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Relationship of microbiological, social, and environmental variables to caries status in young children

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Abstract

This study was undertaken to investigate the significance of social, environmental, and biological variables in relation to caries status in a group of young children, and to determine whether incorporating data on social and environmental variables into a multivariate model could improve the accuracy of a screening approach that relies solely on quantifying levels of salivary Streptococcus mutans. Data regarding fluoride status and sociodemographic characteristics were collected from the dental records of 89 children who ranged in age from 10–71 months, and who had been screened previously for S. mutans. Multivariate analyses (logit) revealed that the probability of having clinically or radiographically detectable caries was associated with 1) higher levels of salivary S. mutans, 2) residing in a single-parent household, 3) having suboptimal levels of fluoride in the drinking water and 4) not being covered by a dental insurance plan. The findings attest to the importance of considering social and environmental factors, in addition to biological variables, when evaluating caries status in young children.

Introduction

Dental caries remains a relatively common childhood affliction. Nevertheless, recent surveys of caries prevalence suggest that at any given point in time a sizeable percentage of children in the U.S. and in most Western countries do not exhibit clinical manifestations warranting restorative treatment (Glass 1982; National Institute of Dental Research 1988). Large clinical studies also have shown that caries is disproportionately distributed, such that 60% of all teeth requiring treatment are likely to be found in 20% of the child population (Bohannan et al. 1981).

The aforementioned observations have fueled interest in developing accurate yet practical approaches for identifying children with existing caries, as well as those at high risk for developing caries. Benefits of such approaches include: 1) improved accuracy of screening examinations conducted in nonclinical settings, 2) reduced childhood radiation exposure (particularly in those children who, without the use of radiographs, could be designated reliably as not having caries or not at high risk to develop caries), and 3) the ability to target special preventive programs to those at high risk for caries.

Based on evidence that *Streptococcus mutans* plays a central role in the initiation and progression of coronal caries (Loesche 1986), a key element in recent screening and risk assessment studies has been the development and testing of practical methods for determining *S. mutans* levels in saliva. Edelstein and Tinanoff (1989) recently reported that a modification of the *S. mutans* assay first described by Kohler and Bratthall (1979) showed a highly significant correlation ($P < 0.001$) between levels of salivary *S. mutans* and caries activity in a population of 200 young children. The *S. mutans* screening test demonstrated a high degree of sensitivity (0.93; i.e., 93% of those children who had clinical or radiographic evidence of caries had a positive test result); however, the specificity of the test was considerably lower (0.57; i.e., only 57% of those with no clinical or radiographic evidence of caries were correctly classified as caries-free). Given the prevalence rate of 0.30 in that sample (30% of the 200 children had clinically or radiographically detectable caries), the *S. mutans* test misclassified 32% of the children, with the majority being false positives.

The present study had two objectives; the first was to investigate the relative importance of social and environmental variables, as well as biological variables, in relation to caries status in young children. The second objective was to determine whether incorporating data on social and environmental factors into a multivariate model could improve the accuracy of a caries screening approach beyond the levels previously found with *S. mutans* testing alone.

Materials and Methods

The study sample was comprised of 89 of the 200 children who participated in the original screening trial conducted by Edelstein and Tinanoff (1989). Children presenting for an initial examination in the private practice of one of the authors (BE) were eligible for the study. The only exclusionary criterion imposed was that subjects could not have had any prior restorative dental care.

During the initial visit, each subject's saliva was sampled for *S. mutans* using a modification of the Kohler and Bratthall (1979) method. A sterile tongue blade was moistened with unstimulated saliva and then impressed onto the raised surface of a selective culture medium, mitis salivarius bacitracin (Gold et al. 1973). The innoculated plates were placed in plastic bags to which expired air was added to enhance environmental $C0_2$ and incubated at 35–37°C. After two days, the plates were visually inspected for the presence of bacteria morphologically resembling *S. mutans* (i.e., dark, discrete raised colonies) (Coykendall 1977). For the purposes of this study, the levels of *S. mutans* were recorded semiquantitatively as none, low (1–10 colonies per plate), moderate (11–100 colonies/plate), or high (>100 colonies/plate).

