Validation of a Simple Approach to Caries Risk Assessment

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Abstract

Objective: *This study examined the predictive validity of a simple subjective method promoted to dentists for assessing their patients' caries risk.* ***Methods:*** *Data from two large group practices that have used guideline-assisted caries risk assessment (CRA) for several years were analyzed retrospectively to determine the receipt of caries-related treatment following a CRA. Patient age and receipt of caries preventive treatment subsequent to the CRA were control variables in logistic regressions to determine the likelihood of caries-related treatment for low, moderate, and high risk groups.* ***Results****: Among 45,693 individuals in the two plans, those categorized as being at high caries risk were approximately four times as likely to receive any caries-related treatment as those categorized as being at low caries risk. Those categorized as at moderate risk were approximately twice as likely to receive any treatment. In addition, for those at elevated risk who required any treatment, the number of teeth requiring treatment was larger.* ***Conclusion****: The results of this study provide the first large-scale, generalizable evidence for the validity of dentists' subjective assessment of caries risk.*

Key Words: dental caries; caries risk assessment; dental caries incidence; dentist practice patterns

Introduction

Methods to assess the likelihood that an individual would develop one or more new caries lesions at some time in the future have been studied for more than three decades (1). A recent systematic review that considered only multivariate models of caries experience progression included 43 studies designed to identify risk predictors for future caries while excluding an additional 126 (2). However, it was not until the publication of a supplement to the Journal of the American Dental Association in 1995 that the practical application of the growing body of information concerning diverse risk indicators for dental caries was clearly explicated for practicing dentists (3). The supplement urged that caries be regarded as a "chronic, infectious multifactorial disease process," and that individuals be assessed routinely for the presence or absence of risk indicators for this process.

The supplement listed a variety of risk indicators to consider when assessing an individual's risk of dental caries, and suggested combinations of these indicators that might be suggestive of low, moderate, and high risk categories, but it did not present any computational method to combine and/or differentially weight the risk indicators. At about the same time that the supplement appeared, a small number of caries risk assessment systems designed to be applied clinically were described that incorporated computational approaches (4-8). Some of these systems were based directly on the results of multivariate modeling of caries incidence data (7, 8), while others used many of the same risk indicators, but they were weighted according to expert opinion (4-6). All but one of these risk classification systems called for an extensive variety of inputs, typically requiring salivary flow rates, *mutans* and/or *lactobacilli* counts, and formal diet histories in addition to results of clinical examinations of the teeth. All required arithmetic operations to produce a categorization score.

Until recently, none of the caries risk assessment systems described in the literature had been validated in clinical practice. In this context, validation means that the accuracy of the caries risk categorizations made at baseline are compared to actual caries experience determined through one or more follow-up examinations in a population other than that used to develop the predictive formula. Within the past few years, validation studies have been reported for two computational systems, the Cariogram system (9, 10), and the Dentprog system (11, 12). Both systems were effective in categorizing children, and in the case of the Cariogram, elderly adults, by the extent of future caries they would experience. However, these validity studies involved relatively small numbers of socially homogenous subjects and were performed using data collected during epidemiological studies and secondary analyses of clinical records. The practicality of using the systems in and the generalizability of these results to dental practice remain in question.

Indirect evidence from dental claims data suggest that practicing dentists may not employ caries risk assessment strategies in their practices (13, 14). The lack of early response to

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the growing number of recommendations to adopt this approach to caries management (15-17) may be due in part to the data requirements of the computational systems, which may represent barriers to their use by practicing dentists (18,19), or by the "vagueness" of the suggestions for implementation in the original journal supplement (20). However, a small pilot study of dentists' adoption of caries and periodontal risk assessment procedures indicated that following a brief introduction to the concepts of risk assessment presented in the journal supplement, dentists were able to assign their patients to risk categories (21). This study did not assess the accuracy of those assignments by longitudinal follow-up, but did find that patients assigned to elevated risk categories had received larger numbers of previous restorative procedures.

The validity of practitioners' subjective or non-computational caries risk assessments has not been directly tested. An early attempt to develop a caries prediction model found that the subjective opinion of the epidemiological examiners was as accurate as any other single predictor or combination of predictors (22). Dentists' apparent ability to assess caries risk subjectively was also indirectly supported by the validation studies of the Cariogram system, where dental academics and dental practitioners ranked a series of case subjects similarly to the model in terms of risk of caries (8, 23). In light of both the apparent ease of adoption of the non-computational approach to risk assessment (21) and the indirect support for the validity of dentists' subjective assessments (8, 22, 23), it seems appropriate to examine the predictive validity of dentists' assessments using the subjective method for assigning risk categorization. Two large group practices organized as HMOs in Portland, Oregon and Minneapolis, Minnesota had adopted caries risk assessment policies shortly after the publication of the journal supplement. The approach to assigning risk categories—the caries risk assessment (CRA)—was similar in both policies, and paralleled the approach outlined in the supplement, essentially leaving the categorization up to the practitioner, but offering guidelines for consideration. The purpose of this study is to examine the subsequent caries-related restorative experience of patients who received caries risk assessments in these practices to determine the predictive validity of dentists' subjective caries risk categorization.

