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Original Article

A comparison of subjective and objective caries risk assessment methods

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Abstract

Background: Dental caries is a serious public health problem significantly affecting oral health. Though there have been many advancements in treating dental caries, complete prevention of dental caries is still beyond reach. Several risk factors are associated with caries formation and progression. Previous studies have been conducted on dental caries and the efficiency of diagnosis using subjective and objective methodologies. Hence, this study was conducted to assess the contradictions in results of subjective and objective interpretations.

Methods: A descriptive study was carried out in the clinical setting of rural areas near Chengalpattu. Using convenience sampling, 285 samples were collected according to inclusion and exclusion criteria within the age range of 7–20 years. The subjects were selected from the Outpatient Department of Karpaga Vinayaka Institute of Dental Sciences. American Dental Association (ADA) questionnaires were used for subjective caries risk assessment (CRA), unstimulated salivary samples were collected to measure salivary pH for objective CRA, and DMFT (decayed, missing, filled tooth) and def indices were measured for reference. After data collection, statistical analysis was performed using SPSS version 22. Chi-square and Pearson correlation tests were performed to find the statistical differences, and a correlation was found between subjective and objective assessment results.

Results: In this study, the correlation between objective risk assessment based on salivary pH and actual caries status was slightly better ($r=0.159$) than other risk assessment methods ($r=0.050$). Moreover, a negative correlation was found between subjective and objective CRA ($r=-0.062$).

Conclusion: The study findings show a negative correlation between subjective and objective assessment. Objective CRA using salivary pH was positively correlated with actual caries status.

Keywords: Dental caries, Risk assessment, Subjective, Objective, Correlation

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Introduction

Dental caries, which significantly affects oral health, is the most serious public health problem. It is a chronic, multifactorial condition that destroys tooth structure and may lead to tooth loss if not treated adequately. It has a significant impact on individuals and the community.[1] The prevalence of dental caries in India is nearly the same at the ages of 5 and 12 years, at 49 %, but then it experiences a steady increase from the age of 15 years (60%) to the 35-44 years age group (78%) and peaks in the 65-74 years group (84%).[2]

Patients with a high risk of dental caries exhibit active carious lesions that have cavitated smooth surfaces of two or more teeth at once. High-risk individuals are those who show signs of recurrent caries or have a history of smooth surface caries in the past years.[3]

Several risk factors are associated with caries formation and progression. A cariogenic diet, including freely fermentable carbohydrates or malnutrition during periods of teeth development, is one of the important risk factors. Also, the effects of aging, with a higher incidence of caries reported towards higher ages, and several other factors, including the nature of the biofilm, type of sugar, socioeconomic status (SES), and systemic diseases, also impose a significant risk of developing dental caries.[4] Hence, assessment of risk factors is essential to predicting future caries development before the clinical onset of the disease.

Caries risk assessment (CRA) is a significant part of patient-centered caries management. The procedure assists clinicians in selecting the appropriate management based on an individual's caries risk level and deciding the appropriate recall interval. Most of the effort to find methods for CRA began in the late 1980s.[5] A conceptual framework for the development of CRA models was proposed by Stamm et al., which included targeting the persons in need through effective prevention procedures, appropriate care, economic efficiency, and cost-effective

procedures.[6]

CRA determines the likelihood of caries incidence during a specific period. It also involves the probability of a change in the size/activity of the lesion in the mouth. Various laboratory and clinical procedures have been conducted to determine this progress and assess caries risk. However, over time, risk assessment is mostly preferred in subjective or objective methodologies.[7]

Several subjective risk assessment models have been proposed, including the cariogram, caries management by risk assessment (CAMBRA), and the American Dental Association and the American Academy of Pediatric Dentistry questionnaires. These four systems vary concerning caries risk categories, type and the number of risk factors/markers, and disease indicators.[8] The preferred subjective methodology includes questionnaires and interviews to determine an appropriate subjective interpretation to arrive at the most likely diagnosis and the best treatment plan. However, subjective interpretations are subjected to incorrect interpretation.

On the other hand, objective CRA methods are based on several important assessments of salivary properties associated with dental caries, including salivary pH, salivary flow rate, consistency of saliva, and buffering capacity. Caries are said to be due to an imbalance between minerals and pH. Scientific evidence shows that fluctuations in the pH level lead to alterations in active remineralization and demineralization cycles.[9]

In order to achieve patient comfort and consent, non-invasive methodologies are preferred during the risk assessment. Even though studies on dental caries and the efficacy of diagnosis using both subjective and objective approaches have been conducted, these studies have the potential to raise concerns among patients.[8,10] Hence in this study, a correlation analysis has been carried out to identify discrepancies between the results of subjective and objective risk assessment methods. This study evaluates the predictive value of objective and subjective CRA, compared with current dental caries status.

