RELIABILITY OF UNIVARIATE AND MULTIVARIATE CARIES RISK ASSESSMENT SYSTEMS: A REVIEW

[1]MOHAMMED Q AL QAHTANI, BDS, MSD

ABSTRACT

Scientific advances in cariology during past 150 years have determined that dental caries is a multi-factorial disease and that to understand the nature of this disease, one has to focus on different variables that help in prediction of caries activity and caries risk assessment. This review article will help readers in classifying the patients into low or high caries risk category and help in understanding of the effective diagnostic methods. The risk assessment models that include multiple variables offer better prediction than single risk variables.

Key words: *Dental caries, caries risk factors, caries activity.*

INTRODUCTION

Dental caries has been traditionally described as a multifactorial disease that involves the interaction of host factors (tooth surface, saliva & acquired pellicle), diet (carbohydrate rich diet), and dental Plaque (cariogenic microflora) over a period of time.[1] Dental caries has some characteristics features (chronic, infectious, slowly progressive, very seldom self-limiting, and often progress to destroy the teeth in the absence of intervention management (preventive measures, actual operative treatment or both), these characteristic are important for management of this disease.[2] The preventive measures and the actual operative treatment of dental caries should be based on appropriate diagnosis and detection of caries in its earliest stage using caries risk assessment systems. These systems help in determined the probability of caries incidence in a certain period of time and also caries risk activity which will help in establishment of an appropriate individual treatment plan.[3] The purpose of this review paper is to focus on the diagnosis of dental caries, caries risk assessment, goals of caries risk assessment, caries risk factors and risk category, variables that predict caries activity, relationship between a predictive test result and the actual disease, reliability of caries risk assessment systems.

DIAGNOSIS OF DENTAL CARIES

The process of caries diagnosis involves both caries activity and caries risk assessment to determine the disease state. Caries activity is depended on the data obtained from clinical examination and assessment of factors associated with the pathogenesis of the disease. There are multiple parameters used for estimation of caries activity including; the clinical appearance and the sites of lesions or cavities and whether the disease process at these sites is active or arrested.[3] Without this information, a logical decision about treatment is impossible. For instance an active lesion requires preventive treatment in combined with operative treatment, whereas no treatment is required for arrested lesion.[3,4]

DENTAL CARIES DETECTION TOOLS

The diagnosis of caries requires good lighting, dry and clean teeth. If there are deposits of calculus or plaque on teeth, teeth should be cleaned before attempting accurate diagnosis. Conventional diagnostic techniques (e.g. sharp explorer and dental radiographs) which are becoming less useful to provide information on caries activity and lack sufficient high sensitivity and specificity for early lesion detection. Clearly, introducing the development of more defined diagnostic tools that are sensitive and specific enough for the

[1] Assistant Professor, Department of Restorative Dental Science, King Saud University, College of Dentistry, Riyadh, Saudi Arabia.

Correspondence: Dr. Mohammed Q Al Qahtani, P.O. Box 60169, Riyadh 11545, Saudi Arabia. Phone: +966 53486898. E-mail: malqathani@ksu.edu.sa or mqahtani@mail.com

detection of changes in early dental caries would allow earlier preventive intervention.[5,6]

The following is a list of more defined diagnostic tools available in market:

- Direct digital radiography (DDR)
- Digital imaging fiber-optic transillumination (DIFOTI)
- Electroconductivity measurements (ECM)
- Impedance spectroscopy (IS)
- Quantitative light-induced fluorescence (QLF)
- Laser fluorescence (DIAGNOdent devices)
- Photothermal radiometric and modulated luminescence methods (PTR and MLM)
- Optical coherence tomography (OCT)
- Ultrasound
- Near-infrared illuminated
- Raman spectroscopy
- Terahertz imaging

CARIES RISK ASSESSMENT

Caries risk assessment is an important part of contemporary dental practice today to ensure an appropriate level of prevention and treatment.[7] Risk is defined as "the probability of an individual developing a given disease" and thus a risk Factor is a factor associated with an increased probability of an individual developing a particular disease.[8, 9] Caries risk assessment is the determination of the probability of person's developing new caries lesions during specific period and the probability of a change in the size or activity of existing lesions over time.[10, 11, 12]

GOALS OF CARIES RISK ASSESSMENT [10, 13, 14]

1. Identify the main etiological factors.
2. Evaluate the degree of the patient's caries-risk.
3. Determine whether additional diagnostic procedures are required.
4. Identify high risk patients before they become caries-active.
5. Monitor changes in disease status in caries-active patients.
6. Identify a preventive treatment plan suitable for the patient.
7. Screen out low risk patients (to allow safe recommendation of long recall intervals).
8. Assess the efficacy of the treatment and plan future treatments.

