14	1.61-2.84	Hispanic	0.62	0.43-0.89
Other	1.51-	0.75-3.04	Other	1.03	0.45-2.32
1st Molar Occlusal Surface			2nd Molar Pit & Fissure		
Age (year 1-4)	1.11	0.89-1.39	Age (year 1-4)	1.83	1.46-2.28
Income†	test for trend p=0.015		Income†	test for trend p=0.340	
< $10,000¶	1		< $10,000¶	1	
$10,000-<$20,000	0.83	0.62-1.11	$10,000-<$20,000	0.97	0.73-1.28
$20,000-<$30,000	0.85	0.55-1.34	$20,000-<$30,000	0.75	0.48-1.17
≥ $30,000	0.58	0.35-0.95	≥ $30,000	0.88	0.56-1.36
Education‡	test for trend p=0.236		Education‡	test for trend p=0.104	
no high school¶	1		no high school¶	1	
some high school	1.74	1.10-2.75	some high school	0.81	0.52-1.26
completed high school	1.58	1.03-2.41	completed high school	0.79	0.53-1.18
some college	1.56	0.99-2.45	some college	0.69	0.45-1.06
Number of erupted teeth	1.26	1.14-1.4	Number of erupted teeth	3.08	1.64-5.77
Ethnicity/race			Ethnicity/race		
White¶	1		White¶	1	
Native American	1.58	0.94-2.66	Native American	2.36	1.42-3.93
Black	1.14	0.69-1.89	Black	1.47	0.93-2.31
Hispanic	1.42	1.05-1.92	Hispanic	1.33	1.00-1.78
Other	1.43	0.69-2.95	Other	1.02	0.5-2.1

* Each variable is adjusted for all of the other variables in the table, caries patterns other than the dependent variable, and age-pattern interactions.
† Caregiver's self-reported household income (< $10,000, $10,000-<$20,000, $20,000-<$30,000 and ≥$30,000)
‡ Caregiver's self-reported highest education level (no high school, some high school, completed high school, at least some college)
¶ Referent group

mates) the risk estimates for ethnicity/race, income or education, and was not retained as a variable in the final models.

The risk of any childhood caries decreased as household income and caregiver education level increased, but the odds ratio is not large (Table 2). Compared to White children, all non-White children were at a statistically significant increased risk for any caries (odds ratios range from 1.4 to 3.6), after controlling for income and education levels. As would be expected, age and the number of erupted teeth were statistically significant and were modeled in all subsequent regression analyses.

Income, education and ethnicity/race results for the any caries pattern were duplicated by the maxillary incisor pattern with the sole exception of "Other" ethnicity/race, for which the risk was not statistically different from White (non-Hispanic) children (Table 3). Table 3 also shows that the other caries pattern types differed in terms of specific SES risk factors. Observed associations for the pattern of occlusal caries of the 1st molars were limited to decreased risk associated with factors of income (OR=0.58), and increased risk associated with His-

TABLE 4
Caries prevalence, stratified by caries intraoral pattern case definition, for N=3,850 subjects with complete ethnicity/race, household income and caregiver's education data (i.e., subjects included in primary analysis) compared with subjects with missing data (N=1,319), among Arizona pre-school children

Caries pattern	Subjects Analyzed (3,850),* n (%) with pattern	Subjects missing data (1,319),† n (%) with pattern	Chi square p-value
Any caries	1060 (28%)	415 (31%)	0.006
Maxillary incisor	579 (15%)	228 (17%)	0.052
Smooth surface	434 (11%)	161 (12%)	0.359
1st molar occlusal	590 (15%)	217 (16%)	0.33
2nd molar pit & fissure‡	621 (16%)	237 (18%)	0.12

* Subjects analyzed in primary analyses.
† Subjects excluded from primary analysis due to incomplete ethnicity/race, income and education level data.
‡ i.e. occlusal, maxillary lingual surface, and mandibular facial surfaces

panic ethnicity (OR=1.42), with a non-

sample reflects the outcome distribu-

ginally stronger (OR= 1.42) and statistically significant (p=0.007).

The revised caries pattern assignment, i.e. a subject's data were "missing" for any pattern not having eligible teeth erupted (n=2,674), likewise produced identical results to the primary analyses. The sole exception for these replicate analyses was that being Black was no longer associated (negatively in the primary analysis) with the smooth caries pattern.

Summary and Discussion

The findings of this study are generally consistent with the findings of others, which have reported an increased risk for primary dentition caries associated with lower socio-economic status, as well as differential and the association remained unchanged with the inclusion of crowned teeth as a variable in the model, which if differentially distributed, would create an artificial increase in apparent smooth surface caries. Further studies will be needed to clarify the underlying reasons for this finding, including culturally specific health practice and their relationship to ECC.

