Assessing patients' caries risk

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Caries treatment remains one of the most common and important aspects of dental practice despite the dramatic decline in caries prevalence during the past 30 years.[1] Since 1960, the rate of edentulous adults has dropped 60 percent among people aged 55 to 64 years.[2] With more Americans keeping their teeth into their later years of life, treatment decisions geared toward preserving tooth structure with noninvasive and preventive interventions will need to be based on the patient's risk of developing caries to be most health- and cost-effective. While there is some research evidence of how to use single (especially previous caries experience) or multiple risk factors to predict caries in either primary or permanent teeth in children, there is little evidence from adults or the elderly to help guide practitioners on how to apply risk assessment models to adult populations.[3]

Historically, caries was thought to be a progressive disease that eventually destroyed the tooth unless the dentist intervened surgically. But the understanding of caries has changed markedly, and this change needs to be reflected in dental practice. In 2001, a National Institutes of Health (NIH) Consensus Statement recognized a paradigm shift in the management of caries. That consensus statement, based on the NIH-sponsored consensus development conference titled Diagnosis and Management of Dental Caries Throughout Life, identified a shift toward improved diagnosis of noncavitated, incipient lesions and treatment for prevention and arrest of such lesions.[4] Restorations repair the tooth structure, do not stop caries, have a finite life span and are susceptible to disease.[4]

This paradigm shift should reflect changes in the modern management of caries. These

ABSTRACT

Background. Caries management historically has focused on the removal of cavitated carious tissue and restoration of the tooth.

Overview. Assessing a patient's risk of developing caries is a vital component of caries management. A comprehensive caries assessment should consider factors such as past and current caries experience, diet, fluoride exposure, presence of cariogenic bacteria, salivary status, general medical history, behavioral and physical factors, and medical and demographic characteristics that may affect caries development. A caries risk assessment also should consider factors that may challenge the patient's ability to maintain good oral hygiene (for example, crowded dentition, deep fissures, wide open restorative margins or placement of oral appliances).

Conclusions and Practical Implications. The authors review the importance of caries risk assessment as a prerequisite for appropriate preventive and treatment intervention decisions and provide some practical information on how general practitioners can incorporate caries risk assessment into the management of caries.

Key Words. Dental caries; risk assessment; disease management.

JADA 2006;137(9):1231-9.

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changes should include the following:
- detection of carious lesions at an early (incipient, noncavitated) stage;
- diagnosis of the disease process;
- identification of all risk factors (including etiologic factors such as diet and bacteria and nonetiologic factors such as socioeconomic status);
- treatment planning that goes beyond caries removal and tooth restoration to include risk factor modification or elimination, arresting or reversing active noncavitated carious lesions, and preventing future caries.

This article discusses how general practitioners in private practice can incorporate caries risk assessment into the comprehensive management of caries in their patients.

CARIES RISK ASSESSMENT

Caries risk assessment determines the probability of caries incidence (that is, number of new cavities or incipient lesions) in a certain period.[5] It also involves the probability that there will be a change in the size or activity of lesions in the mouth. Most dentists likely incorporate into their practice some form of caries risk assessment based on their overall impression of the patient, which together with previous caries experience has been shown to have good predictive power.[6] It is unclear, however, how and if dentists systematically incorporate this information into their treatment decisions.[7] Bahleda and Fontana[8] randomly surveyed 250 dentists in Indianapolis about their use and formal recording of caries risk assessment and management strategies. The survey revealed that 72 percent of respondents performed some type of risk assessment, but only 27 percent of this group documented the outcome. Ninety percent of respondents assessed caries activity (the most commonly cited risk variable in this study), but only 5 percent of respondents assessed salivary flow by measuring volume or weight (the least common risk variable cited in this study). However, on diagnosing white-spot lesions in adults, only 51 percent of respondents provided a treatment or management plan based on the patient's risk status. This finding suggests that caries risk assessment was not incorporated into almost one-half of all patient treatment plans. The process of charting the results of caries detection, diagnosis and risk assessment, as well as informing patients about specific findings and their implications on treatment and prognosis, are as important for appropriate patient care and effective management of the caries disease process as is recording the proposed treatment plan and eventual treatment outcomes.