FACTORS RELEVANT TO CARIES RISK ASSESSMENT [4, 9]

There are multiple factors relevant to caries risk, and Table 1 describes these factors in relation to low and high risk patient. The caries risk factors are listed below.

1. Social and behavioral factors.
2. Medical history.
3. Diet habits.
4. Fluoride exposure.
5. Plaque control.
6. Saliva.
7. Clinical evidence.

VARIABLES THAT PREDICT CARIES ACTIVITY

According to several studies on caries prediction, no single variable has been proven to be successful in predicting caries development and caries susceptibility.[13, 15, 16] Most variables that have been investigated are related to classic caries model: host (age, fluoride exposure, social and economic status, educational level, number of filled teeth), microflora (Mutans streptococci, Lactobacilli), saliva (flow rate, buffering capacity) and diet (sugar).[10, 11, 13, 17]

The terms commonly used to describe the accuracy of a risk models are sensitivity and specificity (Table 2). Sensitivity is the proportion of people with disease who have a positive test result. Specificity is the proportion of people without disease who have a negative test result. Usually, attempts to improve the sensitivity of a test will decrease the specificity and vice versa. Positive predictive value is the probability of having a

disease given a patient with a positive test result. Negative predictive value is the probability of having no disease given a patient with a negative test result.[18] Kingman in 1990 recommended a sum for sensitivity and specificity of 160 as a guideline for estimating the accuracy of caries risk model.[19]

RELIABILITY OF CARIES RISK ASSESSMENT SYSTEMS

PREVIOUS CARIES EXPERIENCE:

Epidemiological studies have shown a positive correlation between past caries experience and future caries development with the sensitivity of approximately 60%.[20,21] Other studies found that the caries prevalence in primary teeth can help predict future caries in permanent teeth, and there was an association between exciting caries and the risk of developing root caries in adults.[22,23] Raitio *et al*[24] in their study used both white spots and DMFT(S) predictors separately as individual predictors and found that sensitivities for both were 79% and the specificities were 43% and 49% respectively.

FLUORIDE EXPOSURE:

The widespread use of fluoride has an effect on reducing the prevalence and the rate of progression of caries lesions. Its use and concentration in the mouth can be considered as one of the most important preventive factor, but its diagnostic or predictive value has been questionable.[25,26]

DENTAL PLAQUE:

Plaque is one of the main risk factor for dental caries and this is due to the presence of a number of endogenous oral microorganisms (Mutans streptococci, Lactobacillus, Actinomyces, and yeast) which can contribute to caries process. Raitio *et al*[24] found that the use of visible plaque (cutoff point for high caries risk was ³25%) as caries risk indicator provided a sensitivity and specificity of 37% and 71% respectively.

SALIVA:

Saliva has a buffering (neutralizing) effect on the acids produced by plaque micro-organisms, and can also clear food particles and acids from mouth. Caries activity is significantly increased in individuals with markedly reduced salivary function and with low buffer capacity of saliva. The use of secretion rate (cutoff point for high risk was £ 0.9ml/min of stimulated saliva) as caries predictor in a 13-year-old population during an 11 months period provided a sensitivity and specificity of 24% and 83% respectively.[24] The use of buffer capacity (cutoff point for high risk was pH of 4-5 pH) as predictor in the same study provided a sensitivity and specificity of 21% and 77% respectively.[24]

CARIOGENIC BACTERIA:

Some studies have shown that a correlation between number of carious lesions and numbers of mutans streptococci in the saliva of children and adults, but the accuracy of these salivary tests for mutans streptococci in predicting caries in the whole population was less than 50%.[27,28] Loesche *et al*[29] in their study on older age patients reported that mutans streptococci levels in saliva per tooth were significantly associated with coronal surface decay, and lactobacilli were significantly associated with root surface decay.

DIET HABITS:

The frequency of eating fermentable carbohydrates has been strongly associated with dental caries. Little caries increment was found in young children with good oral hygiene irrespective of dietary habits.[30] On the other hand, higher sugar intake showed increased caries prevalence only when the oral hygiene was poor.[31] The sensitivity and specificity of using Dextrostok Strips method to measure the final concentration of sucrose in saliva have been shown to be 24% and 90% respectively.[24]

SOCIO-ECONOMIC STATUS:

Socio-economic status is highly relevant to caries prevalence. Caries tend to be more prevalent in lower social classes than in higher classes. Demers and coworkers[32] concluded that, there was a negative association between socio-economic status and caries prevalence in primary and mixed dentitions.