Objectives

- To evaluate the predictive value of the subjective CRA tool (the American Dental Association questionnaire tool – AAPD)
- To evaluate the predictive value of the objective CRA method (salivary pH analysis)
- To compare the subjective and objective CRA assessments with current dental caries status

Methods

Study design

This analytical study was carried out in the clinical setting of the Outpatient Department of Karpaga Vinayaga Institute of Dental Sciences, Chengalpattu. The description of the study protocol was submitted to the Institutional Ethics Committee (IEC), and approval was granted. Written informed consent was obtained from the participants before their enrollment in the study.

Study population

The study was conducted for five months, from October 2022 to February 2023. This study was conducted among the patients who visited the outpatient department of this institute and were selected for this analysis. Samples were collected for five months according to inclusion and exclusion criteria from patients within the 7–20 years age range.

Patients aged 7-20 years who provided consent to participate in the study were included. Physically or mentally disabled children and adults, immune-compromised patients, those with a history of antibiotic therapy, dentures, or fluoride treatment in the past 2-4 weeks, and current or former smokers (>10 packs in lifetime) were excluded from the study.

Sample size calculation and sampling method

The sample size for this study was calculated using G*Power software with a statistical power of 90% at a 95% confidence interval and an effect size of 0.70. The sample size was 281, rounded off to 285 for this study. Participants were recruited based on the inclusion and exclusion criteria through simple random sampling.

Data collection methodology

After obtaining consent, the participants' demographic details, including age, gender, residence location, and SES, were collected. The SES of each patient was assessed using a modified Kuppuswamy scale (2021).

A saliva sample was taken from the 285 patients, and the salivary pH was evaluated. In the present study, saliva sample collection was un-stimulated as the composition and pH might differ in stimulated salivary samples.[11] Saliva was collected by requesting the patients to spit in the provided cup. Patients were asked to bring their head down and face forward. They were also instructed not to talk or swallow until the saliva was collected. An electronic pH meter was used to analyze the pH of the salivary samples, the meter was dipped in the salivary sample for 10 seconds, and pH readings were noted. The risk based on pH values was categorized into high, moderate, and low. Samples with a pH value less than 6.0 were scored as high-risk, pH 6.0–7.4 as moderate -risk, and pH higher than 7.4 as low-risk. The above parameters were recorded along with the patient's demographic details and DMFT (decayed, missing, filled tooth)/def scores. Two examiners recorded the DMFT/def indices to avoid inter-examiner variability. Inter-examiner variability was assessed by kappa statistics (0.85). Based on the DMFT/def scores, current dental caries status was categorized into three levels (low, moderate, and high).

DMFT/def values of 0 and 1 were scored as low, 2 and 3 as moderate, and higher than 3 as high.[12] DMFT and def scores were obtained and calculated separately as some participants were in the mixed dentition period.

The ADA questionnaires were used for subjective assessment[13].The questions were translated into the local language, and the investigator administered them to the selected patients. The questionnaires were analyzed, and the patients were categorized as low-, moderate-, and high-risk based on the ADA assessment tool.

Statistical analysis

The data were collected, and statistical analysis was performed using SPSS version 22 (Armonk, New York) on a personal computer (IBM Corp.). Data comparison was done by applying specific statistical tests. The chi-square test was performed to find the statistical differences between subjective and objective assessments. The correlation was assessed by the Pearson correlation analysis. *P* values < 0.05 were considered significant.

Results

Table 1 shows the demographic characteristics of participants. Out of 285 participants, 160 were female and 125 were male. The mean age of the participants was 13.1 ± 3.85 years. Most of the participants were from the lower-middle and upper social classes. Among the total participants,61% of them were from rural areas.

Table 2 and Figure 1 depict the frequency distribution of salivary pH, the subjective CRA questionnaire, and DMFT scores.

Of the 285 samples, the objective method of CRA by salivary pH analysis categorized 17.5% as low, 74% as moderate, and 8.4% as high in caries development risk. Based on the subjective method of caries assessment by the ADA questionnaire, 11.9% and 53.3% were at low and moderate risk, respectively, and 34.7% were categorized as high-risk. The current dental caries status assessed by DMFT/def scores showed that 53.3% and 31.9% were at low and moderate risk, respectively, and 14.7% were high-risk.

Table 1. Demographic details of the participants

Demographic variables		
Age (mean ± SD)		13.1 ± 3.85
Gender, No. (%)	Male	125 (43.8%)
	Female	160 (56%)
Socioeconomic status, No. (%)	Upper	28 (9.8%)
	Upper-Middle	40 (14.4%)
	Lower-Middle	91 (31.9%)
	Upper-Lower	86 (30%)
	Lower	40 (14.4%)
Residence, No. (%)	Rural	174 (61%)
	Urban	111 (39%)

SD: standard deviation.