Methods

To assess predictive validity, we tested the relationship between a patient's caries risk assessment score (CRA) and caries-related treatment procedures in a subsequent two-year period that started six months after the CRA. We examined this relationship among enrollees of the two dental plans described previously. Plan A is a group practice in a fluoridated community and Plan B is a group practice in a largely nonfluoridated area. Figure 1 summarizes the CRA guidelines employed at these two group practices.

We used the dental plans' administrative data for the analyses, which had the individual enrollee as the unit of analysis. Inclusion criteria were 25 years of age, receipt of a CRA during a specified reference period, and continuous enrollment in the dental plan for at least one year prior to the CRA and for at least 2.5 years following the CRA. One year of enrollment prior to the CRA ensured that sufficient time was available prior to the CRA to address any backlog of care that might have accumulated before enrollment in the plan. The 2.5 years enrollment requirement following the CRA provided time for any caries lesions detected at the examination linked to the CRA to be treated prior to the two-year observation period. Thus, caries-related treatment that occurred during the observation period presumably would be related to lesions that developed after the CRA, i.e., the caries activity the CRA attempts to predict.

For each patient a reference date was established, corresponding to the most recent CRA during the reference period. The reference period was different for the two plans, extending

FIGURE 1
Summary of caries risk assessment guidelines at the two sites

Caries Risk Assessment	Plan A Guidelines	Plan B Guidelines
Low Risk	No caries in the last 3 years	No active caries No or non-progressive incipient caries detected
Moderate Risk	Main criteria · 1 - 2 caries in the last 3 years · Cariogenic diet · Active Ortho Modifiers to be considered · Exposed root surfaces · Restoration with overhangs and open margins · Physical disability	Evidence of 1-5 lesions including: · Incipient caries requiring remineralization · Caries requiring restorative procedures
High Risk	3 or more lesions in the last 3 years Suboptimal fluoride Disease induced xerostomia Radiation induced xerostomia Medication induced xerostomia	Rapidly progressing caries or evidence of 6 or more lesions including: · Incipient caries requiring remineralization · Caries requiring restorative procedures

from 01/01/98 to 06/30/99 for Plan A and from 01/01/00 to 12/31/00 for Plan B. These dates assured that the CRA had been in use for at least two years, and hence was fully implemented at each site. The CRA score assigned (low, moderate, high) and patient age were recorded as of the reference date. Caries-related preventive treatment provided to the patient for the six-month interim period following the reference date was identified and recorded, as this treatment had the potential for influencing subsequent caries experience. At Plan A, preventive procedures were defined as in-office fluoride application, a prescription for fluoride, or a formal recommendation for a home-use fluoride product. At Plan B, preventive treatment was defined as the application of in-office fluoride. Following this six-month interim period all caries-related treatment procedures were identified and recorded for the two-year observation period. At Plan A existing diagnostic codes were used to identify those restorative, endodontic, and surgical procedures provided for a principal reason related to caries. At Plan B existing reason-for-treatment codes were used for the same purpose.

For patients at each risk level at each plan, we calculated the mean number teeth receiving one or more caries-related treatment procedures. Because these distributions were highly skewed, we also calculated the proportion of patients in a given risk level with any teeth receiving one or more caries-related treatment procedures. These analyses were stratified by receipt of any preventive treatment during the interim period. Finally, we used logistic regression models to estimate the odds of one or more teeth with a caries-related treatment procedure in the moderate and high-risk groups as compared to the low risk group while controlling simultaneously for the effects of age and receipt of preventive treatment. Due to our large sample sizes, odds ratios as small as 1.10 for Plan A and 1.06 for Plan B would be significant at an alpha level of .05 with a statistical power of .80, providing us with the ability to detect small effects.

Results

A total of 14,859 individuals from Plan A and 30,834 from Plan B were included in the analyses. Table 1 shows the distributions of these individuals by caries risk level for the two plans, with accompanying age and gender characteristics. The distributions across the three levels of CRA were different for the two plans with greater proportions of individuals at both the low risk and high risk levels at Plan A as compared to Plan B. The samples differed only slightly by age and gender, with Plan A enrollees being a mean of 0.76 years younger overall and comprising 1.8 % more females. These differences were more pronounced when only high caries risk patients are considered.