MEDICAL HISTORY FACTORS:

Some studies have shown that the long-term use of sugary medications by children increases the caries prevalence and that the use of psycho-pharmaceutical medications reduce the flow of saliva hence increasing the risk of caries.[33,34]

TABLE 1: FACTORS RELEVANT TO CARIES RISK ASSESSMENT[4]

High Risk	Low Risk
Social History	
Socially deprived	Middle class
High caries in siblings	Low caries in siblings
Low knowledge of dental disease	Dentally aware
Irregular attendee	Regular attendee
Ready availability of snacks	Work does not allow regular snacks
Low dental aspirations	High dental aspirations
Medical History	
Medically compromised	No medical problem
Handicapped	No physical problem
Xerostomia	Normal salivary flow
Long-term cariogenic medicine	No long-term medication
Dietary Habits	
Frequent sugar intake	Infrequent sugar intake
Use of Fluoride	
Non-fluoride area	Fluoridation area
No fluoride supplement	Fluoride supplement used
No fluoride toothpaste	Fluoride toothpaste used
Plaque Control	
Infrequent ineffective cleaning	Frequent effective cleaning
Poor manual control	Good manual control
Saliva	
Low flow rate	Normal flow rate
Low buffering capacity	High buffering capacity
High Streptococcus Mutans, and Lactobacillus counts	Low Streptococcus Mutans, and Lactobacillus counts
Clinical Evidence	
New lesions	No new lesions
Premature extractions	No extraction for caries
Anterior caries or restorations	Sound anterior teeth
Multiple restorations	No or few restorations
History of repeated restorations	Restorations inserted years ago
No fissure sealants	Fissured sealed
Multiband orthodontics	No appliances
Partial dentures	

TABLE 2: RELATIONSHIP BETWEEN A PREDICTIVE TEST RESULT AND ACTUAL DISEASE.[18]

Test Result	Disease Status		Total
	Positive	Negative	
Positive	a True positive	b False positive	a + b
Negative	c False negative	d True negative	c + d
Total	a + c	b + d	N

Sensitivity: a/a+c; Specificity: d/b+d; Positive predict value: a/a+b; Negative predictive value: d/c+d; Total number: N

GENETIC AND ENVIROMENTAL FACTORS:

Genetic factors such as tooth morphology, tooth position, occlusion, tooth eruption time & sequence, salivary composition and sweet preference are less important in determining caries risk than are environmental influences such as microbial and dietary factors.[12,35] Much about genetic and environmental relationship to caries etiology and risk assessment is still unknown and need more investigation.

COMBINTION OF RISK FACTORS

Demers *et al*[36] found that combination of the caries experience (dmfs) and lactobacilli in children resulted in a combined sensitivity and specificity score of 159%. Grindefjord *et al*[37] reported that the use of combined bacterial levels, dietary factors and social variables in very young children (age one year) resulted in a high combined sensitivity and specificity score 170%. Another study found that the use of mutans streptococci, lactobacilli, and salivary phosphates were excellent short-term predictors of caries development (sensitivity + specificity= 165%).[38] The use of multiple risk factors offers the potential of making relatively good predictions, with reasonable sensitivity/specificity.[8] No wonder that the most commonly used statistical methods for caries risk assessment models today are multivariate regression techniques.

REFERENCES

1 Zero DT. Dental caries process. Dent Clinics North Amer 1999; 43(4): 635-664.

2 Pine CM, ten Bosch JJ. Dynamics of and diagnostic methods for detecting small caries lesions. Caries Res 1996; 30: 381-388.

3 Angmar-Mansson BE, Al Khateeb S, Tranaeus S. Caries diagnosis. J Dent Educa 1998; 62(10): 771-780.

4 Kidd EA. Caries management. Dent Clinics North Amer 1999; 43(4): 743-764.

5 Bader JD, Shugars DA, Bonito AJ. Systematic reviews of selected dental caries diagnostic and management methods. J Dent Educ 2001; 65(10):960-968.

6 Stookey GK, Jackson RD, Ferreira Zandona AG, Analoui M. Dental caries diagnosis. Dent Clinics North Amer 1999; 43(4): 665-677.

7 Anusavice KJ. Treatment regimens in preventive and restorative dentistry. J Am Dent Assoc 1995; 126: 727-743.

8 Disney JA, Graves RC, Stamm JW, Bohannan HM, Abernathy JR, Zack DD. The University of North Carolina risk assessment study: further developments in caries risk prediction. Community Dent Oral Epidemiology 1992; 20: 64-75.

9 Kidd EA. Assessment of caries risk. Dental Update 1998; 25: 385-390.

10 Fontana M, Zero DT. Assessing patient's caries risk. J Am Dent Assoc 2006; 137(9):1231-1239.

11 Zero DT, Fontana M, Martinez-Mier E.A, Ferreira-Zandona A, Ando M, Gonzalez-Cabezas C, Bayne S. The biology, prevention, diagnosis and treatment of dental caries: scientific advances in United States. J Am Dent Assoc 2009; 140: 24S-34S.