IMPORTANCE OF CARIES ACTIVITY IN CARIES DIAGNOSIS

The detection of frank cavitations in teeth requiring restorations has been a hallmark of dentistry. In contrast, modern caries management also focuses on the detection of incipient, noncavitated lesions and the practitioner's ability to diagnose whether those lesions are active. This diagnosis should be one of the guiding factors for caries risk assessment and management decisions. An active carious lesion progresses over time and requires management (remineralization or restoration). An inactive lesion may be visible either clinically or radiologically (like "scar tissue" that reminds us of past damage to the tooth), but it will not progress or change over time. In remineralized lesions, not only has the caries process been arrested, but also the affected area has experienced one or more of the following changes that signal remineralization: increased radiodensity, decreased lesion size, increase in mineral concentration, increased hardness and increased sheen as compared with a previously matte surface texture.[9] Arrested or remineralized lesions do not require intervention since they do not represent active disease, unless the lesions are so advanced that they interfere with oral function or esthetics.

Available data suggest that previous caries experience is a strong predictor of caries risk in people.[3,4,6] However, Zero and colleagues[3] suggested that determining caries activity may be a stronger predictor of caries risk than decayed, filled or missing teeth. The determination of caries activity can be made in a single visit and involves subjectively assessing the appearance and physical properties of affected tooth surfaces while considering other risk factors that may be present (for example, plaque accumulation can be an indicator of activity present) or following the lesion's characteristics over time (for example, roughness can be an indicator that the lesion is being demineralized).[10,11] Research on caries detection methodology should focus on developing methodologies that provide real-time chairside caries diagnosis and more accurate monitoring of lesion activity and severity over time.

ROLE OF CARIES RISK ASSESSMENT IN PATIENT MANAGEMENT

Caries is a disease of multifactorial etiology, and a risk assessment should evaluate all factors involved with the disease. Individual risk factors studied separately from the pool of risk factors tend to be poor predictors of caries onset.[12] The assessment of all risk factors not only allows for a more accurate assessment of risk of developing a disease, but it also identifies the etiologic factors responsible for the disease in a particular patient. This approach encourages management strategies developed specifically for the patient. Therefore, caries risk assessment may be useful in the clinical management of caries by helping dental professionals do the following:

- evaluate the degree of the patient's risk of developing caries to determine the intensity of the treatment (for example, a 226 parts per million sodium fluoride [NaF] rinse versus a 5,000 ppm NaF brush-on gel) and frequency of recall appointments or treatments (for example, every three months, every six months, every year);
- help identify the main etiologic agents that contribute to the disease or that, because of their recent onset, may contribute to future disease, to determine the type of treatment (for example, plaque control, diet control, increased fluoride exposure, antimicrobial agents);
- determine if additional diagnostic procedures are required (for example, salivary flow rate analysis, diet analysis);
- aid in restorative treatment decisions (for example, cavity designs, choice of dental materials);
- improve the reliability of the prognosis of the planned treatment;
- assess the efficacy of the proposed management and preventive treatment plan at recall visits.

DEFINITION OF CARIES RISK CATEGORIES

Although there are many ways to categorize caries risk, we recommend an initial decision-making process based on three categories: high risk, moderate risk and low risk. Our classification model (Figure 1) begins with caries experience, since this is one of the strongest predictors of future caries. It is, however, unfortunate that dentists must wait until the disease manifests itself before they can predict it accurately.[13] Any patient with active disease faces an increased risk of developing the disease in the future. In most patients, the disease is a chronic disorder, so there is a great chance that patients with active lesions may have developing lesions that are not yet visible during a standard clinical examination. Patients who do not have active disease or clinical signs of caries are not necessarily at low risk of developing the disease. For example, life stressors such as leaving home for college for the first time, having orthodontic brackets placed on teeth or experiencing other significant life events can affect caries risk. Therefore, an assessment of the patient's behavior, lifestyle, oral hygiene habits (for example, plaque removal and frequency of exposure to fluorides) and dietary habits should inform the decision-making process.[14]