Table 2 shows the mean number of teeth with at least one caries-related procedure in the two-year follow-up period by risk level. These calculations are shown separately for those with and without preventive treatment during the interim period. Higher risk was associated with more teeth with caries-related procedures at both sites. For both patients with and without preventive treatment, those in the moderate risk group had approximately two times and the high risk group approximately five times more teeth with a caries-related procedure than those in the low risk group. Statistical tests of these differences were not performed as the distributions of the number of teeth with any caries-related procedure were highly skewed.

TABLE 1
Distribution of caries risk levels with age and gender, by plan

	Plan A			Plan B		
	n (percent)	mean age	percent female	n (percent)	mean age	percent female
Low CRA	8,992 (60.5%)	48.3	59.5%	16,913 (54.9%)	48.8	58.7%
Mod CRA	4,233 (28.5%)	52.2	57.0%	12,688 (41.1%)	52.6	54.3%
High CRA	1,634 (11.0%)	51.7	53.9%	1,233 (4.0%)	53.0	47.3%

TABLE 2
Mean number of teeth with caries-related procedures, by caries risk level

	Plan A	Plan B
	No Preventive Treatment	
Low CRA	0.24 (0.64)*	0.36 (0.85)
Mod CRA	0.53 (1.07)	0.71 (1.33)
High CRA	1.23 (2.03)	1.46 (2.43)
	Some Preventive Treatment	
Low CRA	0.32 (0.77)	0.65 (1.24)
Mod CRA	0.64 (1.17)	1.22 (1.83)
High CRA	1.43 (2.09)	3.66 (3.63)

* standard deviation

TABLE 3
Percent of individuals with any teeth receiving a caries-related procedure, by caries risk level

	Plan A	Plan B
	No Preventive Treatment	
Low CRA	16.8%	22.3%
Mod CRA	30.4%	34.7%
High CRA	44.8%	47.2%
	Some Preventive Treatment	
Low CRA	20.6%	34.1%
Mod CRA	34.5%	50.9%
High CRA	53.8%	79.1%

Table 3 shows the distributions by risk level of the percent of patients with any teeth receiving caries-related treatment during the observation period, again stratified by receipt of preventive treatment. Chi-square tests were applied separately to these distributions. The tests were significant for Plan A patients with and without preventive treatment(χ^2=303.96, df=2, p<.001 and χ^2=213.96, df=2, p<.001, respectively), and for Plan B (χ^2=859.25, df=2, p<.001 and χ^2=325.76, df=2, p<.001, respectively)

Logistic regression was used to determine if the relationship between CRA and presence or absence of caries-related procedures in the follow-up period remained after controlling for age of the individual and receipt of preventive treatment during the interim period. The models were significant for Plan A (χ2=1268.97, df=4, p<.001) and Plan B (χ2=1462.36, df=4, p<.001).

Table 4 presents the odds ratios for both plans. Those assessed as being at high caries risk were over four times more likely at Plan A and Plan B to have had a caries-related procedure in the follow-up period than those in the low risk group controlling for age and preventive treatment. Those in the moderate risk group were nearly two times more likely than the low risk group at both plans to have a caries-related procedure. An additional logistic regression predicting any caries-related procedures in the follow-up period was conducted with only those patients in the moderate and high caries risk groups to examine differences between the two plans in assignment to these risk levels. Caries risk level (moderate vs high), age and preventive treatment were included in the model. The model was significant at both sites; χ2=292.82, df=3, p<.001 for Plan A and χ2=314.70, df=3, p<.001 for Plan B. The odds ratios (Table 4) indicate that patients in the high caries risk group at both plans were slightly more than twice as likely than those in the moderate risk group to have a caries-related procedure in the follow-up period.

Discussion

The results of these retrospective analyses of caries risk assessments demonstrate convincingly that dentists using general risk assessment guidelines can categorize their patients into groups who will experience low, moderate, and high need for caries-related restorative treatment. It must be noted at the outset that this demonstration relies on two untested associations: first that the development of a caries lesion will lead to the provision of a restorative, endodontic, or surgical procedure indicated as needed due to caries activity; and second, that this caries-related treatment will be received promptly. We have confidence in the first assumption. The accuracy of the reason-for-treatment codes has been previously examined in one of the group practices and found to be good (24). However, there is no guarantee that the lesion associated with the treatment developed following the CRA. Although members of both HMOs tend to receive regular examination visits and follow-up care as needed, some proportion of that care may not be delivered within one year of enrollment, or within six months of a routine examination, as has been assumed in these analyses. Of course, that same delay in receiving caries-related treatment has the potential of reducing the amount of caries-related treatment recorded in the observation period. While use of HMO patient records presumably reduces financial barriers to prompt receipt of needed care, it certainly does not guarantee that all caries-related treatment will be prompt. For that reason we must regard the surrogate outcome of caries-related treatment as being a theoretically correct, but practically unproven substitute for formal assessment of caries incidence.