12 Reich E, Lussi A, Newbrun E. Caries-risk assessment. Int Dent J 1999; 49(1):15-26.

13 Powell LV. Caries risk assessment: Relevance to the practitioner. J Am Dent Assoc 1998; 129: 349-353.

14 Masser LB. Assessing caries risk in children. Aust Dent J 2000; 45(1):10-16.

15 Stamm JW, Stewart PW, Bohannan HM, Disny JA, Graves RC, Abernathy JR. Risk assessment for oral diseases. Adv Dent Res 1991; 5: 4-17.

16 Tinanoff N.: Critique of evolving methods for caries risk assessment. J. Dent. Edu 1995; (59): 980-984.

17 Tagliaferro EP, Pereira AC, Meneghim Mde C, Ambrosano GM. Assessment of dental caries predictors in seven-year longitudinal study. J Public Health Dent 2006; 66(3): 169-173.

18 Fletcher RH, Fletcher SW, Wagner EH. Clinical epidemiology: The essentials. 2nd ed. Baltimore: Williams & Wilkins 1988: 46-52.

19 Kingman A. Risk assessment in dentistry. In: Bader JD, ed. Chapel Hill. N.C.: University of North Carolina Dental Ecology 1990:193-200.

20 Steiner M, Helfenstein U, Marthaler TM. Dental predictors of high caries increment in children. J Dent Res 1992; 71(12):1926-1933.

21 Sheiham A. Impact of dental treatment on the incidence of dental caries in children and adult. Comm Dent Oral Epidemiol 1997; 25(1): 104-112.

22 Helm S, Helm T. Correlation between caries experience in primary and permanent dentition in birth-cohorts 1950-70. Scand J Dent Res 1990; 98(3): 225-227.

23 DePaola PF, Soparkar PM, Tavares M, Kent RL Jr. Clinical profiles of individuals with and without root surface caries. Gerodontology1989; 8(1): 9-15.

24 Raitio M, Pienihakkinen K, Scheinin A. Assessment of single risk indicators in relation to caries increment in adolescents. Acta Odontol Scand 1996; 54(2):118-121.

25 Stookey GK, DePaola PF, Featherstone JD, Fejerskov O, Moller IJ, Rotberg S, Stephen KW, Wefel JS. A critical review of relative anticaries efficacy of sodium fluoride and sodium monofluorophoshate dentifrices. Caries Res 1993; 27(4): 337-360.

26 Tenovuo J. Salivary parameters of relevance for assessing caries activity in individuals and populations. Community Dent Oral Epidemiol 1997; 25(1):82-86.

27 Newbrun E. Matsukubo T, Hoover CI, Graves RC, Brown AT, Disney JA, Bohannan HM. Comparison of two screening tests for streptococcus mutans and elevation of their suitability for mass screenings and private practice. Community Dent Oral Epidemiol 1984; 12(5):325-331.

28 Russell JI, MacFarlane TW, Aitchison TC, Stephen KW, Burchell CK. Prediction of caries increment in Scottish adolescents. Community Dent Oral Epidemiol 1991; 19(2):74-77.

29 Loesche WJ, Taylor GW, Dominguez LD, Grossman NS, Stoll J. Factors which are associated with dental decay in the older individual. Gerodontology. 1999;16(1):37-46.

30 Schroder U, Granath L. Dietary habits and oral hygiene as predictors of caries in 3-year-old children. Community Dent Oral Epidemiol 1983; 11(5):308-311.

31 Kleemola-Kujala E, Rasanen L. Relationship of oral hygiene and sugar consumption to risk of caries in children. Community Dent Oral Epidemiol 1982; 10(5):224-233.

32 Demers M, Brodeur JM, Simard PL, Mouton C, Veilleux G, Frechette S. Caries predictors suitable for mass-screening in children: A literature review. Community Dent Health 1990; 7:11-21.

33 Hobson P, Fuller S. Sugar-based medicines and dental disease:progress report. Community Dent Health 1987; 4(2):169-176.

34 Rundegren J, Van Dijken J, Mornstad H, von Knorring L. Oral conditions in patients receiving long-term treatment with cyclic antidepressant drugs. Swed Dent J 1985; 9(2): 55-64.

35 Hassel TM, Harris EL. Genetic influences in caries and periodontal disease. Crit Rev Oral Biol Med 1995; 6(4): 319-342.

36 Demers M, Broeur JM, Mouton C, Simard PL, Trahan L, Veilleux G. A multivariate model to predict caries increment in Montreal children aged 5 years. Community Dent Health 1992; (9): 273-281.

37 Grindefjord M, Dahllof G, Nilsson B, Modeer T. Prediction of dental caries development in 1-year old children. Caries Res 1995; 29(5): 343-348.

38 Leverett DH, Proskin HM, Featherstone JD, Adair SM, Eisenberg AD, et al. Caries risk assessment in a longitudinal discrimination study. J Dent Res 1993; 72(2): 538-543.