Table 3 depicts the comparison of the objective method and subjective assessment method and the current dental status of the participants. Based on this analysis, the subjective and objective CRAs were significantly different from the current dental caries status (DMFT/def scores) ($P < 0.05$).

Table 4 depicts the correlation between dental caries status (DMFT/def) and patients' age. Age is the only factor significantly affecting dental caries ($P < 0.05$*). According to these results, with the progress of age, dental caries and susceptibility to it increase.

Table 5 depicts the correlation between objective and subjective CRA with current dental caries scores (DMFT). Subjective and objective CRAs show a slight positive correlation with DMFT/def scores ($r = 0.159$ and $r = 0.050$, respectively). This correlation indicates that participants' subjective and objective CRA scores slightly correlated with the current caries status.

Table 6 depicts the correlation between salivary pH and the CRA questionnaire. The correlation yielded a value of $r = -0.062$, i.e., a negative correlation between subjective and objective assessment. This denotes that each participant's caries risk assessed by subjective and objective methods were inversely related, i.e., if a participant was categorized as low-risk by the subjective method of assessment, the caries risk of the same participant was categorized as either moderate or high by the objective method.

Discussion

CRA is a methodology for categorizing patients into risk groups based on the potential to develop new

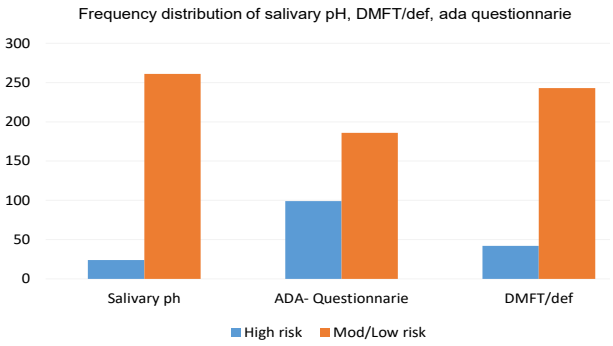

Figure 1. Frequency distribution of salivary pH, the subjective CRA questionnaire, and DMFT scores. CRA: caries risk assessment; DMFT: decayed, missing, filled tooth; ADA: American Dental Association.

Table 2. Frequency distribution of objective salivary pH, subjective CRA questionnaire, and DMFT/def scores

	0 (Low risk)	1 (Moderate risk)	2 (High risk)
Salivary pH	50 (17.5%)	211 (74%)	24 (8.4%)
DMFT/def	152 (53.3%)	91 (31.9%)	42 (14.7%)
ADA questionnaire	34 (11.9%)	152 (53.3%)	99 (34.7%)

CRA: caries risk assessment; DMFT: decayed, missing, filled tooth; ADA: American Dental Association.

Table 3. Comparison of salivary pH, CRA questionnaire tool, and DMFT scores

	Chi-square value	*P* value
Salivary pH * DMFT/def scores	5.552	0.018*
ADA questionnaire * DMFT/def scores	30.616	0.000*
Salivary pH * ADA questionnaire	58.316	0.000*

CRA: caries risk assessment; DMFT: decayed, missing, filled tooth; ADA: American Dental Association.
*Chi-square test; $P<0.05$: statistically significant.

Table 4. Correlation between DMFT and age of the patients

	Age	
	r value	*P* value
DMFT	0.189	0.001*

DMFT: decayed, missing, filled tooth
Pearson correlation analysis; *$P<0.05$: statistically significant.

Table 5. Correlation between salivary pH and the CRA questionnaire with DMFT scores

	DMFT	
	r value	*P* value
Salivary pH	0.159	0.007*
ADA - questionnaire	0.050	0.399

CRA: caries risk assessment; DMFT: decayed, missing, filled tooth; ADA: American Dental Association.
Pearson correlation analysis; *$P<0.05$: statistically significant.

Table 6. Correlation between salivary pH and the CRA questionnaire

	ADA - questionnaire	
	r value	*P* value
Salivary pH	0.062	0.297

CRA: caries risk assessment; DMFT: decayed, missing, filled tooth; ADA: American Dental Association.
Pearson correlation analysis; *$P<0.05$: statistically significant.

carious lesions over time. It bases the assessment on the patient's past and present caries history and known risk factors or indicators for disease using data gleaned from the patient's medical, dental, social, and preventive history, dietary screening, clinical determinants of caries status and history, salivary function tests, and fluoride exposure.[12]

The rationale for using a risk assessment approach is to tailor appropriate preventive strategies to the individual patient. Those patients who are at greater risk for disease require more aggressive intervention at more frequent intervals.