Providing an evidence-based definition for each of these caries risk categories is not an easy task.[15-17] Common sense dictates that a high-risk group of patients is a subset of a patient population considered at greater risk of developing caries (that is, patient examination results clearly suggest that if conditions remain unchanged, caries will progress over time) than is a subset at average risk.[5] In most cases, data show that short-term predictions of risk (less than two years) are more reliable than long-term predictions of risk (more than five years) because lifestyle changes that may occur can affect the accuracy of long-term predictions. Considering the current understanding of the caries disease process, we have expanded the caries risk definitions developed by Reich and colleagues.[5] We propose that the following factors will yield a moderate-to-high assessment of caries risk whether appearing singly or in combination: the development of new carious lesions, the presence of active lesions and the placement of restorations due to active disease since the patient's last examination (assuming a one- to two-year lapse between the previous and current appointment). We further propose that the differentiation between a moderate-to-high assessment of caries risk will depend on the following combined factors: time (that is, the faster the lesions develop, the higher the risk of developing caries), and number and severity of the lesions. However, any assessment developed from these factors should be qualified, because a patient who develops one new lesion within a three-month interval may be at a higher risk than a patient who develops five

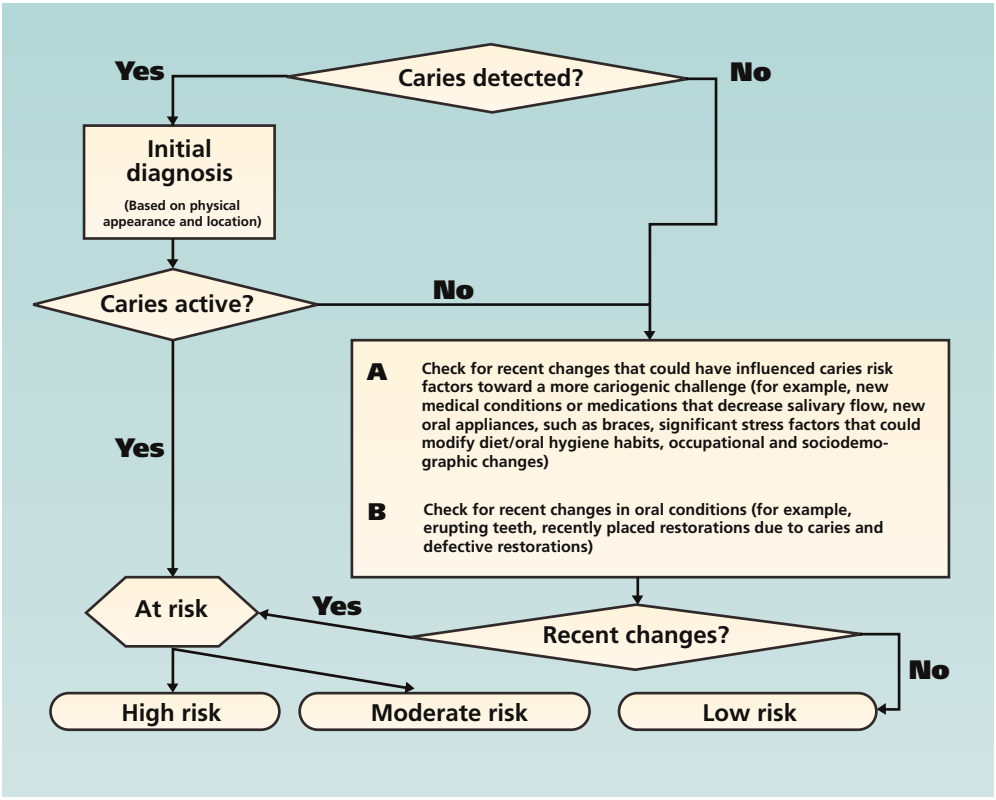

Figure 1. Flowchart depicting clinician's initial decision-making process in determining a patient's caries risk.

new lesions during a two-year period. Generally, the date and accuracy of the last examination drive the level of uncertainty associated with predicting caries. The longer the interval, the more difficult it is to assess the speed of progression and changes in disease activity accurately and, therefore, the greater the level of uncertainty at predicting disease.