Additional data regarding social and environmental factors were obtained restrospectively from each child's dental record. Variables for which data were available included the children's ages, sexes, drinking water fluoride concentration, parents' marital and employment status, and whether they were covered by a dental insurance plan.

Logistic regression models (Cornfield et al. 1961) were used to assess the significance of the factors upon which data had been collected in relation to the probability of having clinically or radiographically detectable caries. Each child's sex, water fluoride status, parents' marital status (presently married or not), mother's employment status, and dental insurance coverage status were coded as dichotomous variables. *S. mutans* levels initially were coded as 0 (none), 1 (1–10 colonies/plate), 2 (11–100 colonies), and 3 (>100 colonies); subsequent analyses coded *S. mutans* levels dichotomously (i.e., 0 vs. ≥1 colony and ≤10 vs. >10 colonies).

Results

The sample demonstrated considerable heterogeneity with respect to sociodemographic characteristics and fluoride exposure (Table 1). Mean age (44.4 months) and caries prevalence rate (0.30) for this subsample of 89 youngsters were nearly identical to the respective values for the original sample of 200. Approximately 40% of the children exhibited no *S. mutans*-like colonies on the selective medium plates (Table 1). Roughly 20% exhibited 1–10 colonies; another 30% had 11–100 colonies; and the remaining 9% had more than 100 colonies per plate.

Table 1. Descriptive Statistics for Variables Considered in Caries Risk Assessment Models

Mean age in months (S.D.)		*44.4 (13.1)*
		Per cent
Percent female		52.8
Percent with fluoridated drinking water		70.0
Percent from single-parent households		10.1
Percent with mother at home		49.4
Percent with dental insurance		62.9
Percent with *S. mutans* levels of:	0	38.0
	1–10	21.0
	11–100	31.0
	>100	9.0
Percent diagnosed as having caries		69.7

N = 89.

Table 2. Logistic Regression Models Dependent Variable: Caries Status*

Independent Variable	*Model 1 Estimated Coefficient (P-value)*	*Model 2 Estimated Coefficient (P-value)*	*Model 3 Estimated Coefficient (P-value)*
Constant	1.22	1.14	1.79
S. mutans (4 levels)	1.28 (<0.001)	–	–
S. mutans (0/≥ 1 colony)	–	2.44 (0.004)	–
S. mutans (≤ 10/> 10 colonies)	–	–	3.10 (<0.001)
Single-parent household	2.06 (0.049)	2.44 (0.013)	2.36 (0.033)
Insurance coverage	−1.31 (0.049)	−1.13 (0.069)	−1.56 (0.036)
Fluoridated water	−1.12 (0.10)	−1.26 (0.049)	−1.14 (0.11)
Mother at home	0.90 (0.155)	0.88 (0.146)	0.96 (0.166)
Female	−0.22 (0.593)	−0.16 (0.872)	−0.38 (0.675)
Age	−0.02 (0.503)	−0.01 (0.643)	−0.02 (0.503)
Percent correctly predicted	85.4	82.0	83.1

N = 89.
(0 = No caries detected; 1 = Caries detected)

Table 2 shows the results of three logistic regression models. The only differences in the structure of the analyses was that in Model 1, *S. mutans* levels were coded semiquantitatively according to four categories (none, low, moderate, high), whereas in Models 2 and 3, *S. mutans* levels were coded dichotomously to reflect two possible diagnostic cutoff points (0 vs. ≥1 colony and ≤10 vs. >10 colonies, respectively). The estimated coefficients obtained from the logit models represent the log of the odds of being in a particular category (in this case, having or not having detectable caries).