The strengths of this study were the large sample size, caries prevalence (27.5% of the analyzed sample) and SES diversity. The modeling used for this project was an additional strength. Specifically, two potential problems were addressed. First, the fact that caries patterns are not necessarily independent from one another was taken into consideration by incorporating those patterns that were not the outcome of immediate interest into the model. Secondly, because each of the caries patterns is age dependent, the eruption age distributions result in pattern probability differences that vary by age. The models used in this project attempted to adjust for these two concerns by introducing three controlling variables. The number of teeth present is reflective of the potential to have specific caries patterns, as was age. Therefore, both of these two variables were modeled to incorporate a potential lag period expected between tooth eruption, risk exposure, and the diagnosis of caries. Additionally, a third set of controlling variables forced into the models were age by pattern interaction terms.

An additional strength was the inclusion of two secondary analyses. The presence or absence of a given caries pattern was reclassified as present, absent, or missing due to no eligible erupted teeth, and imputed income and education values for those cases missing such data were modeled. Each replicate secondary analytic approach duplicated the primary analyses results for all but one variable in one model.

Several limitations should be considered. The study was cross-sectional. One result of this is that untreated lesions may have progressed to involve multiple surfaces that would not be observed if treated at an earlier stage. Further, posterior proximal caries were clinically and not radiographically diagnosed, likely leading to an underestimate of proximal surface caries, classified in the smooth surface pattern. This underestimate would be significant only if there was a differential detection of smooth/proximal lesions between ethnicity/race groups, income, or education levels, or if underestimation caused a decreased power to detect a difference. Additionally, treatment, specifically crowns and occlusal-proximal restorations, may incorporate non-carious as well as carious surfaces, leading to some pattern misclassification.

Differential dental treatment related to the SES factors considered in this study would have influenced the results. This would result in an overestimation for the group(s) having higher treatment rates by the potential misclassification of non-carious as carious for posterior smooth surfaces. US data have revealed differential treatment associated with social-economic status and ethnicity/race (13, 14). However, the children whose data were analyzed in this study had little treatment regardless of SES or ethnicity/race (5). Three-way ANOVA, utilizing Tukey's multiple comparison procedure, failed to demonstrate a statistically significant difference in the individual decayed surfaces/dmfs ratio values associated with income or education (15). Notably, the results were not affected when the analysis controlled for the presence or absence of crown restorations.

The high kappa (0.97) for caries prevalence reflects general broad examiner diagnostic agreement and may not reflect specific agreement when applied to caries patterns, thus some degree of misclassification may have resulted. Fluoride exposure data were not available. The inability to include this important exposure in the analyses reinforces the need for caution in the interpretation of these findings. The data regarding ethnicity/race, household income and caregiver's education were obtained using a self-administered questionnaire, and this resulted in incomplete data for some subjects. Income is a particularly sensitive subject (16), and this was likely exacerbated by the fact that subject recruitment sites included WIC and Head Start programs with income eligibility criteria. This categorization, while conducive to more accurate data at generalized levels(16), causes some loss of measurement precision in the analyses, as well as a degree of misrepresentation, if not mis-classification.

Household income and caregiver's education levels may additionally be misclassified relative to caries initiation due to the cross-sectional study design employed. A caregiver's relative current income and education level may not be the same as they were at the time of a particular caries pattern initiation. This issue would apply primarily to the later age-years of children, and be particularly important if there is a lack of independence between patterns, i.e., an earlier pattern being a risk factor for a later pattern. Additionally, education levels are reflective of the caregiver and not of the household, which may include a differently educated adult. The potential misclassifications and loss of measurement precision for income and education may have resulted in residual confounding, being reflected in the ethnicity/race parameter estimates, but would likely lead to an underestimate, not an overestimate, of the effect of income and education themselves.

The findings of this study suggest that while the ECC seen in young children occurs in specific patterns, household income and caregiver education are not universally associated with all of these ECC patterns. While some ECC patterns may be associated with both of these socioeconomic indicators, other patterns were associated only with one or neither of these indicators, and differences in patterns were differentially associated by race-ethnicity. The practical importance of these findings is that global measurement of ECC, without regard to specific caries pattern, looks to invite the potential for substantial non-differential misclassification of disease (i.e., mixing apples and oranges so to speak). The consequence of this is the very real potential for important ECC-socioeconomic-ethnicity/race associations to be masked. This, in turn, decreases the ability of surveys and investigations to accurately identify sub-groups of the population at greatest risk of developing ECC. These findings may therefore be helpful to public health planners wishing to be certain that vulnerable population subgroups at highest risk for ECC are not overlooked.

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