We also propose that a moderate-to-low assessment of caries risk be based on the following factors: no carious lesion development or progression since the previous examination, the amount of plaque accumulation, the frequency of the patient's sugar intake, the presence of salivary problems, behavioral or physical disability changes, history of fluoride exposure and pattern of fluoride usage. Finally, a low assessment of caries risk (new lesions will not develop or existing lesions will not progress over time) should be based on the following factors, singly or combined: no current active caries; restorations necessitated by caries were placed five or more years ago; other caries risk factors are negligible or, if they are present, there is evidence that over many years they have not resulted in any lesions; and the patient has demonstrated no evidence of active disease over many years. Generally, the longer the interval during which no new activity or change occurs, the more reliable the assessment of low caries risk.

CARIES RISK INDICATORS

We recommend a caries risk assessment that relies on information from the patient's medical and dental history and a clinical examination.

Bacteria and oral hygiene. Caries is a microbial disease in which the etiologic agents are normal constituents of the oral flora that cause problems when their pathogenicity and proportions change in response to environmental conditions. The microbial component of caries can be viewed from the perspective of specific microorganisms that contribute to the disease, or whole plaque.

Specific organisms. Mutans streptococci and lactobacilli historically have captured the greatest interest among researchers and clinicians. However, the accuracy of salivary tests for mutans streptococci in predicting future caries in the whole population is less than 50 percent.[4,5,18] In populations with low caries prevalence, the caries-predictive ability of microbiological tests is even lower.[5,19] In addition, lactobacilli microbiological tests are less sensitive in predicting caries than are the tests for mutans streptococci.[20] In the United States, dentists can purchase several types of saliva tests to measure the amount of cariogenic microorganisms in saliva.

Because these tests estimate bacterial levels in saliva, dentists readily can identify patients with a high salivary bacterial load. This type of test can be useful to motivate patients and monitor oral hygiene changes. In addition, it can be useful when monitoring dietary changes because it has

been suggested that the levels of lactobacilli in saliva can be related to the intake of carbohydrates and sugars. These tests, however, have disadvantages because they require incubators, enumerate bacteria in saliva only—not in plaque—and correlate poorly with future caries risk. Manufacturers are developing alternatives to effectively quantify bacteria and plaque pH from site-specific plaque areas. Another site-specific plaque approach is an impression material that changes color from blue to pink in areas of lactic acid production, which presumably would be at higher risk for caries. Supporting data on this material still are scarce,[21] and the material is not approved for sale in the United States.

Available bacterial salivary tests could be used to determine cariogenic bacteria in the mouth and perhaps motivate patient behavioral changes, as well as help monitor the efficacy of antimicrobial therapies such as chlorhexidine therapy, which decreases the levels of mutans streptococci in the mouth but works less effectively on decreasing lactobacilli levels. However, based on the paucity of available data, using only the available bacterial salivary tests to predict future caries is not recommended.

Whole plaque. Evidence shows that because caries is a microbial disease, without plaque there would be no caries. Most patients, however, do not remove plaque effectively.[22] To evaluate the effectiveness of mechanical cleaning is difficult because toothbrushing usually involves using a fluoridated dentifrice. Furthermore, most plaque indexes are ineffective predictors of future caries because caries typically develops in fissures and interproximal areas, while most plaque indexes were developed to evaluate periodontal disease or gingivitis on smooth surfaces.[5] Because plaque is one of the main etiologic factors for caries, it is important to estimate the number of surfaces affected, the amount of plaque accumulated, the age of the plaque and whether the presence of plaque is associated with the presence of carious lesions in those same sites. For a patient at low risk, a quick estimate should suffice. For a patient at high risk, however, a surface-by-surface investigation to determine risk sites and help guide plaque control measures tailored to the patient's needs is warranted.

Conditions that compromise the long-term maintenance of good oral hygiene are associated positively with caries risk. These may include physical and mental disabilities, the presence of existing defective restorations (for example, wide open margins, overhangs) or oral appliances (for example, orthodontic brackets).[4] Therefore, a risk assessment should consider not only the presence of plaque, but also other factors such as crowded teeth, deep fissures, restoration overhangs, gingival recession and appliances.