Two variables were found to be associated significantly with caries status at an alpha level of 0.05, regardless of the method used to categorize *S. mutans* counts—those being the levels of salivary *S. mutans* and whether the child came from a single-parent household. Both factors were associated positively with having caries. Having access to fluoridated drinking water was significantly and negatively related to caries status at the 0.05 level when *S. mutans* was entered as either present or absent (Model 2); however, the relationship was not as strong in the other two models. Having insurance coverage was significantly and negatively associated with having caries in both Models 1 and 3 ($P < 0.05$), and nearly so in Model 2 ($P = 0.069$). When controlling for the other factors, the presence of the mother at home with the child did not constitute a consistent influence on caries status in this population. Likewise, the probability of having caries was not related to the age or sex of the youngsters in this study.

Overall, Models 1, 2, and 3 correctly predicted the clinical caries status of 85, 82, and 83% of the subjects, respectively. The respective figures for sensitivity and specificity for the three models were 85.0 and 85.5 (Model 1), 72.0 and 85.9 (Model 2), and 75.0 and 86.2 (Model 3).

Discussion

The multivariate logistic regression models resulted in improved performance in terms of screening young children for the presence or absence of caries as evidenced by the reduction in the misclassification rate from 32% in the previous trial (Edelstein and Tinanoff 1989) to 15–18% in the present study. This improved performance is consistent with theories regarding the multifactorial nature of caries and underlies the importance of considering social and environmental factors when assessing caries activity.

The sensitivity and specificity of the previous screening approach that relied solely on an assay of salivary *S. mutans* levels were shown to be 0.93 and 0.57, respectively (Edelstein and Tinanoff 1989). The multifactorial assessment models used in the present study resulted in a decrease in sensitivity to levels ranging from 0.72 to 0.85, depending on the model; however, specificity was increased to at least 0.85 in each case. Stamm et al. (1988) noted that to be useful, working assessment models of this nature should produce a sensitivity level of 0.75 or higher and a specificity level of at least 0.85. Model 1 in the present study exceeded those standards; Model 2 met them; and Model 3 was slightly below with respect to sensitivity. Thus the multifactorial assessment approach demonstrated acceptable performance as a screening method for identification of concurrent caries in this population.

Having demonstrated the utility of this approach for concurrent caries screening in a limited sample of young children, additional studies are planned to: 1) test the models in other populations to determine the stability and replicability of the results and 2) apply these and other models in a prospective manner to investigate their utility in assessing the risk for developing caries in children who are initially "clinically caries-free" at the time of screening. Related to the latter objective, it should prove interesting to determine whether those patients labeled "false negatives" using the present approach actually have caries at a subclinical level (i.e., not yet diagnosable by clinical or radiographic means) which may predispose them to develop more advanced caries in time.

Studies of this type are capable of highlighting statistical relationships among various factors (e.g.: social, environmental, and biological variables) and the presence or absence of disease. Because of their design and retrospective nature, they cannot in and of themselves establish causation nor can they definitively identify mechanisms by which etiological factors are related to the development of the disease. However, these types of exploratory analyses can 1) provide valuable insights into the importance of various factors, 2) help to generate or develop hypotheses regarding relationships among variables that subsequently can be tested, 3) suggest additional factors on which data should be collected. Thus they often serve as valuable initial steps in the research process.

Some of the relationships that are identified through these models may seem implausible or irrational at first glance. An example from the present study is the link between insurance coverage and caries status. Obviously, having insurance coverage is unlikely to play a direct role in the development of caries. However, upon further reflection, one might speculate that the observed relationship was due to children with insurance coverage receiving more preventive care at an earlier age (a testable hypothesis). While that suggestion might be true, it would not appear to be relevant in the present study since all children were examined at their initial

visit. It could well be that insurance coverage served as a proxy for the parents' socioeconomic status, a variable that was not assessed directly in this study but which could be examined in greater detail in future investigations.

Conclusions

The multifactorial screening approach described herein represents an improvement over an approach that relied solely on *S. mutans* assays. This new approach achieves acceptable levels of performance in screening for existing caries in a sample of young children. The results of this study demonstrate the importance of considering social and environmental factors in addition to biological variables when assessing caries activity in children.

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