CRA models currently rely on a series of common elements. However, differences exist among the models because of differences in emphasis and interpretation. Most of the subjective assessments are based on questionnaires collecting responses from patients. Objective assessment is based on analysis of certain parameters, including salivary flow, salivary pH, and colony counting and analysis. As the critical pH in the saliva is essential to the colonization and growth of bacteria, salivary pH analysis was chosen as the objective risk assessment. This study assessed the correlation between the predictive validity of the subjective and objective assessments.

The age range included in the study to predict caries risk was 7 to 20 years old. This is primarily because caries activity is the highest in this age group due to increased intake of sugars and starchy foods and increased frequency of eating.[13]

In the present study, age was positively correlated with dental caries. An increase in age was associated with an increase in dental caries. Several studies have reported that an increase in age and decreased salivary pH is associated with increased dental caries among patients with systemic diseases.[14-17] Aging affects the salivary glands' quantity, quality, and flow rate. Thus, as the age increases, adults may suffer from dry mouth and taste aberrations, which invariably result in an increased risk of caries.

A slight positive correlation was seen between the risk categories predicted by the subjective and objective methods and the actual caries increment assessed using DMFT/def indices. The participant's risk assessment by subjective and objective methods is similar to the actual caries increment status. This is in line with the study done by Rai et al[18] on the correlation between subjective risk assessment and the actual caries status, showing that the subjective assessment model correlated with actual caries status. Another 18-month follow-up study by Jyoti Sharma et al[19] compared the predictive value of cariogram and informal CRA with caries increment status. There was a positive correlation between the real caries increase and the subjective risk assessment using the cariogram.

In the present study, the correlation between objective risk assessment by salivary pH and actual caries status was slightly better ($r=0.159$) than that of subjective risk assessment methods and actual caries increment ($r=0.050$). Both these risk assessment methods replicate the current status of caries increment.

Another finding of our study stated that a negative correlation was found between subjective and objective risk assessment methods ($r=-0.062$). This shows that the categorization of risk by subjective methods was inversely related to objective methods. This could be due to the variability in subjective measurement relying on human judgment or due to inter-examiner variability. However, objective measurements are quantifiable, impartial, and recorded with a diagnostic instrument. Personal feelings, fear of judgment, or opinions about facts can influence subjective measurement. Subjective satisfaction, as defined by Kahneman and Krueger,[20] is the overall retrospective judgment based on the respondent's present mood and recollection. Research involving subjective indicators is difficult due to each individual's different perceptions and preferences and the difficulty of collecting data.

Strengths and Limitations

This is the first study comparing the subjective and objective CRA methods. However, the relatively small sample population is one of the limitations of this study.

Conclusion

Based on our findings, the results of the subjective and objective methods of determining the risk of dental caries are independent of each other. Moreover, the objective method of CRA using salivary pH showed a slight positive correlation with actual dental caries status, meaning that the objective method of risk categorization better reflects the actual current caries status. Caries risk is not the same for all individuals, so an individualized protocol should be followed based on the balance between risk and protective factors.

Recommendation

Appropriate standardized strategies should be used to assess dental caries to aid future prevention, diagnosis, caries -related treatment, prognosis, and management. Future studies with various modes of subjective and objective CRA are warranted.

Authors' Contribution

Conceptualization: Karthikayan Ravi, Indra Priyadharsini.
Data curation: Karthikayan Ravi, Vishnu Prasad, Indra Priyadharsini, Mahesh Jagadeson.
Formal Analysis: Karthikayan Ravi, Indra Priyadharsini.
Investigation: Karthikayan Ravi, Vishnu Prasad, Indra Priyadharsini.
Methodology: Karthikayan Ravi, Indra Priyadharsini, Mahesh Jagadeson.
Project administration: Karthikayan Ravi, Mahesh Jagadeson.
Resources: Karthikayan Ravi, Mahesh Jagadeson.
Supervision: Vishnu Prasad.
Software: Mahesh Jagadeson.
Validation: Karthikayan Ravi, Indra Priyadharsini.
Visualization: Karthikayan Ravi, Vishnu Prasad.
Writing–original draft: Karthikayan Ravi, Indra Priyadharsini, Mahesh Jagadeson.
Writing–review & editing: Karthikayan Ravi, Indra Priyadharsini.

Competing Interests

None declared.

Data Availability Statement

All relevant data can be made available upon request.

Ethical Approval

This study was approved by Institutional Ethical Committee of Karpaga Vinayaga Institute of Dental Sciences (Ethics Number: KIDS/IEC/2024/I/010).

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