Saliva. It is well-established that saliva plays an important role in the health of soft and hard tissues in the oral cavity. Oral complications as a result of salivary gland hypofunction include altered oral sensations, taste dysfunction, mucosal dryness resulting in infection and tooth wear due to abrasion.[23,24] Pain and diminished quality of life also are common complaints associated with salivary hypofunction. A chronically low salivary flow rate has been found to be one of the strongest salivary indicators for an increased risk of developing caries.[25]

Many dentists tend to rely on a patient's complaint of xerostomia to diagnose hyposalivation. Unfortunately, a subjective complaint of xerostomia often does not correlate with objective findings of reduced salivary flow rate.[26] Therefore, dentists should assess the true presence and extent of salivary gland hypofunction before developing an appropriate preventive and restorative treatment plan for a patient. However, dentists rarely evaluate their patients' salivary gland functions, probably because of the cumbersome nature of the available sialometric methods.[26,27] Fox and colleagues[26] recommended that dentists ask their patients the following questions:

- Does your mouth feel dry when eating a meal?
- Do you sip liquids to aid swallowing dry foods?
- Do you have difficulty swallowing any foods?
- Does the amount of saliva in your mouth seem to be too little, too much or you do not notice it?

The dentist should consider the following factors when evaluating the patient's answers:

- Are there any clinical signs that the patient's salivary flow rate is decreased (for example, dry lips)?
- Does the mouth mirror stick to the oral mucosa?
- Is there a lack of pool of saliva in the floor of the patient's mouth?
- Is there difficulty expressing saliva from the patient's major salivary ducts?
- Does the mucosa appear dry?
- Is there an increase in caries in an unusual location (for example, mandibular incisors)?

- Does the patient have any systemic condition (for example, autoimmune exocrinopathy, uncontrolled diabetes) that may cause decreased salivary flow rate?
- Is the patient taking any medications known to decrease salivary flow rate?
- Has the patient received or will the patient receive radiation of the head and neck that could affect salivary gland function?

A positive answer to any of these questions should prompt the dentist to consider how long the patient has experienced the problem and whether an increased caries experience has resulted. The dentist also should determine if the hyposalivation is related to dehydration, as this would affect the management strategy. Studies have shown that patients at risk of developing caries due to hyposalivation can be treated successfully by exposing them to fluoride.[28,29] As caries risk increases, patients should be exposed to fluoride more frequently, at higher doses than solely from dentifrice or both. These additional sources of fluoride may include one or more of the following: 0.05 percent NaF over-the-counter rinses, high concentration (1.1 percent NaF) prescription fluoride dentifrices and in-office high-concentration fluoride applications. When conducting a risk assessment, a dentist should consider as many factors as possible, including fluoride exposure, to avoid arriving at an erroneous conclusion.

If a patient is considered at risk and saliva is one of the influencing risk factors, an objective assessment of unstimulated flow rate should be performed for diagnostic purposes and be recorded for future comparisons. Salivary flow rates can vary greatly not only between people, but also within the same person depending on time of day, body position, amount of light and other factors.[30,31] Navazesh and colleagues[32] found that unstimulated flow rates have the strongest predictive validity for estimating caries risk. When measuring unstimulated salivary flow rate, dentists should ask patients to not drink, eat, chew anything or smoke at least one to two hours before the appointment. The normal unstimulated flow rate varies between 0.3 and 0.4 milliliters per minute,[33,34] and values of less than 0.1 mL per minute should be considered abnormal.[32,35] Dentists also should assess the stimulated flow rates to determine if management strategies based on salivary stimulation (for example, recommending chewing sugarless gum, prescribing pilocarpine) would benefit patients. Commercially available kits contain all the supplies that the dental office may need to assess salivary flow rate.

Diet. Sugar exposure is an important etiologic factor in caries development.[36,37] Owing to the wide use of fluoride and its effect in lowering the incidence and rate of caries, it is difficult to show a strong clear-cut positive association between a person's sugar consumption and his or her caries development; if a patient consumes a lot of sugar, but at the same time uses a lot of fluoride, the teeth may not be as damaged as they would be if there were no fluoride use.