Another caveat should also be noted. We have validated the risk assessment against caries treatment re-

TABLE 4
Odds ratios for having at least one caries-related treatment procedure

	Plan A Odds Ratio	Plan B Odds Ratio
Mod vs. Low CRA	2.07 (1.98-2.26)*	1.83 (1.74-1.92)
High vs. Low CRA	4.61 (4.10-5.19)	4.07 (3.60-4.60)
High vs. Mod CRA (low not included)	2.20 (1.97-2.50)	2.22 (1.96-2.50)

* 95% confidence interval
Note: age and preventive treatment were included as covariates in the models

ceived, rather then caries incidence. While this is a realistic validation standard from the standpoint of patient and dental plan outcomes, it is quite possible that caries treatment received is not perfectly correlated with true caries experience. Three reasons for a possible degradation of this correlation might be inaccurate diagnoses, more aggressive application of subjective criteria for caries diagnoses among patients perceived as being at higher risk to caries, and differential treatment thresholds by risk level given an enamel caries diagnosis. Because we are not able to test for any of these effects, we have used the caries treatment outcome, and urge caution in extending our observations to caries incidence.

Support for validity of caries risk assessment comes not only from the increasing rates of teeth receiving treatment and patients with at least one tooth receiving treatment, but also from a consideration of the mean number of teeth receiving treatment among those patients needing any treatment within a caries risk group. From data presented in Tables 2 and 3, it can be calculated that the mean number of teeth receiving treatment in the low, medium, and high groups was 1.44, 1.83, and 2.67 in Plan A and 1.81, 2.29, and 4.10 in Plan B. Thus, not only are there fewer patients who experience caries-related treatment as the risk category lowers, but also, among those who receive any treatment, there are fewer teeth requiring such treatment as the risk category declines. Obviously, low risk doesn't mean zero risk; in this analysis, 17% and 22% of patients categorized as being at low risk in Plans A and B required treatment. But, as odds ratios from the logistic regressions demonstrate, in both group practices the likelihood of receiving caries-related treatment for the low risk group was about half of the likelihood for patients classified as being at moderate risk, and less than one-fourth of the high risk group.

We consider these results to be generalizable. They represent the risk assessments of 70 dentists in Plan A and 167 dentists in Plan B. Further, despite dissimilar overall caries-related treatment rates during the two-year observation period (Plan A=25.7%, Plan B=36.9%), the relative differences in these rates among the risk groups were similar (Table 4). Somewhat surprisingly, the stratified analyses (Tables 2 and 3) show that these differences were approximately the same among patients who did and did not receive any preventive treatment. Subsequent analyses will examine aspects of the effectiveness of the provision of preventive treatment by risk category. The distributions of patients across the three risk groups did differ somewhat between plans, however. Plan A dentists tended to categorize more patients as being at low or high risk (71.5%), and fewer at moderate risk (28.5%), than Plan B dentists (58.9% and 41.1%). The differences in these distributions may be related to both the difference in caries incidence in the enrolled populations and the differences in the guidelines employed for CRAs in the two group practices. Although at Plan A low risk criteria seem more restrictive, suggesting no caries lesions in the past three years, Plan B low risk criteria suggest exclusion of any patient with a white spot lesion, which may be prevalent in this non-fluoridated population. Plan B high-risk criteria are more restrictive, suggesting a minimum of six or more lesions, while Plan A criteria suggest half that many. The differences in these locally developed criteria may be a reflection of caries experience in the practices' patients. Both plans' experience in categorizing high risk patients is similar to that identified in a previous examination of the adoption of risk assessment in private practices, wherein a low and relatively narrow range of proportions of patient categorized as being at high risk of caries was observed (21).

This validation of a subjective approach to caries risk assessment should serve as a signal to practitioners and programs that are not currently categorizing their patients by risk that the procedure is reasonably accurate. However, risk assessment with accurate categorization is only the first clinical decision in an efficient and effective approach to caries prevention (25). If CRA is to be useful, patients' preventive regimens must be informed by the risk categorization, and appropriate preventive treatment, counseling, and recall frequencies identified and applied.

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