Starches are considered less cariogenic than the simple sugars sucrose, glucose and fructose, with sucrose possibly being the most cariogenic owing to its unique role in the production of extracellular glucans.[38] Other dietary considerations include the retentiveness of the food, the presence of protective factors in foods (calcium, phosphate, fluoride) and the type of carbohydrate. Although sugar in liquid form (for example, soft drinks) is less cariogenic than sugar in solid form (for example, candy), excessive frequent consumption of soft drinks remains a major risk factor that may be partly responsible for the rate of caries in teenagers and young adults.[39,40]

A dietary assessment should feature a probing interview with follow-up questions. Patients may be unaware of the cariogenicity of certain components of their diet, and they may not volunteer important information. The interview process should focus on eating behaviors in between meals, including late-night snacking. Follow-up questions should determine the consumption pattern. For example, does the patient consume food or drink rapidly, or does he or she nibble or sip over an extended period? Sipping a soft drink over a five-hour period can be more detrimental than drinking three soft drinks during one meal. Dentists should ask patients who drink coffee if they add sugar or a nondairy creamer, which may contain sugar, to their coffee. Dentists also should ask patients if they frequently consume hard candies or lozenges, especially if active carious lesions are evident. For at-risk patients, dietary assessments could feature several additional approaches, including conducting 24-hour recall interviews and asking patients to complete three-, five- or seven-day diet diaries, especially if the dentist cannot identify dietary etiologic factors during the interview process.

Lifestyle changes and occupation also can affect caries risk status. For example, young adults living away from home for the first time may experience significant changes in their diet and resort to frequent snacking. Also, people who work evening or sedentary jobs might tend to snack on high-sugar foods and caffeinated beverages.

Generally, diet alone is an inadequate indicator of caries risk. For example, a patient may snack several times a day but then brush immediately afterward, which would minimize the impact of diet alone on caries risk. Therefore, other risk factors also need to be considered, such as assessing a patient's pattern and frequency of carbohydrate intake and its relationship with oral hygiene habits. In addition, assessing the patient's eating and oral hygiene habits over time can help the dentist determine if the behavior has produced a history of caries experience. If the potentially negative behaviors are recent, then the patient should be considered at risk. If the negative behaviors are established and have not produced any problems over many years, then the risk may be lower than expected.

Exposure to fluoride. The widespread use of fluoride has reduced the prevalence of caries and the rate of the progression of carious lesions dramatically. Its use, which can be considered one of the most important protective factors when assessing a patient's caries risk, allows more conservative management strategies for the prevention and treatment of caries.

What constitutes adequate fluoride exposure for an adult or a child? We suggest that the dentist first consider all fluoride sources to which the patient is exposed—for example, fluoridated drinking water (community water, well water or bottled water), food and drinks (such as sardines and tea), home topical fluoride products (frequency and type of toothpaste or mouthrinse) and periodical professional fluoride exposures. The dentist then should determine if this pattern of fluoride exposure has arrested the appearance or progression of incipient or cavitated carious lesions over time. A patient who uses a fluoride dentifrice once daily can be considered to have adequate fluoride exposure if he or she is classified as being at low risk and has shown no evidence of caries activity. If new lesions have appeared or existing lesions have progressed, then the patient's fluoride exposure is inadequate. General guidelines for fluoride use based on caries risk status are shown in Figure 2. Fluoride use should be determined for each patient based on his or her age, physical abilities, health awareness and attitude.

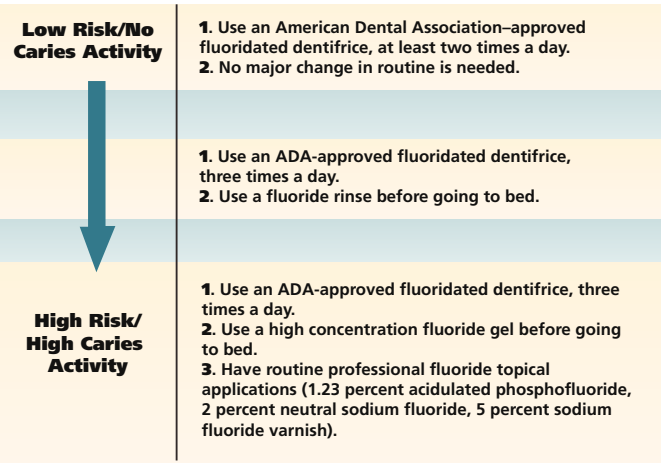

Figure 2. Recommendations for fluoride use based on caries risk status.

Past caries experience. As we mentioned, epdemiological studies have shown a positive strong correlation between past caries experience and future caries development. This single caries risk indicator provides the greatest predictive ability.[3,4,6] The presence of caries in the mother increases a young child's risk.[4] Caries prevalence in primary teeth can help predict future caries in permanent teeth.[41,42] In adults, there is an association between existing caries and the risk of developing root caries.[43]

To analyze the information from this risk indicator adequately, at the examination dentists should record the number of teeth lost owing to caries; when those teeth were lost; the number and size of restorations; when the restorations were placed; and the number, location and activity status of carious lesions present in the mouth. If activity status of the carious lesions cannot be determined adequately, we recommend monitoring lesions by taking intraoral pictures of occlusal, buccal and lingual surfaces or radiographs of interproximal surfaces over time so that comparisons can be made later. If lesions are active and noncavitated, we suggest that the dentist attempt to arrest and possibly remineralize these lesions. When assessing a patient's caries history, more emphasis should be placed on caries experience occurring over the past one to two years and current caries activity status, which are more indicative of current risk factors (Figure 1).

Medical and demographic factors. Epidemio-

logical surveys show that caries prevalence increases with age. In addition, newly erupted teeth are more susceptible to caries than are teeth that have erupted and have had a chance to mature in the oral cavity.[5,44,45] Also, until the newly erupted teeth have reached the occlusal plane, they are difficult to clean, especially at pit and fissure sites.

Socioeconomic status is a stronger predictor of caries risk in children than it is in adults.[4] Because caries generally is more prevalent in lower socioeconomic groups than in higher socioeconomic groups, the dentist should consider social variables such as the patient's education and occupation. One example of how social variables can play a role in the determination of caries risk was presented in a study that showed that bakery workers have a higher prevalence of caries than do workers in other industries.[46]

Another example of how social variables can play a role is shown in studies of identical twins raised separately. These studies suggest that etiologic or behavioral factors could be more important than genetic factors (for example, tooth morphology, position and occlusion, eruption time and sequence) in determining caries risk,[5,47] even when there still is a lot that is not known between the genetic-environmental relationships in caries etiology and risk assessment.

Certain medications such as psychopharmaceutical drugs reduce the flow rate of saliva and may affect caries risk.[48] Diseases such as Sjögren's syndrome and uncontrolled diabetes that are related to decreases in salivary flow rate can increase the risk of developing caries. Mental or physical disabilities that affect regular oral hygiene or require a carbohydrate-enriched diet also may affect the person's risk. Additionally, enamel defects, such as hypoplasia, have been related to increased caries risk in children.[13] Lastly, long-term regular use of medications that contain glucose, fructose or sucrose, also may contribute to caries risk.[4]

CONCLUSIONS

Because caries is a multifactorial disease, the incorporation of caries risk assessment into the concept of caries management should include factors that may affect caries development. Factors such as past and current caries, diet, fluoride exposure, presence of cariogenic bacteria, salivary status, general medical history and sociodemographic influences should be included when evaluating a patient's caries risk status. The preventive and restorative caries management plan and frequency of recall visits should depend on a patient's caries risk. Furthermore, the risk assessment, any proposed management strategy and outcomes should be recorded formally over time to monitor and measure treatment efficacy. Patients should be given an opportunity to formally acknowledge the outcomes of a complete risk assessment evaluation. Thus, empowered patients can become true partners in and contributors to their oral care. ■

This article was prepared as a Practical Science article in cooperation with the American Dental Association Council on Scientific Affairs, the Division of Science and The Journal of the American Dental Association. The mission of Practical Science is to spotlight scientific knowledge about the issues and challenges facing today's practicing dentists.

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